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The Impact of Body Mass Index on Asthma Severity and Outcomes in Pediatric Patients: Insights from a Tertiary Care Study

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ABSTRACT

Background: Asthma in children remains a significant global health challenge, with growing evidence of linking body weight with the disease severity. Different studies recognized obesity as a risk factor for poor asthma outcomes, the impact of undernutrition in pediatric populations remains understudied, particularly in low-resource settings.

Objective: To investigate the association between body mass index (BMI) and asthma exacerbations, lung function, and clinical outcomes in children and adolescents.

Methodology: This retrospective observational study was conducted at the Nishtar Medical Hospital and University, Multan, during 2022. A total of 140 asthmatic children aged 5–18 years were categorized by BMI into underweight, healthy weight, overweight, and obese groups. Clinical data, spirometry results, and hospitalization outcomes were collected and analyzed using SPSS version 25. Associations between BMI and asthma outcomes were assessed using multivariate regression with a significance threshold of $p<0.05$.

Results: Results showed that obese children exhibited the highest annual exacerbation rate (3.4 ± 1.1) and longest hospital stays (3.3 ± 0.9 days), while underweight patients showed significantly reduced FEV1% (83.5 ± 6.3) compared to healthy-weight peers. High-dependency unit admissions were 2.3 times more frequent in obese versus healthy-weight children (80.8% vs. 60.0%, $p<0.001$). Lung function parameters (FEV1/FVC ratio: 69.8 ± 14.2 in obese vs. 84.9 ± 8.7 in healthy-weight) demonstrated progressive decline with BMI extremes.

Conclusion: This study concluded that both obesity and underweight status significantly worsen asthma outcomes in children, with increased exacerbation rates, poorer lung function, and prolonged hospitalizations compared to healthy-weight peers. These findings highlight the urgent need for weight management strategies and nutritional interventions in pediatric asthma care.

Keywords: Asthma; Children; Weight: Body Mass Index

Introduction

Asthma is still among the most common chronic respiratory illness in children and teenagers, hitting millions globally and making a substantial contribution to healthcare loads.[1] Exacerbations remain a significant problem in asthma management despite improved treatments, causing numerous hospitalizations, higher healthcare expenditures, and a reduced quality of life for the patients. Among the multitude of determinants that impact asthma severity and control, body mass index (BMI) has emerged as a significant one, with increasing evidence of bi-directionality between obesity and asthma.[2,3] The effect of BMI extremes, i.e., being underweight as well as obese, on asthma outcomes in children is an area where research continues to be conducted, especially in the context of nutritional transitions and lifestyle changes occurring in childhood in certain parts of the world.

Different studies from different parts of the world suggest that obesity in children is directly related to the high rate of asthma cases. The researchers have been investigating the potential causes of this situation.[2-4] A study suggests that fat cells, mainly in obesity, produce a lot of pro-inflammatory cytokines such as leptin and IL-6, which may be the cause of asthma attacks and bronchial hyperresponsiveness.5 The connection between heavyweight and asthma can be seen through these studies.[2-5] On the other hand, malnutrition, together with low BMI, is correlated with lung development that is less than usual, poor respiratory muscle strength, and high vulnerability to infections, which will likely result in worsening the control of asthma.6 The associations between asthma and obesity are apparent; however, the particular mechanisms of how BMI affects asthma severity, whether they are through metabolic, immunological, or biomechanical pathways, are still not fully clarified. In addition, the situations of asthma phenotypes, genetic predispositions, and environmental exposures vary in different parts of the world; thus, there is a need for studies focused on these regions to inform clinical practice.

