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Pulmonary function test in children with asthma of 6–14 years visiting asthma and allergy clinic at Birat medical college teaching hospital

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ABSTRACT

Background: An obstructive pattern and positive bronchodilator response are the typical findings of spirometry in asthmatic children. However, this pattern fails to meet the diagnostic criteria recommended by various guidelines. **Aims and Objectives:** This article aims to study the spirometry pattern in asthmatic children attending asthma and allergy clinics. **Materials and Methods:** This was an observational cross-sectional study that included 75 asthmatic children between 6 and 14 years of age visiting the Asthma and Allergy Clinic at the Pediatric Department who needed a spirometry test. Patterns of spirometry were studied and analyzed using standard statistical tests. **Results:** Among 75 asthmatic children, there were 44 (58.7%) males. Normal spirometry pattern was found in 20 (26.7%) of all cases, obstructive in 22 (29.3%), mixed in 23 (30.7%), and restrictive in 10 (13.3%) of cases. Forced expiratory volume in 1 s reversibility >12% was found in 23 (30.7%), whereas forced expiratory flow (FEF) between 25% and 75% of forced vital capacity (FEF25–75%) <60% in 26 (34.7%) and its post-bronchodilator change >30% in 27 (36%) of cases. **Conclusion:** This study highlights the abnormal spirometry pattern in the majority of children with asthma. Abnormal FEF of 25–75% and its positive post-bronchodilator changes were also observed in a considerable proportion of cases, emphasizing the importance of this pattern for the diagnosis of asthma in children.

Key words: Asthma; Child; Pulmonary function test; Spirometry

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INTRODUCTION

Asthma is one of the most common chronic diseases in children. It is a major cause of frequent admissions to hospital and emergency room visits, leading to significant morbidity and mortality in children worldwide.[1]

Reversible bronchial obstruction is the main characteristic of asthma. Spirometry is a tool that is used to objectively detect reversible airflow. This test is recommended by various guidelines for the diagnosis and monitoring of asthma. The National Institute for Health and Care Excellence guideline mentions abnormal spirometry tests when forced expired volume in 1 s/forced vital capacity (FEV_1/FVC) ratio <70% of predicted or below the lower limit of normal (LLN), improvement in FEV1 of 12% or more in bronchodilator response (BDR) test.[2] Similarly, the Global Initiative for Asthma recommends the cutoff value for FEV_1/FVC ratio of below LLN or <0.90, a BDR of at least 12% in FEV_1.[3] Studies have shown conflicting results regarding the sensitivity of different spirometry parameters. A study revealed normal FEV1, even in severe persistent childhood asthma, whereas FEV1/FVC declines as asthma severity increases.[4] Some research highlights the

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significance of other spirometry parameters in assessing asthma. A study demonstrated statistically significant differences in pre- and post-bronchodilator forced expiratory flow (FEF) 25–75% values among pediatric asthma patients.[5] Another study showed no significant difference in FEV_1/FVC ratio between asthmatics and non-asthmatics and also concluded that FEF25–75% is a better parameter for assessment of severity of asthma than FEV_1 and FVC.[6] However, a study done in India showed FEV1 as the best index for assessing the severity of asthma and FEF25–75% as better in predicting mild asthma.[7]

There has been ongoing debate about the value and relative sensitivity of spirometry patterns and there have been limited studies that have evaluated the spirometry patterns in children with asthma in Nepal. Hence, this study was planned to evaluate the pattern of spirometry in children with asthma in 6–14-year-old children.

Aims and objectives

The objective of this study is to evaluate spirometry patterns in children aged 6 to 14 years with asthma.

