




Research Article

Thoracic mobility in school-aged asthmatic children

Stefanie Tonguino-Rosero^{1,2,3,4} , Nelsy-Liliana Holguín-Ordoñez^{1,3} , Juan Esteban Ossa Tabares^{1,3},
Isis Yinela Correa Mejía^{1,3}, Carolina Ramírez Paz^{1,3}, Luis-David García-Basto^{1,3} ^a

¹ Hotbed for Cardio-respiratory research (SEINCAR), Institución Universitaria Escuela Nacional del Deporte, ² Faculty of Health, School of Human Rehabilitation, Universidad del Valle, ³ Faculty of Health and Rehabilitation, Institución Universitaria Escuela Nacional del Deporte, ⁴ Cardiopulmonary Health Research Group (GIESS), Institución Universitaria Escuela Nacional del Deporte

Keywords: asthma, thoracic wall, child, thorax

<https://doi.org/10.29390/001c.131921>

Canadian Journal of Respiratory Therapy

Vol. 61, 2025

Abstract

Introduction

Asthma is a chronic respiratory condition frequently observed in childhood, which can have detrimental effects on breathing and thoracic mobility.

Objective

To describe the thoracic mobility of 6- to 11-year-old children diagnosed with asthma and compare it with that of non-asthmatic children in schools in Cali, Colombia.

Materials and methods

This cross-sectional analytical study used a non-probabilistic convenience sampling technique to assess thoracic mobility. Data were analyzed using STATA 14® statistical software. Measurement of thoracic mobility was performed using cirtometry at the axillary (CAx) and xiphoid (CX) levels according to the protocol established by Bockenhauer et al. Asthma prevalence, history, symptoms, and associated risk factors were assessed using the self-administered International Asthma and Allergies in Childhood (ISAAC) questionnaire. In addition, anthropometric measurements were collected to account for potential confounding variables.

Results

Of the 282 children enrolled, 193 met the inclusion criteria, and 11.9% were diagnosed with asthma. The asthmatic group exhibited several identified risk factors, including exposure to dust (47.8%), environmental fumes (30.4%), tobacco smoke (13%), and colds (47.8%). There were no statistically significant differences in anthropometric variables between the two groups. However, the asthmatic group showed significantly reduced thoracic mobility compared to the non-asthmatic group, especially in the CAx measurement ($5.82 \text{ cm} \pm 2$ for the non-asthmatic group vs. $5.18 \text{ cm} \pm 1.2$ for the asthmatic group; $p = 0.047$).

Conclusions

Individuals diagnosed with asthma have reduced thoracic mobility compared to those without the condition.

INTRODUCTION

Asthma is a chronic inflammatory condition of the airways that poses a significant global public health concern, especially in childhood. It is estimated to affect approximately 262 million individuals worldwide and results in 461,000

deaths annually.¹ In Latin America, childhood asthma has a prevalence of 17.3% at 6-7 years of age and 15.8% at 13-14 years of age.² In Colombia, confirmed asthma has a prevalence of 9%, while unconfirmed cases stand at 69.9%, indicating a potential underdiagnosis within the population. These findings establish asthma as the country's sec-

a Corresponding author at: ft.bastodavid@gmail.com

and most prevalent chronic respiratory condition.³ Furthermore, the city of Cali in Colombia has reported an elevated risk of mortality attributable to respiratory diseases.⁴

A hallmark of asthma is airway narrowing, which can challenge an individual's ventilatory mechanics. Bronchial obstruction can result in increased breathing work, changes in lung volumes, imbalances in ventilation/perfusion (V/Q) ratios, and impaired gas exchange.^{5,6} In addition, these conditions can affect thoracic mobility, which refers to the ability of the thoracic cage to expand during inhalation and exhalation.^{5,7,8}

In contemporary clinical practice, cardiopulmonary physiotherapists emphasize the importance of conducting comprehensive assessments to determine suitable intervention strategies for various respiratory pathologies.⁹⁻¹¹ In recent years, cirtometry has emerged as a vital and reliable method for evaluating thoracic mobility.¹² This assessment technique is characterized by its simplicity, cost-effectiveness, and consistent reliability across different examiners, within the same examiner, and when repeated.¹³ It involves the application of a non-distensible tape around the thorax at the axillary (CAx) and xiphoid (CX) levels to obtain non-invasive measurements.¹⁴

Given the limited research on thoracic mobility in asthmatic children, this study aimed to describe the thoracic mobility of 6- to 11-year-old children diagnosed with asthma and compare it with that of non-asthmatic children in schools in Cali, Colombia.

MATERIALS AND METHODS

In June 2023, a cross-sectional analytical study was conducted with healthy children and children diagnosed with asthma from two schools in Cali, Colombia. These schools were selected because they are located in socio-demographically representative areas of the city. The parents or guardians of the children were contacted to explain the study's objectives and request consent for their children's participation. The study followed the recommendations of the Declaration of Helsinki (2013)¹⁵ and was approved by the Ethics Committee of the *Institución Universitaria Escuela Nacional del Deporte* (Act Number 40.07.101/May 29, 2023). In addition, the confidentiality of the participants was guaranteed through an informed consent procedure in accordance with the Colombian Law on the Protection of Personal Data (Law 1581 of 2012).¹⁶ The study included children aged 6 to 11 who attended schools in 2023 and whose parents or guardians voluntarily signed the informed consent form. Participants with respiratory, cardiac, rheumatic, musculoskeletal, and orthopedic diseases and children without signed consent forms were excluded from the study. Non-probability convenience sampling was used to allow voluntary participation in the study.