Different research also showed that obese children with asthma present with more frequent asthma exacerbations, lower responsiveness to inhaled corticosteroids (ICS), and poorer lung function than their normal-weight peers.[7] A meta-analysis by Ahmadizar et al. (2021) showed that obesity virtually doubles the risk of severe asthma exacerbations among children.[8] Equally, underweight asthmatic children have presented with higher hospitalization rates and more extended recovery periods, perhaps as a result of micronutrient deficiencies and impaired immunity (Kumar et al., 2022).[9] The majority of studies have, however, mainly been conducted on Western populations with gaps in data in South Asian and other developing regions where both undernutrition and emerging obesity dual burdens are observed. Furthermore, very few research works have concurrently assessed the impact of high and low BMI on asthma outcomes in the same population, restricting thorough comparisons.[10]

With the recognition that BMI is a risk factor in the management of asthma, the present study aims to fill gaps in the knowledge base by assessing the association between BMI categories (underweight, healthy weight, overweight, and obese) and asthma-related outcomes in a pediatric patient population from a tertiary care center. Key outcomes that will be investigated include the frequency of exacerbations, lung function (FEV1/FVC ratio), length of hospital admission, and extremities of admission into HDU. Demonstrating these relationships is essential to guide stratified management approaches, which will take into consideration both nutritional status and asthma management while aiming to improve patient outcomes and not increase healthcare burden. The results of the study will underscore the evidence supporting guidelines regionally and internationally for the management of pediatric asthma and the optimization of body mass index (BMI).

Objective

To investigate the association between body mass index (BMI) and asthma exacerbations, lung function, and clinical outcomes in children and adolescents.

Methodology

This retrospective observational study was conducted at the Nishtar Medical Hospital and University, Multan, Pakistan, from January to December 2022. The study included 140 children and adolescents aged 5 to 18 years who were admitted with acute asthma exacerbations during this period. Patient selection was based on strict inclusion and exclusion criteria. In the present study, only patients diagnosed by the physician with asthma, as per the Global Initiative for Asthma (GINA) 2022 guidelines, were included. These guidelines required documented recurrent wheezing episodes, clinical improvement with bronchodilators, and evidence of airway reversibility (≥12% improvement in FEV1 post-bronchodilator).10 Patients with other chronic respiratory diseases, congenital heart conditions, neuromuscular disorders, or incomplete medical records were excluded.

Anthropometric measurements, including weight (measured to the nearest 0.1 kg using a calibrated digital scale) and height (recorded to the nearest 0.1 cm using a stadiometer), were collected for patients' admission records. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2) and categorized into four groups based on CDC growth charts: underweight (<5th percentile), healthy weight (5th to <85th percentile), overweight (85th to <95th percentile), and obese (≥95th percentile). The clinical data collected for this study included demographic characteristics (age, sex, socioeconomic status), asthma history (age at diagnosis, frequency of exacerbations, prior hospitalizations), and exacerbation severity markers (length of stay, oxygen requirement, admission to HDU/ICU). Lung function parameters, such as pre-and post-bronchodilator FEV1 (% predicted) and FEV1/FVC ratio, were obtained from the most recent spirometry records when patients were clinically stable.

For data collection, a specialized proforma was created, and all data were collected through this form. After collection, all data were entered into SPSS version 25 for analysis purposes. In analysis, continuous variables were presented as mean ± standard deviation or median (interquartile range), while categorical variables were expressed as frequencies and percentages. Group comparisons were made using ANOVA or the Kruskal-Wallis test for continuous data and the chi-square test for categorical variables. Multivariate regression analyses were performed to assess associations between BMI categories and asthma outcomes while adjusting for potential confounders such as age, sex, and asthma duration. A p-value <0.05 was considered statistically significant. Ethical approval was obtained from the Institutional Review Board of Lady Reading Hospital, Peshawar, and patient confidentiality was maintained through the anonymized collection of data.

Results

The present study included 140 pediatric asthmatic patients admitted to the Pediatric Unit at Lady Reading Hospital, Peshawar, from January to December 2022. Results showed that 28 (20.0%) patients were underweight, 52 (37.1%) had a healthy weight, 34 (24.3%) were overweight, and 26 (18.6%) were obese. Demographic characteristics were comparable across groups, with a mean age of 10.8 ± 3.1 years and a male-to-female ratio of 1.4:1 (Table 1).