MATERIALS AND METHODS

An observational cross-sectional study was conducted on 6 and 14-year-old children with asthma who visited the Asthma and Allergy Clinic at the Pediatric Department of Birat Medical College Teaching Hospital from June 2024 to January 2025. This is a tertiary care hospital located in Eastern Nepal that is equipped to perform spirometry tests on pediatric patients. As an ethical requirement, written consent from parents and assent of children above 7 years of age were obtained before including in the study. This study was started after approval by the Research Ethics Committee of Birat Medical College (Reference number: IRC-PA-384/2024). Subjects were sampled by the non-probability consecutive sampling technique. The study included clinically suspected cases of asthma based on a history of respiratory symptoms such as wheezing, shortness of breath, chest tightness, and cough that vary over time and in intensity[3] and who were able to perform spirometry. Children who were uncooperative, declined to give consent or assent, or failed to meet the acceptablility and reproducibility criteria[8] for spirometry were excluded from the study. We used an Easy Connect spirometry device manufactured by ndd Medical Technologies (Switzerland).

We categorized spirometry results into four types of patterns: Normal, obstructive, restrictive, or mixed. A normal pattern was defined when the values of FVC (≥80% of predicted), FEV1 (≥80% of predicted), and FEV1/FVC (≥0.9) were normal. An obstructive pattern was defined when FEV1 (<80% of predicted) and FEV1/FVC (<0.9) were decreased, with a normal FVC. A restrictive pattern was identified when both FVC and FEV1 were decreased and FEV1/FVC was normal or increased. A mixed pattern was described when all three parameters were decreased.[2,3] A positive response to bronchodilators is diagnosed when FEV1 improves by >12% or 0.2 L after 15 min following inhalation of 200 μg of salbutamol.[3] Evidence of obstruction within the middle and small airways of the lungs was considered abnormal when FEF 25–75% was <60% of the predicted value and showed improvement >30% of baseline after 15 min of salbutamol inhalation.[9] Standard spirometry instructions were explained before the procedure. American Thoracic Society guidelines were followed for the procedure and measurements.[8] Age, gender, height, weight, and ethnicity were noted. The use of short-acting β2-agonist and long-acting β2-agonist were withheld for at least 4 h and 24 h before the procedure, respectively. It was performed in an upright seated position with a nose clip and sterile mouthpiece. The child was instructed to take a deep breath and blast out air quickly for 3–6 s, then inhale completely. The subject was encouraged to repeat the procedure until the acceptability and reproducibility criteria were fulfilled. A maximum of eight trials were performed. A bronchodilator test was performed after giving 2 puffs (200 μg) of salbutamol by metered dose inhaler with a spacer and the procedure was carried out after 15 min. A minimum of three acceptable measurements with the difference between the two largest FVC ≤0.150 L and the difference between the two largest FEV1 ≤0.150 L were accepted for the study.[8] Socio-demographic data such as age and gender were noted.

We used the n =4×P×Q/L2 formula to calculate sample size (n – sample size, P – approximate prevalence, Q=1-P, L=Allowable error of 5%, P was taken as 90% as the pre-bronchodilator was 90% in children with normal FEV1, normal FEV1/FVC, and normal FEF25–75.[10] The calculated sample size came out 144. We performed around 150 (N) spirometry tests last year. Hence, the adjusted sample size for the finite population is

Corrected sample size (n1)=n/1+n-1/n.

Hence, the calculated sample size was 73.

Data entry and analysis were performed using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). Categorical data were presented in the form of frequency, percentage, and pie chart.

RESULTS

A total of 75 children with asthma between 6 and 14 years of age from June 2024 to January 2025 were included in this study. The average age of presentation was 10.55±2.52 years (mean+SD), and 44 (58.7%) were male (Figure 1). The pattern of spirometry parameters is shown in Table 1. The common abnormal patterns of spirometry were mixed patterns in 23 (30.7%), followed by obstructive 22 (29.37%), normal 20 (26.7%), and restrictive 10 (13.3%). Post-bronchodilator FEV1 >12% of baseline was seen in 23 (30.7%) and abnormal FEF25–75% was observed in 26 (34.7%) and its post-bronchodilator reversibility in 27 (36%) cases.