MEASURING INSTRUMENTS AND PROCEDURES

The study used the self-administered International Study of Asthma and Allergies in Childhood (ISAAC)¹⁷ question-

naire to examine sociodemographic variables, prevalence, and risk factors for asthma. This questionnaire was developed in a multi-center study and has been rigorously validated in medical institutions around the world. It encompasses a range of open and closed questions on sociodemographic characteristics such as sex, age, socioeconomic status, and aspects related to wheezing, rhinitis, eczema, treatment modalities, and the child's medical history.¹⁷ Notably, the Spanish version of the questionnaire has demonstrated high specificity (91.6%) and sensitivity (64.7%) in identifying asthma in the general population.¹⁸ The questionnaires were distributed online, with parents completing them using the Google Forms® platform.

A non-distensible tape measure (Lufkin W606PM) was used for cirtometry according to the established protocol of Bockenhauer et al.¹⁴ Mobility assessment included measurements at two specific levels: CAx at the level of the third intercostal space and the fifth thoracic spinous process, and CX at the level of the xiphoid and the tenth thoracic spinous process. The anatomical reference points of each level were marked with an indelible ink marker by a single examiner with expertise in this area to ensure accurate placement of the tape measure. Measurements were taken with the subject standing, arms relaxed at the sides, and chest uncovered (or with a strapless top for female subjects).

The tape measure was placed comfortably over the marked reference points to ensure the subject's comfort throughout the process. The subject was then instructed to inhale deeply through the nose and exhale through the mouth, with verbal commands from the examiner to encourage maximal inhalation and exhalation. The maximum diameter of the chest during inhalation and exhalation was measured in centimetres, and the difference between the two movements was calculated. The examiner remained vigilant to prevent compensatory gestures. Three attempts were made ten seconds apart, and the highest measurement was selected.

Anthropometric weight, height, and BMI measurements were obtained to assess potential confounding factors. Weight was assessed using a calibrated scale while the participant maintained an upright posture with arms resting naturally. Height was measured using a SECA 206 wall-mounted measuring rod, with the participant standing against the wall and performing a sustained inhalation for an accurate centimetre measurement. BMI was calculated by dividing weight by the square of height (weight/height²). Participants were then categorized as obese, at risk for obesity, average weight, or underweight based on age-specific percentiles using WHO criteria.

ANALYSIS OF RESULTS

Data were analyzed using STATA 14® statistical software. Participants with more than 20% data loss from the ISAAC questionnaire were excluded from the analysis. Descriptive statistics were used to present quantitative variables, reporting mean and standard deviation, and qualitative variables, reporting frequency and percentage. The normality of data was assessed using the Kolmogorov-Smirnov test.

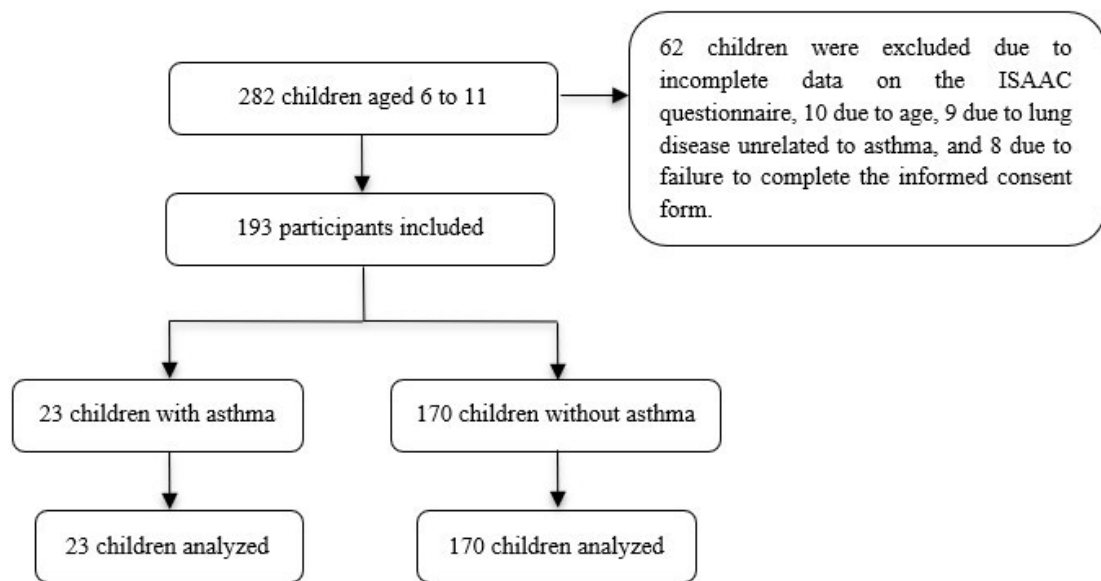


Figure 1. Flowchart of the study population

Group differences were assessed using the Student's t-test and Wilcoxon-Mann-Whitney test, which were selected based on variable characteristics. Statistical significance was set at $p < 0.05$. Analysis of covariance was not required because no baseline differences in confounding variables were observed between groups.

RESULTS

Of the 282 children initially recruited, 62 were excluded because of incomplete data on the ISAAC questionnaire, 10 because of age, 9 because of lung disease other than asthma, and 8 who did not provide informed consent. Finally, 193 children who met the inclusion criteria were included ([Figure 1](#)). Among them, 11.9% received a diagnosis of asthma.

The sex distribution was 52.9% male, with the majority in the second (26.9%), third (24.9%), and fifth (25.4%) grades of primary school. Regarding age, 50.3% were between 6 and 8 years old, and 49.7% were between 9 and 11. The majority identified themselves as of mestizo ethnicity (54.9%) and came from lower socioeconomic strata: 1 (55.4%) and 2 (34.7%). In addition, 92.8% reported belonging to the Colombian health system ([Table 1](#)).

A statistically significant difference was found in the prevalence of maternal asthma history when comparing children with and without asthma (47.8% for children with asthma vs. 19.4% for the healthy group, $p = 0.000$). No other statistically significant differences in sociodemographic characteristics were found.