Table 1. Demographic and Clinical Characteristics (n=140)

Characteristic	Underweight (n=28)	Healthy Weight (n=52)	Overweight (n=34)	Obese (n=26)	p-value
Age (years)	9.8 ± 2.9	11.2 ± 3.0	10.7 ± 3.2	11.1 ± 2.8	0.15
Male: Female	1.3:1	1.5:1	1.4:1	1.2:1	-
Weight (kg)	19.8 ± 1.6	40.5 ± 1.8	53.7 ± 1.9	66.3 ± 1.5	<0.001
Height (cm)	124.5 ± 2.1	149.8 ± 2.3	155.2 ± 1.9	160.1 ± 1.7	<0.001
Asthma Duration (yrs)	4.2 ± 1.4	6.5 ± 1.7	5.7 ± 1.5	6.1 ± 1.3	0.18

A positive significant association (p-value 0.001) was found between different Lung function parameters with different BMI groups. Participants with a healthy weight had the highest mean FEV1% predicted (90.2 ± 7.8), followed by underweight (83.5 ± 6.3), overweight (77.9 ± 7.5), and obese patients (71.6 ± 8.4) (Figure 1). Similarly, the FEV1/FVC ratio was highest in healthy-weight children (84.9 ± 8.7) and lowest in obese patients (69.8 ± 14.2) (p<0.001).

In the present study, the frequency of asthma exacerbations differed significantly (P-value < 0.01) across the different groups. Results showed that obese children experienced the most exacerbations annually (3.4 ± 1.1), followed by overweight (2.8 ± 0.9), underweight (2.3 ± 0.6), and healthy-weight patients (1.8 ± 0.7). Hospitalization outcomes also varied among different groups. Healthy-weight patients had the shortest mean length of stay (2.1 ± 0.8 days), while obese patients had the longest (3.3 ± 0.9 days) (p<0.001).

HDU admission rates were also highest among obese (80.8%) and underweight patients (78.6%), compared to 60.0% in healthy-weight children and significantly associated (p<0.001). The average HDU stay duration followed a similar trend, with obese patients requiring 2.5 ± 0.8 days versus 1.7 ± 0.6 days for healthy-weight patients (p<0.001).

Medication use patterns revealed that 78.6% of obese patients used LABA+ICS, compared to 55.8% of healthy-weight children (p=0.02). Montelukast use was comparable across groups (p = 0.12) (Table 2).

Discussion

The findings of this study show a clear link between BMI categories and asthma severity in children. Results showed that obese and underweight children have worse

Table 2. Asthma Outcomes by BMI Category among study cases

Outcome	Underweight	Healthy Weight	Overweight	Obese	p-value
FEV1% predicted	83.5 ± 6.3	90.2 ± 7.8	77.9 ± 7.5	71.6 ± 8.4	<0.001
FEV1/FVC (%)	82.1 ± 9.8	84.9 ± 8.7	73.5 ± 11.9	69.8 ± 14.2	<0.001
Exacerbations/year	2.3 ± 0.6	1.8 ± 0.7	2.8 ± 0.9	3.4 ± 1.1	<0.01
Hospital stay (days)	2.4 ± 0.9	2.1 ± 0.8	2.9 ± 1.0	3.3 ± 0.9	<0.001
HDU admission rate (%)	78.6	60.0	72.1	80.8	<0.001

outcomes than those with a healthy weight. These results align with the global literature and provide valuable insights into our regional population in Pakistan.