DISCUSSION

In our study, there were predominantly more males than females (1.4:1), which is in agreement with findings from a study done by Melgert et al., who observed a higher prevalence of asthma in boys than in girls during early childhood.[11] However, another study concluded that there is no gender difference among asthmatic children aged 9–11 years.[12] In addition, another study revealed that the prevalence of asthma is higher in females than males as their age increases.[13,14] Boys have smaller airways as compared to girls under 10 years of age which predisposed them to increased airway reactivity as compared with girls of the same age, height, and weight.[15]

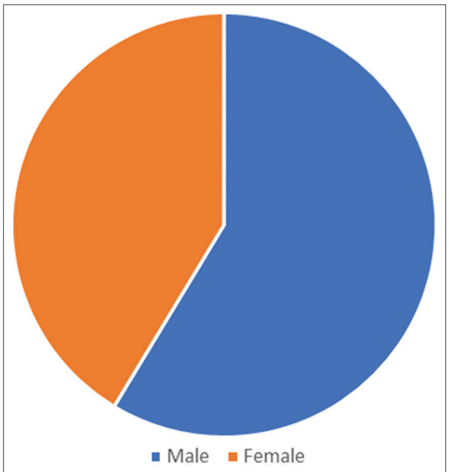

Figure 1: Gender distribution of children with asthma

Table 1: Distribution of pattern of spirometry parameters of asthmatic children

Spirometry pattern	Number (n)	Percentage
Normal	20	26.7
Obstructive	22	29.3
Restrictive	10	13.3
Mixed	23	30.7
FEV1 reversibility >12%	23	30.7
FEF 25–75% <60%	26	34.7
FEF 25–75% BDR positive	27	36

FEF: Forced expiratory flow, FEV: Forced expiratory volume, BDR: Bronchodilator response

This study identified abnormal spirometry patterns in 73.3% of participants. In contrast, Yimlamai et al. reported an overall prevalence of 58.1%, which is lower than the findings of our study.[16] Another study recorded a 23.5% prevalence of abnormal spirometry tests among clinically diagnosed asthma cases.[17] Our study reported a higher prevalence of abnormal spirometry due to the inclusion of all types of abnormal patterns.

Among abnormal spirometry patterns, the most common observed in our study was an improvement in post-bronchodilator FEF25–75% in 36% and a decrease in FEF25–75% in 34.7% of cases. Klein et al. demonstrated that FEF25–75% is the most specific and sensitive measure of airway obstruction.[18] A study by Lebecque et al. showed a similar finding in children with asthma.[9] In addition, a study revealed that using the percent change in FEF25–75% from baseline may be helpful in identifying bronchodilator responsiveness in asthmatic children with a normal FEV(1).[8] FEF25–75% is less effort dependent as compared to FEV and is considered a measurement of small airway patency.[19] These results suggest that in addition to FEV1 and FEV1/FVC, as mentioned by various guidelines, pre- and post-FEF25–75% may also be considered a good indicator of airflow patency in children with asthma, as it is less effort-dependent than other spirometry parameters. In our study, the obstructive pattern was found in 29.3% of cases. The reported prevalence of airflow obstruction in pediatric asthma ranges from 23.5% to 60%.[16] A study conducted in the United Kingdom found airflow obstruction in 23.5% of cases, which is similar to our study.[17] A diagnosis of asthma is based on a combination of clinical features such as wheezing, coughing, and chest tightness, alongside objective evidence of variable airway obstruction confirmed by spirometry tests.[20,21] The presence of reversible airflow obstruction in response to bronchodilators is one of the major criteria used to diagnose asthma in children.[3] In our study, 30.7% of asthmatic children showed a change in FEV1 >12% after bronchodilator test. Another study by Coverstone et al. found that out of 220 children with asthma, 112 (51%) had a significant increase in FEV1 by 12% following bronchodilator testing.[22] However, another study showed that bronchodilator reversibility was positive in 54 (9%) of 624 children.[23] Post-bronchodilator FEV1 >12% in asthmatic children is considered a major finding supporting a diagnosis of asthma as it shows improvement in lung function after inhaling the bronchodilator.