Regarding anthropometric characteristics, the mean height was $1.34 \text{ m} \pm 0.1$, the mean weight was $33.9 \text{ kg} \pm 10$, and the BMI was at the upper limit of underweight with a mean of 18.4 ± 3.3 . No statistically significant differences were found in the variables of height ($p = 0.394$), weight ($p = 0.311$), and BMI ($p = 0.210$) when comparing the groups of children with and without asthma ([Table 2](#)).

The data indicate a significantly higher prevalence of asthma symptoms in the asthmatic group compared to the non-asthmatic group during the past year. Specifically, the asthmatic group showed significantly higher rates of wheezing (73.9% vs. 11.2%, $p = 0.000$), wheezing or whistling before or after exercise (30.4% vs. 2.9%, $p = 0.000$), chest congestion with secretions in the absence of a cold (30.4% vs. 8.2%, $p = 0.001$), rhinitis or nasal allergy (43.5% vs. 24.7%, $p = 0.026$), hospital admissions for wheeze or asthma (21.7% vs. 2.9%, $p = 0.000$), and full days of absence from school due to wheeze or asthma (43.5% vs. 2.4%, $p = 0.000$) compared to the non-asthmatic group ([Table 3](#)).

The asthmatic group had a higher prevalence of wheeze triggers compared to the non-asthmatic group for exposure to weather changes (17.4% vs. 5.3%, $p = 0.053$), fumes (30.4% vs. 2.9%, $p = 0.000$), dust (47.8% vs. 3.5%, $p = 0.000$), colds (47.8% vs. 9.4%, $p = 0.000$), and tobacco smoke (13% vs. 1.8%, $p = 0.023$) ([Table 4](#)).

In assessing thoracic mobility using cirtometry, the asthmatic group exhibited lower values in the CAx measurement, with a mean of $5.18 \text{ cm} \pm 1.2$, compared to the non-asthmatic group, which demonstrated a mean of $5.82 \text{ cm} \pm 2$. This disparity showed statistical significance ($p = 0.047$). Similarly, the CX measurement for the asthmatic group displayed reduced values, with a mean of $4.78 \text{ cm} \pm 1.3$, in contrast to the non-asthmatic group, with a mean of $5.35 \text{ cm} \pm 2$. However, this variance did not attain statistical significance ($p = 0.096$) ([Figure 2](#)).

Table 1. Comparison of the sociodemographic characteristics and background of the study population: children with and without asthma

Variable	Category	Total n=193		Asthmatic n=23		Non- asthmatic n=170		Statistic	p
		n	%	n	%	n	%		
Sex	Male	102	52.9	13	56.5	89	52.4	$\chi^2 = 0.1413$	0.707
	Female	91	47.2	10	43.5	81	47.7		
Age (years)	6-8	97	50.3	12	52.2	85	50.0	$\chi^2 = 0.0383$	0.845
	9-11	96	49.7	11	47.8	85	50.0		
Socioeconomic stratum	1	107	55.4	10	43.5	97	57.1	Fisher's Test	0.285
	2	67	34.7	9	39.1	58	34.1		
	3 and 4	19	9.8	4	17.4	15	8.8		
Ethnicity	Mestizo	106	54.9	16	69.6	90	52.9	Fisher's Test	0.340
	Afro-descendant	23	11.9	2	8.7	21	12.4		
	Indigenous	15	7.8	0	0.0	15	8.8		
	Caucasian	48	24.9	4	17.4	44	25.9		
	No answer	1	0.5	1	4.4	0	0.0		
Affiliated with the health system	YES	179	92.8	21	91.3	158	92.9	Fisher's Test	0.675
	NO	14	7.3	2	8.7	12	7.1		
School grade	First	6	3.11	1	4.4	5	2.9	Fisher's Test	0.332
	Second	52	26.9	9	39.1	43	25.3		
	Third	48	24.8	4	17.4	44	25.9		
	Fourth	38	19.6	2	8.7	36	21.2		
	Fifth	49	25.3	7	30.4	42	24.7		
Mother's educational level	Elementary School	18	9.33	2	8.7	16	9.4	Fisher's Test	0.411
	High School	142	73.58	15	65.2	127	74.7		
	College/ University	31	16.06	6	26.1	25	14.7		
	No answer	2	1.04	0	0.0	2	1.2		
Father's educational level	Elementary School	22	11.4	3	13.0	19	1.2	Fisher's Test	0.381
	High School	131	67.9	13	56.5	118	69.4		
	College/ University	23	11.9	5	21.7	18	10.6		
	None	14	7.3	1	4.4	13	7.7		
	No answer	3	1.6	1	4.4	2	1.2		
Asthmatic mother	YES	44	22.8	11	47.8	33	19.4	$\chi^2 = 9.2933$	0.000*
	NO	149	77.2	12	52.2	137	80.6		
Asthmatic father	YES	24	12.4	5	21.7	19	11.2	$\chi^2 = 2.0758$	0.150
	NO	169	87.6	18	78.3	151	88.8		
Mother's age	15 to 25 years	13	6.7	3	13.0	10	5.9	Fisher's Test	0.265
	26 to 30 years	48	24.9	5	21.7	43	25.3		
	31 to 35 years	54	28.0	6	26.1	48	28.2		

Variable	Category	Total n=193		Asthmatic n=23		Non-asthmatic n=170		Statistic	p
		n	%	n	%	n	%		
	36 to 40 years	37	19.2	2	8.7	35	20.6		
	41 to 45 years	26	13.5	3	13.0	23	13.5		
	46 to 55 years	7	3.6	2	8.7	5	2.9		
	No answer	8	4.2	2	8.7	6	3.5		
Father's age	21 to 30 years	31	16.1	4	17.4	27	15.9	Fisher's Test	0.544
	31 to 35 years	53	27.5	4	17.4	49	28.8		
	36 to 40 years	42	21.8	8	34.8	34	20.0		
	41 to 45 years	33	17.1	5	21.7	28	16.5		
	46 to 55 years	16	8.3	1	4.4	15	8.8		
	No answer	18	9.3	1	4.4	17	10.0		
Who responded to the questionnaire?	Father	20	10.4	1	4.4	19	11.2	Fisher's Test	0.646
	Mother	167	86.5	22	95.7	145	85.3		
	Other	6	3.1	0	0.0	6	3.5		