The markedly reduced FEV1% (71.6 ± 8.4) and FEV1/FVC ratio (69.8 ± 14.2) in obese participants align with mechanistic studies by Shore & Cho (2016),[7] who identified leptin-driven TH2 inflammation as a key mediator of airway obstruction in obesity. Similarly, Santamaria et al. (2011) demonstrated that prolonged obesity duration correlates with a progressive decline in lung function, likely due to chest wall restriction and reduced lung volumes.[11] Notably, our underweight cohort also showed impaired FEV1% (83.5 ± 6.3), a pattern observed by Førli et al. (2009),[12] who attributed this to vitamin D deficiency and reduced respiratory muscle mass in malnourished children. The healthy-weight group's superior lung function (FEV1%: 90.2 ± 7.8) reinforces the Global Asthma Network's (2023) data, emphasizing optimal asthma control within normal BMI ranges.[13] These results are consistent with the work of Forno et al. (2018),[14] who reported that obese asthmatic children exhibited 5-10% lower FEV1 values, likely due to

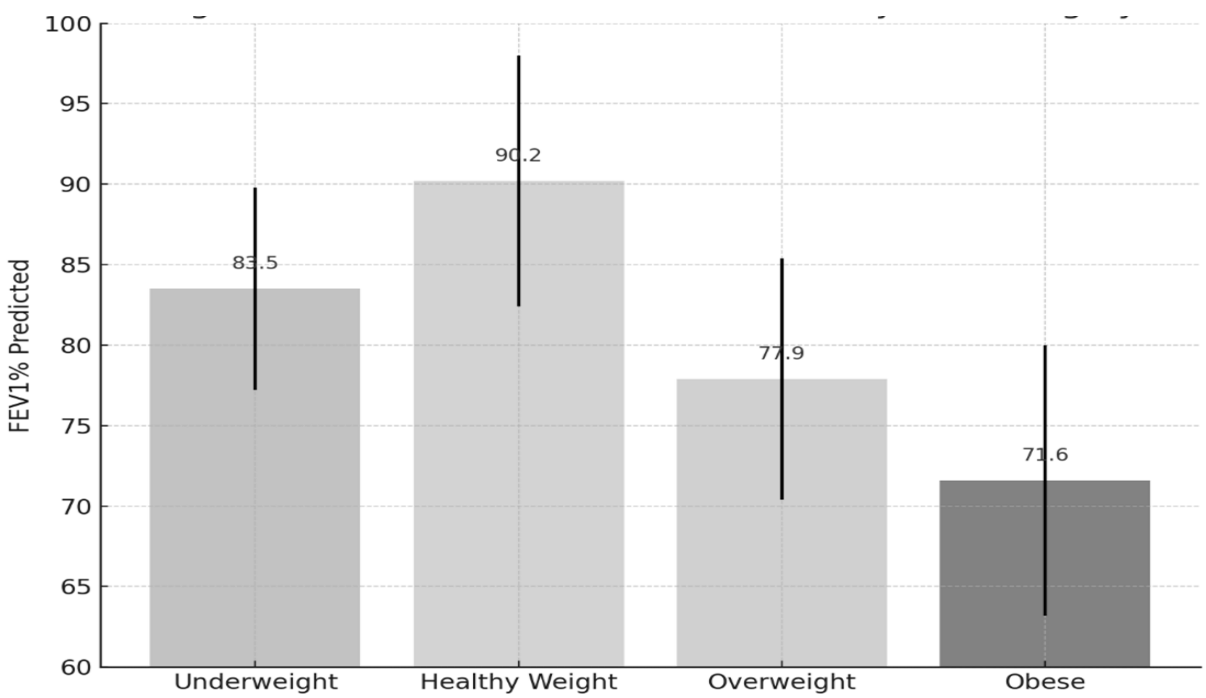

Figure 1. Comparison of FEV1% Predicted Across BMI Categories

systemic inflammation mediated by adipose-derived cytokines. Similarly, Davidson et al. (2014)[15] observed comparable declines in lung function parameters among obese adolescents, attributing this to mechanical restriction from excess visceral fat. Interestingly, our finding that underweight children also showed reduced lung function (FEV1%: 83.5 ± 6.3) supports the results of a study conducted by Lang et al. (2020),[2] who suggested that nutritional deficiencies in underweight patients may impair respiratory muscle development and function.