Limitations of the study

This study was conducted at a single center with a small sample size, which may have influenced the findings.

CONCLUSION

This study of asthmatic children aged 6–14 years provides valuable information into the spirometry pattern. Our findings highlight that pre and post-bronchodilator FEF25–75% and post-FEV1 changes were the most common pattern in pediatric asthma. The study suggests that asthmatic children pre- and post-FEF25–75% and post-FEV1 study can be considered for diagnosis, and we also suggest further research to explore the underlying factors influencing these variations.

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REFERENCES

1. GBD 2015 Chronic Respiratory Disease Collaborators. Global, regional, and national deaths, prevalence, disability-adjusted life years, and years lived with disability for chronic obstructive pulmonary disease and asthma, 1990-2015: A systematic analysis for the global burden of disease study 2015. Lancet Respir Med. 2017;5(9):691-706.
   https://doi.org/10.1016/S2213-2600(17)30293
2. National Institute for Health and Care Excellence (Nice). Asthma: Diagnosis, Monitoring and Chronic Asthma Management: Nice Guideline (NG80); 2021. Available from: https://www.nice.org.uk/guidance/ng80 [Last accessed on 2025 Feb 20].
3. Global Initiative for Asthma (GINA). Global Strategy for Asthma Management and Prevention; 2022. Available from: https://ginasthma.org/gina-reports [Last accessed on 2024 Aug 03].
4. Bacharier LB, Strunk RC, Mauger D, White D, Lemanske RF Jr and Sorkness CA. Classifying asthma severity in children: Mismatch between symptoms, medication use, and lung function. Am J Respir Crit Care Med. 2004;170(4):426-432.
   https://doi.org/10.1164/rccm.200308-1178OC
5. Hegde K, Saxena AS and Rai RK. Evaluation of spirometry in asthmatic children. Int J Contemp Pediatr. 2017;4(3):729-729.
   https://doi.org/10.18203/2349-3291.ijcp20171071
6. Ratageri VH, Kabra SK, Lodha R, Dwivedi SN and Seth V. Brief report. Lung function tests in asthma: Which indices are better for assessment of severity? J Trop Pediatr. 2001;47(1):57-59.
   https://doi.org/10.1093/tropej/47.1.57
7. Puneeth HR, Gopalakrishna Mithra CA and Ratageri VH. Pulmonary function tests in childhood asthma: Which indices are better for assessment of severity? Indian J Pediatr. 2023;90(6):566-571.
   https://doi.org/10.1007/s12098-022-04258-1
8. Loeb JS, Blower WC, Feldstein JF, Koch BA, Munlin AL and Hardie WD. Acceptability and repeatability of spirometry in children using updated ATS/ERS criteria. Pediatr Pulmonol. 2008;43(10):1020-1024.
   https://doi.org/10.1002/ppul.20908
9. Lebecque P, Kiakulanda P and Coates AL. Spirometry in the asthmatic child: Is FEF25-75 a more sensitive test than FEV1/FVC? Pediatr Pulmonol. 1993;16(1):19-22.
   https://doi.org/10.1002/ppul.1950160105
10. Rao DR, Gaffin JM, Baxi SN, Sheehan WJ, Hoffman EB and Phipatanakul W. The utility of forced expiratory flow between 25% and 75% of vital capacity in predicting childhood asthma morbidity and severity. J Asthma. 2012;49(6):586-592.
    https://doi.org/10.3109/02770903.2012.690481
11. Melgert BN, Ray A, Hylkema MN, Timens W and Postma DS. Are there reasons why adult asthma is more common in females? Curr Allergy Asthma Rep. 2007;7(2):143-150
    https://doi.org/10.1007/s11882-007-0012-4