χ^2 : Chi-square test; $p < 0.05^*$

Table 2. Comparison of the anthropometric characteristics of the study population: children with and without asthma

Variable	Total n=193		Asthmatic n=23		Non-asthmatic n=170		Statistic	p
	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD		
Height (m)	1.34	0.1	1.4	0.1	1.3	0.1	$t = -0.8552$	0.394
Weight (kg)	33.9	10	37.3	13.4	33.4	9.4	$z = -1.011$	0.311
BMI	18.4	3.3	19.5	4.2	18.3	3.2	$z = -1.255$	0.210

t: T-test; z: Wilcoxon Mann-Whitney Test; $p < 0.05^*$

DISCUSSION

This study aimed to describe thoracic mobility in a group of children with obstructive diseases, particularly asthma. The results indicate that children diagnosed with asthma had reduced thoracic mobility compared to those without the condition. In addition, they presented a higher prevalence of pathological history, increased exposure to triggering factors, and a more pronounced experience of daytime and nocturnal respiratory symptoms.

This study demonstrates an association between a parent's history of asthma and the likelihood that their children will develop the disease. The evidence suggests that there is a "multifactorial inheritance model" that links the occurrence of asthma to the degree of kinship within a family.¹⁹ This model can be explained using Falconer's thresh-

old model,²⁰ which utilizes a standard distribution curve to illustrate how the disease occurs.

According to that model, greater relatedness increases the likelihood of crossing the threshold and displaying the disease. The risk of developing asthma is 10% for second-degree relatives with the disease, 25% for first-degree relatives with the disease, and 50% in cases where both parents are affected.^{19,21-23} Notably, 19.4% of undiagnosed children had a family history of asthma. Because of their family background, this underscores the potential risk for these children to develop the disease in the future.

In this study, 11.9% of the children reported being diagnosed with asthma. When these results were compared with the global data from the ISAAC study, the prevalence of asthma ranged from 2.1% to 32.2% depending on the geographical area (2.1% in Indonesia, 32.2% in the United

Table 3. Asthma symptomatology in school children: comparison between children with and without asthma

Variable	Category	Total n=193		Asthmatic n=23		Non-asthmatic n=170		Statistic	p
		n	%	n	%	n	%		
Has your child ever experienced episodes of wheezing in the past?	YES	36	18.7	17	73.9	19	11.2	$\chi^2 = 52.5501$	0.000*
	NO	157	81.4	6	26.1	151	88.8		
Has your child ever wheezed before or after exercise?	YES	12	6.2	7	30.4	5	2.9	$\chi^2 = 26.2626$	0.000*
	NO	181	93.8	16	69.6	165	97.1		
Has your child experienced chest congestion from non-cold-related secretions in the past year?	YES	21	10.9	7	30.4	14	8.2	$\chi^2 = 10.2961$	0.001*
	NO	172	89.1	16	69.6	156	91.8		
Has your child experienced rhinitis or nasal allergies?	YES	52	26.9	10	43.5	42	24.7	$\chi^2 = 4.952$	0.026*
	NO	139	72.0	11	47.8	128	75.3		
	No answer	2	1.0	2	8.7	0	0.0		
Has your child ever experienced atopic dermatitis?	YES	40	20.7	8	34.8	32	18.8	$\chi^2 = 3.571$	0.059
	NO	151	78.2	14	60.9	137	80.6		
	No answer	2	1.0	1	4.4	1	0.6		
Has your child been hospitalized for wheezing or asthma the previous year?	YES	10	5.2	5	21.7	5	2.9	$\chi^2 = 14.5715$	0.000*
	NO	183	94.8	18	78.3	165	97.1		
Have you administered allergy or asthma shots to your child?	YES	3	1.6	1	4.4	2	1.2	FT	0.401
	NO	189	97.9	22	95.7	167	96.2		
	No answer	1	0.5	0	0.0	1	0.6		
Has your child been absent from school due to wheezing or asthma in the past year?	YES	14	7.3	10	43.5	4	2.4	FT	0.000*
	NO	179	92.8	13	56.5	166	97.7		

χ^2 : Chi-square test, FT: Fisher's Test; $p < 0.05$ *

Kingdom, and 15% in Latin America).^{21,24} In Colombia, the prevalence varied by age group, with rates of 24.3% in children younger than 4 years, 12.4% in children aged 5-11, and 11.5% in children aged 12-18.²⁵

The prevalence found in this study is consistent with national levels, although other studies in Cali, Colombia, have reported higher levels. For instance, Herrera et al.²⁶ documented a prevalence of 20.6% in children under 6 years of age, and Betancourt et al.²⁷ reported a prevalence of 21.38% in children aged 6-14 years. This disparity may be due to the higher prevalence of asthma at an early age, possibly related to the increased frequency of respiratory infections during this stage of life.²⁸⁻³¹

Regarding wheeze triggers, the study reveals that children diagnosed with asthma show increased symptomatology due to external factors such as weather changes, respiratory infections, inhalation of fumes, exposure to dust, and exposure to tobacco smoke. Early sensitization to house dust mites, especially between the first and second year of life, is associated with significantly increased odds

ratios of 3.3 and 6.4²¹ (OR: 1 year, 3.31 [95 % CI 1.59-6.91]; OR: 2 years, 6.37 [95 % CI, 3.48-11.66]).