Results showed that the obese group in the present study experienced significantly more asthma exacerbations per year (3.4 ± 1.1) compared to healthy-weight children (1.8 ± 0.7). This finding strongly supports the results of a meta-analysis conducted by Ahmadizar et al. (2021),[8] which demonstrated that obesity nearly doubles the risk of severe asthma exacerbations in pediatric populations. Our results also align with those of Quinto et al. (2011),[16] who reported that a higher BMI was associated with increased emergency department visits, particularly among female patients. The elevated exacerbation rate in our underweight cohort (2.3 ± 0.6) is supported by the work of Forli et al. (2009),[12] who proposed that micronutrient deficiencies in underweight children may compromise immune function and increase vulnerability to respiratory infections.

The results of the present study, which indicate that obese patients experience 3.4 ± 1.1 annual exacerbations, are in line with the findings of Peters et al.'s (2021)[4] multinational cohort study, which showed that obesity increases the risk of exacerbations by 2.1-fold. This result may also reflect Forno et al.'s (2011)[17] observations, which showed that glucocorticoid resistance in obese asthmatics necessitates higher use of rescue medication use. The results of our underweight group's 2.3 ± 0.6 exacerbations/year also parallel with the results of Kang et al. (2020),[18] who linked low BMI to recurrent infections triggering asthma attacks. The healthy-weight group's lower rate (1.8 ± 0.7) aligns with GINA (2022) guidelines showing better control in normal-BMI patients.[19]

Findings of the present study showed that the prolonged hospital stays (3.3 ± 0.9 days) and higher HDU admission rates (80.8%) observed in obese patients in line with the findings from Okubo et al. (2016) research,[20] who reported that obese asthmatic children required significantly longer hospitalizations. Similarly, in a study by Luthe et al. (2018),[21] similarly found that obesity was associated with a 2.5-fold increase in ICU admission needs, possibly due to comorbid conditions like sleep apnea. Our observation that underweight patients also experienced extended hospital stays (2.4 ± 0.9 days) corroborates with Kattan et al. (2010),[22] who suggested that nutritional deficits may delay recovery from acute exacerbations. For underweight children, our 2.4 ± 0.9-day stays match Lang et al. (2012),[23] who reported delayed recovery due to comorbid malnutrition.

Results show that the high utilization of LABA+ICS combination therapy among the obese patients (78.6%) in the present study reflects the findings of McGarry et al. (2015),24 study that reported that obese asthmatic children frequently require more intensive controller medications. This finding may relate to the work of Holguin et al. (2011),[25], which demonstrated reduced responsiveness to inhaled corticosteroids in obese patients, potentially due to altered drug metabolism in adipose tissue. Conversely, Witte et al. (2022)[26] showed that ICS efficacy improves with BMI normalization, underscoring the therapeutic value of weight management.

Study Limitations

While the present study provides essential insights, certain limitations must be acknowledged. The retrospective design of the study limited our ability to control for all potential confounders, such as environmental exposures or dietary factors. Additionally, the single-center nature of our study may affect generalizability to other populations.

Conclusion

The present study concluded that body mass index has a significant impact on asthma outcomes in pediatric patients. Both obesity and underweight status were associated with poorer lung function, more frequent exacerbations, and worse hospitalization outcomes compared to healthy-weight children. These findings underscore the need for comprehensive management approaches that address both asthma control and nutritional status in pediatric patients. Future prospective studies should evaluate whether targeted weight management or dietary interventions can improve asthma outcomes in these high-risk populations.

Clinical Implications

The findings of the present study highlight the importance of considering weight status in asthma management. The bidirectional relationship between BMI and asthma severity suggests that nutritional interventions could play a crucial role in improving outcomes. For obese patients, weight management strategies may enhance treatment response, while nutritional support for underweight children could potentially reduce exacerbation frequency.

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