12. Osman M, Tagiyeva N and Wassall HJ. Changing trends in sex specific prevalence rates for childhood asthma, eczema, and hay fever. Pediatr Pulmonol. 2007;42(1):60-65.
    https://doi.org/10.1002/ppul.20545
13. Vink NM, Postma DS, Schouten JP, Rosmalen JG and Boezen HM. Gender differences in asthma development and remission during transition through puberty: The tracking adolescents' individual lives survey (TRAILS) study. J Allergy Clin Immunol. 2010;126(3):498-504.e1-6.
    https://doi.org/10.1016/j.jaci.2010.06.018
14. Chen Y, Stewart P, Johansen H, Mcrae L and Taylor G. Sex difference in hospitalization due to asthma in relation to age. J Clin Epidemiol. 2003;56(2):180-187.
    https://doi.org/10.1016/S0895-4356(02)00593-0)
15. Becklake MR and Kauffmann F. Gender differences in airway behaviour over the human life span. Thorax. 1999;54(12):1119-1138.
    https://doi.org/10.1136/thx.54.12.1119
16. Yimlamai S, Ruangnapa K, Anuntaseree W, Saelim K, Prasertsan P and Sirianansopa K. A longitudinal study of a selected pediatric asthmatic population with normal and abnormal spirometry at baseline: An emphasis on treatment outcomes. J Asthma Allergy. 2024;17:61-68.
    https://doi.org/10.2147/JAA.S432648
17. Lo DK, Beardsmore CS, Roland D, Richardson M, Yang Y, Danvers L, et al. Lung function and asthma control in school-age children managed in UK primary care: A cohort study. Thorax. 2020;75(2):101-107.
    https://doi.org/10.1136/thoraxjnl-2019-213068
18. Klein RB, Fritz GK, Yeung A, Mcquaid EL and Mansell A. Spirometric patterns in childhood asthma: Peak flow compared with other indices. Pediatr Pulmonol. 1995;20(6):372-379.
    https://doi.org/10.1002/ppul.1950200607
19. Gelb AF and Zamel N. Simplified diagnosis of small-airway obstruction. N Engl J Med. 1973;288(8):395-398.
    https://doi.org/10.1056/NEJM197302222880805
20. Bui DS, Walters HE, Burgess JA, Perret JL, Bui MQ, Bowatte G, et al. Childhood respiratory risk factor profiles and middle-age lung function: A prospective cohort study from the first to sixth decade. Ann Am Thorac Soc. 2018;15(9):1057-1066.
    https://doi.org/10.1513/AnnalsATS.201806-374OC
21. Dharmage SC, Bui DS, Walters EH, Lowe AJ, Thompson B, Bowatte G, et al. Lifetime spirometry patterns of obstruction and restriction, and their risk factors and outcomes: A prospective cohort study. Lancet Respir Med. 2023;11(3):273-282.
    https://doi.org/10.1016/S2213-2600(22)00364-2
22. Coverstone AM, Bacharier LB, Wilson BS, Fitzpatrick AM, Teague WG, Phipatanakul W, et al. Clinical significance of the bronchodilator response in children with severe asthma. Pediatr Pulmonol. 2019;54(11):1694-1703.
    https://doi.org/10.1002/ppul.24473
23. Murray C, Foden P, Lowe L, Durrington H, Custovic A and Simpson A. Diagnosis of asthma in symptomatic children based on measures of lung function: An analysis of data from a population-based birth cohort study. Lancet Child Adolesc Health. 2017;1(2):114-123.
    https://doi.org/10.1016/S2352-4642(17)30008-1

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SY- Concepts, design, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation, guarantor; **RBS**- Data acquisition, statistical analysis, manuscript editing, manuscript review; **HR**- Design, definition of intellectual content, manuscript editing, manuscript review

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