In addition, exposure to tobacco smoke significantly increases the prevalence of asthma in all age groups. It is a potent pollutant that promotes lung inflammation and mucociliary epithelial damage. This exposure correlates with an incidence rate of up to 17.1% and triggers excessive mucus production in affected children.^{32,33}

In this study, significant triggers were attributed to external factors, while genomic variations contributing to increased susceptibility to the development or severity of asthma symptoms were identified. Genome-wide association studies (GWAS) conducted worldwide have predominantly focused on populations of European ancestry. However, there is a growing consensus that a more comprehensive approach is needed, particularly in regions such as Latin America, to improve understanding of the genetic makeup of these populations.³⁴

Research in Brazil has identified variations in IL-10 genes that correlate with the risk of atopic wheeze and al-

Table 4. Comparison of wheeze triggers in school children: with and without asthma

Variable	Category	Total n=193		Asthmatic n=23		Non-asthmatic n=170		Statistic	p
		n	%	n	%	n	%		
Has the wheezing or whistling in your child's chest worsened due to weather changes?	YES	13	6.7	4	17.4	9	5.3	FT	0.053*
	NO	180	93.3	19	82.6	161	94.7		
Has your child experienced wheezing due to pollen allergy in the past year?	YES	3	1.6	1	4.4	2	1.2	FT	0,318
	NO	190	98.5	22	95.7	168	98.8		
Has your child experienced fume-induced wheezing in the past year?	YES	12	6.2	7	30.4	5	2.9	$\chi^2 = 26.2626$	0.000*
	NO	181	93.8	16	69.6	165	97.1		
Has your child experienced dust-induced wheezing in the past year?	YES	17	8.8	11	47.8	6	3.5	$\chi^2 = 49.4897$	0.000
	NO	176	91.2	12	52.2	164	96.5		
Has your child experienced wheezing due to pet exposure in the past year?	YES	7	3.6	2	8.7	5	2.9	FT	0.197
	NO	186	96.4	21	91.3	165	97.1		
Has your child experienced wheezing due to wearing wool clothing in the past year?	YES	3	1.6	1	4.4	2	1.2	FT	0.318
	NO	190	98.5	22	95.7	168	98.8		
Has your child experienced wheezing due to colds in the past year?	YES	27	14.0	11	47.8	16	9.4	$\chi^2 = 24.8455$	0.000*
	NO	166	86.0	12	52.2	154	90.6		
Has your child experienced wheezing due to exposure to tobacco smoke in the past year?	YES	6	3.1	3	13	3	1.8	FT	0.023*
	NO	187	96.9	20	87.0	167	98.2		
Has your child had wheezing caused by soaps, sprays, or detergents in the past year?	YES	9	4.7	3	13.0	6	3.5	FT	0.077
	NO	184	95.3	20	87.0	164	96.5		

χ^2 : Chi-square test, FT: Fisher's Test; $p < 0,05^*$

lergy markers. In addition, genes such as 14q11 and 15q22 have shown associations with asthma symptoms in Latin America, while the LTB4 gene has been implicated in inflammatory and immune response pathways.²⁴

The exacerbation triggered by risk factors is postulated to be associated with bronchial hyperresponsiveness (BHR), defined as airway narrowing in response to inhaled agents that induce bronchial smooth muscle contraction. This narrowing is the result of two distinct processes: hypersensitivity and hyperresponsiveness.^{35,36} The research results on human bronchial segments indicate that an excess of airway smooth muscle contributes to BHR.³⁷ However, there is no consensus on the pathophysiological mechanism of BHR.

Some researchers have proposed that asthmatic patients have increased calcium (Ca^{2+}) levels in the cytoplasm near

the actin-myosin filaments, which may account for hyper-reactivity. Additionally, an increased frequency of Ca^{2+} waves released from the sarcoplasmic reticulum due to receptor activation may modify the threshold for agonist-induced contraction, thus explaining the hypersensitivity phenomenon.³⁶

Other researchers suggest that BHR may be influenced by changes in lung volume during the respiratory cycle. Specifically, the radial force applied to the airway during inspiration may trigger mechanisms that suppress tonic cholinergic activity, thereby promoting bronchodilation. In addition, this force could directly impact the smooth bronchial muscle due to the induced stretch.

In conditions such as asthma, the elongation of actin filaments and the more elastic behaviour of smooth muscle may contribute to an increased contractile capacity and

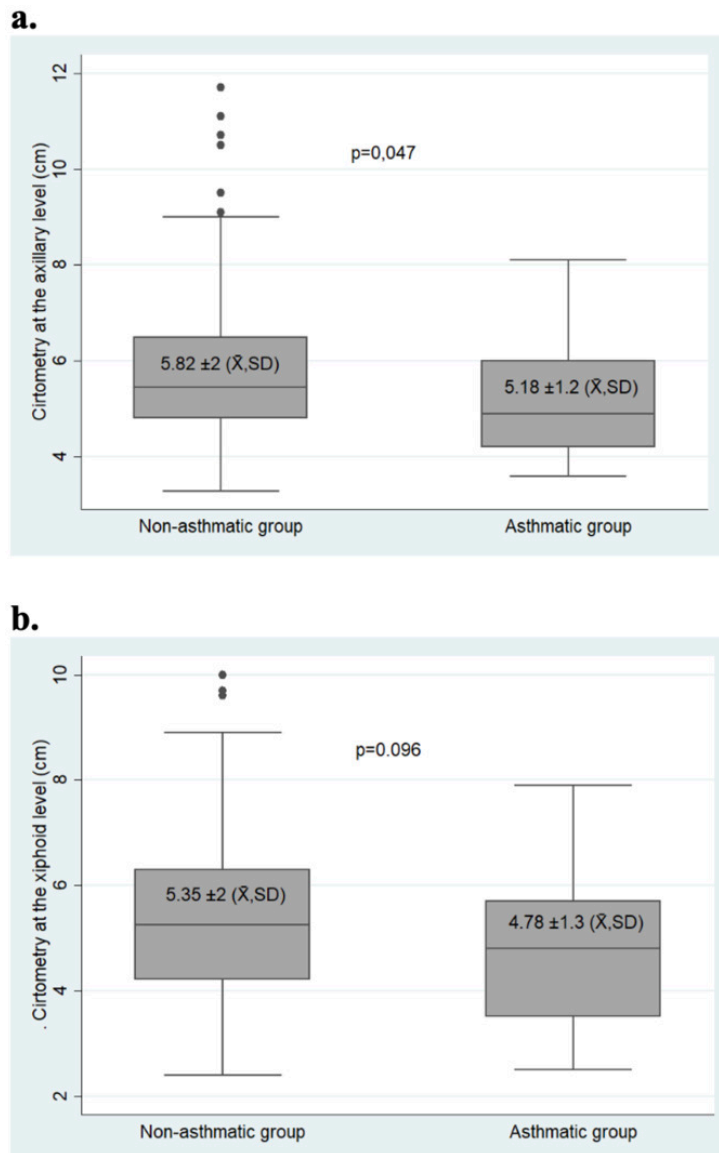


Figure 2. Comparison of the thoracic mobility of children with and without asthma

a. Cirtometry at the axillary (CAx) level; b. Cirtometry at the xiphoid (CX) level

shortening velocity, potentially exacerbating symptoms by inducing more profound airway constriction.³⁶

In this study, a reduction in thoracic mobility values was observed in participants within the asthmatic group, possibly due to the airway obstruction associated with BHR, which induces changes in respiratory mechanics.^{5,38} This finding is noteworthy because previous studies have not prioritized evaluating this aspect of respiratory function in this population.

Previous research has generally relied on complex and costly pulmonary function tests that require specialized equipment and laboratory facilities. These tests have shown that individuals with this condition have a peak expiratory flow (PEF) variability of 20% or greater and a forced expiratory volume (FEV) of less than 80% of the air exhaled in the first second.³⁹

The decreased thoracic mobility observed in children with asthma is related to the obstructive nature of asthma and to BHR, which leads to changes in respiratory mechan-

ics due to several factors, including smooth muscle contraction —referred to as bronchospasm, increased mucus secretion, and thickening of the tracheobronchial wall.^{5,38} These changes contribute to increased work of breathing, ventilation/perfusion (V/Q) imbalance, impaired gas exchange, and altered lung volumes associated with pulmonary hyperinflation, reducing thoracic mobility.³⁸

It is crucial to highlight the role of the cardiopulmonary physiotherapist in facilitating disease control measures and delivering an appropriate response to symptom exacerbation. To achieve this, it is essential to augment the assessment measures with objective methods, such as cirtometry, which are straightforward, accessible, and cost-effective, particularly in developing countries.

The results of this study indicate that children diagnosed with asthma have reduced thoracic mobility and experience more pronounced respiratory symptoms both during waking hours and at night compared to their non-asthmatic counterparts. It is crucial to recognize that age, develop-

mental stage, and individual anthropometric characteristics may influence these differences in thoracic mobility.^{40, 41} This underscores the need to recognize that underlying pathology and an interplay of variables may influence thoracic mobility.

Further research is required to determine the validity and comparability of cirtometry as an assessment method with high-tech equipment. Also, further research is needed to better understand the efficacy of thoracic mobility measurements in children with asthma. Therefore, the results of this research could significantly impact cardiopulmonary physiotherapy, particularly in relation to managing this condition. It should be noted that the study was population-based, which precludes the possibility of confirming the diagnosis with an airflow limitation test.

CONCLUSION

Children diagnosed with asthma have reduced thoracic mobility compared to their non-asthmatic counterparts. In addition, a higher percentage of these children have mothers with a history of pulmonary pathology, increased exposure to triggers that exacerbate symptoms, and more pronounced diurnal and nocturnal symptomatology. Cirtometry, a method used to assess thoracic mobility, offers the potential to evaluate and monitor the efficacy of interventions in populations affected by pulmonary pathology, particularly asthma.

ACKNOWLEDGMENTS

Thank you to the children and schools for their participation in the study.

CONTRIBUTORS

Conceptualization: T.R.S, G.B.L.D, H.O.N.L, C.M.I.Y, O.T.J.E and R.P.C; Formal analysis: T.R.S, G.B.L.D, H.O.N.L, C.M.I.Y, O.T.J.E and R.P.C; Investigation: T.R.S, G.B.L.D, H.O.N.L, C.M.I.Y, O.T.J.E and R.P.C; Methodology: T.R.S; Project administration: T.R.S, G.B.L.D, H.O.N.L, C.M.I.Y and R.P.C; Resources: T.R.S; Supervision: T.R.S; Visualization: T.R.S, G.B.L.D, H.O.N.L; Writing – original draft: T.R.S, G.B.L.D, H.O.N.L; Writing – review & editing: T.R.S, G.B.L.D, H.O.N.L.

FUNDING

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

COMPETING INTERESTS

All authors have completed the ICMJE uniform disclosure form and declare no conflict of interest.

ETHICAL APPROVAL

The study was approved by the Ethics Committee of the *Institución Universitaria Escuela Nacional del Deporte* (Act Number 40.07.101/May 29, 2023).

AI STATEMENT

The authors confirm no generative AI or AI-assisted technology was used to generate content.

Submitted: September 06, 2024 EDT. Accepted: March 06, 2025 EDT. Published: April 07, 2025 EDT.



This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CCBY-NC-4.0). View this license's legal deed at <https://creativecommons.org/licenses/by-nc/4.0> and legal code at <https://creativecommons.org/licenses/by-nc/4.0/legalcode> for more information.

REFERENCES

1. Asma. Accessed September 23, 2022. <https://www.who.int/es/news-room/fact-sheets/detail/asthma>
2. García G, Bergna M, Vásquez JC, et al. Severe asthma: adding new evidence - Latin American Thoracic Society. *ERJ Open Res.* 2021;7(1):00318-02020. doi:[10.1183/23120541.00318-2020](https://doi.org/10.1183/23120541.00318-2020)
3. Epidemiología del asma en Colombia | Revista Colombiana de Neumología. Accessed September 10, 2023. <https://revistas.asoneumocito.org/index.php/rcneumologia/article/view/78>
4. Alcaldía de Santiago de Cali. Accessed February 27, 2023. <https://www.cali.gov.co/documentos/buscar/www.cali.gov.co/>
5. Becerra MHV. Fisiopatología del asma. *Neumol Cir Tórax.* 2009;68(Suppl: 2):111-115.
6. Basso RP, Regueiro EMG, Jamami M, Di Lorenzo VAP, Costa D. Relação da medida da amplitude tóraco-abdominal de adolescentes asmáticos e saudáveis com seu desempenho físico. *Fisioter Em Mov.* 2011;24:107-114. doi:[10.1590/S0103-51502011000100012](https://doi.org/10.1590/S0103-51502011000100012)
7. García Merino Á, Mora Gandarillas I. Diagnóstico del asma. *Pediatría Aten Primaria.* 2013;15:89-95. doi:[10.4321/S1139-76322013000300010](https://doi.org/10.4321/S1139-76322013000300010)
8. Dweik RA, Boggs PB, Erzurum SC, et al. An official ATS clinical practice guideline: interpretation of exhaled nitric oxide levels (FENO) for clinical applications. *Am J Respir Crit Care Med.* 2011;184(5):602-615. doi:[10.1164/rccm.9120-11ST](https://doi.org/10.1164/rccm.9120-11ST)
9. Malaguti C, Rondelli RR, de Souza LM, Domingues M, Dal Corso S. Reliability of chest wall mobility and its correlation with pulmonary function in patients with chronic obstructive pulmonary disease. *Respir Care.* 2009;54(12):1703-1711.
10. Garcia Júnior A, Caromano FA, Contesini AM, Escorcio R, Fernandes LAY, João SMA. Thoracic cirtometry in children with Duchenne muscular dystrophy--expansion of the method. *Braz J Phys Ther.* 2013;17(1):1-8. doi:[10.1590/S1413-35552012005000064](https://doi.org/10.1590/S1413-35552012005000064)
11. Oliveira KMC, Macêdo TMF de, Borja R de O, et al. Força Muscular Respiratória e Mobilidade Torácica em Crianças e Adolescentes com Leucemia Aguda e Escolares Saudáveis. *Rev Bras Cancerol.* 2011;57(4):511-517. doi:[10.32635/2176-9745.RBC.2011v57n4.651](https://doi.org/10.32635/2176-9745.RBC.2011v57n4.651)
12. Parreira VF, Bueno CJ, França DC, Vieira DSR, Pereira DR, Britto RR. Breathing pattern and thoracoabdominal motion in healthy individuals: influence of age and sex. *Rev Bras Fisioter Sao Carlos Sao Paulo Braz.* 2010;14(5):411-416. doi:[10.1590/S1413-35552010000500010](https://doi.org/10.1590/S1413-35552010000500010)
13. Caldeira V da S, Starling CCD, Britto RR, Martins JA, Sampaio RF, Parreira VF. Reliability and accuracy of cirtometry in healthy adults. *J Bras Pneumol Publicacao Of Soc Bras Pneumol E Tisiologia.* 2007;33(5):519-526. doi:[10.1590/s1806-37132007000500006](https://doi.org/10.1590/s1806-37132007000500006)
14. Bockenbauer SE, Chen H, Julliard KN, Weedon J. Measuring thoracic excursion: reliability of the cloth tape measure technique. *J Am Osteopath Assoc.* 2007;107(5):191-196.
15. WMA - The World Medical Association- Declaración de Helsinki de la AMM – Principios éticos para las investigaciones médicas en seres humanos. Accessed October 3, 2022. <https://www.wma.net/es/policies-post/declaracion-de-helsinki-de-la-amm-principios-eticos-para-las-investigaciones-medicas-en-seres-humanos/>
16. Política de Protección de Datos Personales. Accessed October 3, 2022. <https://www.minambiente.gov.co/politica-de-proteccion-de-datos-personales/>
17. Grupo ISAAC Español. Objetivo y métodos del estudio ISAAC (International Study of Asthma and Allergy in Childhood). *An Sist Sanit Navar.* 1997;20(1):57-69. doi:[10.23938/ASSN.0598](https://doi.org/10.23938/ASSN.0598)
18. Mata Fernández C, Fernández-Benítez M, Pérez Miranda M, Guillén Grima F. Validation of the Spanish version of the Phase III ISAAC questionnaire on asthma. *J Investig Allergol Clin Immunol.* 2005;15(3):201-210.
19. Corona-Rivera J, Peña-Padilla C, Morales-Domínguez GE, et al. Aspectos genéticos implicados en el asma. *Rev Alerg México.* 2022;69(1):21-30. doi:[10.29262/ram.v69i1.1031](https://doi.org/10.29262/ram.v69i1.1031)

20. Hill WG, Mackay TFC. D. S. Falconer and Introduction to Quantitative Genetics. *Genetics*. 2004;167(4):1529-1536. doi:[10.1093/genetics/167.4.1529](https://doi.org/10.1093/genetics/167.4.1529)
21. Kuruvilla ME, Vanijcharoenkarn K, Shih JA, Lee FEH. Epidemiology and risk factors for asthma. *Respir Med*. 2019;149:16-22. doi:[10.1016/j.rmed.2019.01.014](https://doi.org/10.1016/j.rmed.2019.01.014)
22. Ntontsi P, Photiades A, Zervas E, Xanthou G, Samitas K. Genetics and Epigenetics in Asthma. *Int J Mol Sci*. 2021;22(5):2412. doi:[10.3390/ijms22052412](https://doi.org/10.3390/ijms22052412)
23. Decoding the genetic and epigenetic basis of asthma - Stikker - 2023 - Allergy - Wiley Online Library. Accessed June 8, 2024. <https://onlinelibrary.wiley.com/doi/full/10.1111/all.15666>
24. Cooper PJ, Figueiredo CA, Rodriguez A, et al. Understanding and controlling asthma in Latin America: A review of recent research informed by the SCAALA programme. *Clin Transl Allergy*. 2023;13(3):e12232. doi:[10.1002/ctt2.12232](https://doi.org/10.1002/ctt2.12232)
25. Ministerio de Salud y Protección Social. Guía de atención integral-Asma, Alcances y objetivos de la Gai. Accessed June 8, 2024. https://www.minsalud.gov.co/salud/Documents/Presentaci%C3%B3n_alcances%20y%20obj%20comp%20eto%20MPS%20ASMA%5B1%5D.pdf
26. Herrera MA, Reyes MA, Victoria L, Villegas A, Badiel M, Herrera S. Asma y rinitis alérgica en pre-escolares en Cali. *Colomb Medica*. 2003;34(1):4-8. doi:[10.25100/cm.v34i.1.246](https://doi.org/10.25100/cm.v34i.1.246)
27. Betancourt-Peña J, Olaya-Tamayo RA, Giraldo-Mosquera MC, et al. Factores de riesgo y síntomas de asma infantil en estudiantes de dos colegios de Cali. *Univ Salud*. 2021;23(2):85-91. doi:[10.22267/rus.212302.219](https://doi.org/10.22267/rus.212302.219)
28. Miranda-M P. Prevalencia de asma infantil en la ciudad de Cartagena. 2014;23.
29. Munayco CV, Aran J, Torres-Chang J, Saravia L, Soto-Cabezas MG. Prevalencia y factores asociados al asma en niños de 5 a 14 años de un área rural del sur del Perú. *Rev Peru Med Exp Salud Publica*. 2009;26(3):307-313.
30. Páginas - Infecciones Respiratorias Agudas (IRA). Accessed June 8, 2024. [https://www.minsalud.gov.co/salud/Paginas/Infecciones-Respiratorias-Agudas-\(IRA\).aspx](https://www.minsalud.gov.co/salud/Paginas/Infecciones-Respiratorias-Agudas-(IRA).aspx)
31. 2024 GINA Main Report. Global Initiative for Asthma - GINA. Accessed June 8, 2024. <https://ginasthma.org/2024-report/>
32. Reyes-Baque JM, Cajape-González AL, Jaramillo-Baque Y, Hidalgo-Acebo R. Características clínicas y epidemiológicas del asma bronquial en niños. *Dominio Las Cienc*. 2021;7(2):1371-1390. doi:[10.23857/dc.v7i2.1886](https://doi.org/10.23857/dc.v7i2.1886)
33. Álvarez MJ, Olaguíbel JM, Lasa E, Arroabarren E, Gómez A, Gómez B. De la rinitis al asma: ¿una o dos enfermedades? *An Sist Sanit Navar*. 2003;26:49-55. doi:[10.4321/S1137-66272003000400007](https://doi.org/10.4321/S1137-66272003000400007)
34. Forno E, Brandenburg DD, Castro-Rodriguez JA, et al. Asthma in the Americas: An Update: A Joint Perspective from the Brazilian Thoracic Society, Canadian Thoracic Society, Latin American Thoracic Society, and American Thoracic Society. *Ann Am Thorac Soc*. 2022;19(4):525-535. doi:[10.1513/AnnalsATS.202109-1068CME](https://doi.org/10.1513/AnnalsATS.202109-1068CME)
35. Bradding P, Porsbjerg C, Côté A, Dahlén SE, Hallstrand TS, Brightling CE. Airway hyperresponsiveness in asthma: The role of the epithelium. *J Allergy Clin Immunol*. 2024;153(5):1181-1193. doi:[10.1016/j.jaci.2024.02.011](https://doi.org/10.1016/j.jaci.2024.02.011)
36. Perpiñá-T M. Hiperrespuesta bronquial en el asma. Patogenia y medición. 2004;40(Supl 5):8-13. doi:[10.1157/13077882](https://doi.org/10.1157/13077882)
37. Camoretti-Mercado B, Lockey RF. Airway smooth muscle pathophysiology in asthma. *J Allergy Clin Immunol*. 2021;147(6):1983-1995. doi:[10.1016/j.jaci.2021.03.035](https://doi.org/10.1016/j.jaci.2021.03.035)
38. Río-Navarro BE del, Hidalgo-Castro EM, Sienra-Monge JLL. Asma. *Bol Méd Hosp Infant México*. 2009;66(1):3-33.
39. Guía de diagnóstico y tratamiento: asma bronquial en niños ≥ 6 años. Actualización 2021. Sociedad Argentina de Pediatría. February 12, 2021. Accessed June 8, 2024. https://www.sap.org.ar/uploads/consensos/consensos_guia-de-diagnostico-y-tratamiento-asma-bronquial-en-ninos-menores-de-6-anos-actualizacion-2021-118.pdf
40. Tonguino-Rosero S, Rosero-Carvajal HE, Mondragón-Gómez A. Valores de la movilidad torácica en niños colombianos sanos entre 8 y 11 años. *Fisioterapia*. 2019;41(4):213-218. doi:[10.1016/j.ft.2019.02.009](https://doi.org/10.1016/j.ft.2019.02.009)
41. Cardona Garcia N, Granada Ramirez JC, Tapasco Ypia MA, Tonguino-Rosero S. The effects of a respiratory and aerobic exercises program in an aquatic environment versus a land environment for elderly people. *Revista de la Universidad Industrial de Santander Salud*. 2016;48(4):516-525.