

RESEARCH PAPER

# Correlation of Undernutrition and Peak Expiratory Flow Rate in the School Going Adolescents of Puducherry

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## ABSTRACT

**Background:** Adolescence is a critical stage where nutrition supports growth and lifelong health. Undernutrition impairs pulmonary function by reducing skeletal muscle mass, including the diaphragm, weakening respiratory mechanics and lowering Peak Expiratory Flow Rate (PEFR). Malnourished children often show reduced FVC and FEV1, likely from delayed airway growth. Recognizing the link between nutrition and PEFR highlights how deficiencies extend beyond stunted growth to compromise lung function. PEFR, as a simple non-invasive measure, can aid early detection and guide targeted nutritional and respiratory interventions for adolescents.

**Materials and Methods:** This cross-sectional study was carried out to ascertain the relationship between undernutrition and peak expiratory flow rate in Puducherry's school-age adolescents (10–19 years). The height and BMI Z scores were calculated using the WHO growth chart. The peak expiratory flow rate is measured using peak flow meters.

**Results:** The study included 540 adolescents (48.7% males, 51.3% females) with a balanced age distribution across 10–18 years. PEFR was found to correlate positively with age and gender, increasing steadily with age and consistently higher in males. Undernutrition, particularly stunting and thinness, showed a significant negative impact on PEFR, underscoring how nutritional deficiencies impair lung function. Overnutrition also demonstrated a negative association, though not statistically significant, suggesting a possible double burden of malnutrition. Stunting exerted a stronger effect than thinness, reflecting the irreversible impact of chronic malnutrition compared to the potentially reversible effects of acute muscle wasting.

**Conclusion:** Timely diagnosis and intervention during adolescence are crucial to enable catch-up growth and preserve lung function. Periodic nutritional assessments can help detect stunting early and prevent long-term pulmonary complications. Undernourished adolescents presenting with respiratory illness require heightened clinical care to reduce morbidity and mortality, emphasizing the importance of integrated nutritional and respiratory health strategies.

**Keywords:** Undernutrition, Peak Expiratory Flow Rate (PEFR), malnutrition, Stunting.

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## INTRODUCTION

Adolescence, spanning ages 10–19, marks the transition from childhood to adulthood, initiated by puberty and characterized by profound physiological, psychological, and social changes. It is divided into three phases: early (10–13 years), middle (14–16 years), and late adolescence (17–19 years) (1-5). Globally, adolescents number about 1.2 billion, representing one in six individuals, with India alone home to approximately 253 million (6,7). During this stage, adolescents gain nearly half of their adult body weight, skeletal mass, and over 20% of their adult height, making nutrition critical to sustaining rapid growth and laying the foundation for long-term health (8).

Adolescence is second only to infancy in terms of developmental pace (9-11). Nutritional status during these years strongly influences future health outcomes, including cardiovascular fitness, immune function, and susceptibility

to non-communicable diseases (4). Malnutrition in adolescence—whether undernutrition, micronutrient deficiency, or overnutrition—poses significant risks. Undernutrition, particularly prevalent in emerging economies like India, is a major contributor to adolescent morbidity and mortality (7). Stunting (low height for age,  $<-2$  SD) reflects chronic undernutrition linked to poverty, poor maternal health, recurrent illness, and inadequate early-life care. Thinness, defined as low BMI for age ( $<-2$  SD), indicates recent or severe weight loss and is assessed using BMI, a cost-effective tool for evaluating nutritional status (12).

Pulmonary function, measured through Peak Expiratory Flow Rate (PEFR), provides insight into respiratory health. PEFR, expressed in liters per minute, represents the maximum flow achieved during forceful expiration and is widely used in asthma management and self-monitoring

(13). It is influenced by age, sex, and anthropometric variables (14). Emerging evidence suggests a link between undernutrition and impaired pulmonary function. Malnutrition reduces skeletal muscle mass, including the diaphragm, compromising inspiratory and expiratory muscle strength. This leads to decreased vital capacity, increased residual volume, and reduced efficiency of respiratory mechanics, thereby lowering PEFr (15). Studies also report reduced forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) among malnourished children, likely due to delayed airway growth (16).

Understanding the relationship between undernutrition and PEFr in adolescents is crucial. It highlights how dietary deficiencies extend beyond growth retardation to impair lung function, increasing vulnerability to respiratory complications. Establishing PEFr as a simple, non-invasive measure of functional impact can aid in early detection of nutritional deficits affecting respiratory health. Such findings can inform targeted nutritional and respiratory interventions, reducing long-term morbidity and guiding adolescent health policies. By looking to the undernutrition healthcare systems can improve population health indicators and prevent future respiratory disease burden.

In summary, adolescence is a vital stage where nutrition gives both immediate growth and lifelong health. Undernutrition not only stunts physical development but also compromises pulmonary function, underscoring the need for integrated strategies that combine nutritional support with respiratory health monitoring. It is essential for preventive healthcare in adolescents should ensure healthier transitions into adulthood and stronger public health outcomes.

## AIM AND OBJECTIVES

**Primary objective:** To determine the association between undernutrition and peak expiratory flow rate in the school going adolescents of Puducherry.

**Secondary objective:** To compare the impact of thinness and stunting on peak expiratory flow rate in the school going adolescents of Puducherry.

## MATERIALS AND METHODS

This is a cross-sectional study conducted to determine the correlation of undernutrition and peak expiratory flow rate in the school going adolescents (10-19 years) of Puducherry. History of any febrile illness in the preceding 1 week, history of symptoms of upper or lower respiratory tract infection in the preceding 1 week, chronic respiratory disease e.g., bronchial asthma, systemic disease like

cardiac or renal disorders, and obvious deformity of thorax or spine were excluded from the study.

**Ethical clearance:** The nature and purpose of the study was explained to the Institutional Ethical Committee (IEC) of SVMCH and ethical clearance was obtained with registered number 37/ SVMCH/IEC-Cert/May 23.

**Sample size calculation:** Sample size calculation was followed by the earlier study of Senevirathna et al (17) figure (1). Estimated sample size is 347 and after applying design effect of 1.5, sample size becomes 520, where Alpha ( $\alpha$ ) 0.05; Beta ( $\beta$ ) 0.05; and Correlation coefficient 0.05.

$$n \geq \left( \frac{Z_{1-\alpha/2} + Z_{1-\beta}}{\frac{1}{2} \log_e \frac{1+r}{1-r}} \right)^2 + 3$$

Alpha ( $\alpha$ ): Type 1 error rate

Beta ( $\beta$ ): Type 2 error rate

r: Expected correlation coefficient

## Figure 1: Formula for sample size calculation

**Study procedure:** After obtaining permission from the SRC and IEC and after getting informed written agreement, healthy schoolchildren aged 10 to 19 who met the inclusion criteria were enrolled in the study. Using the WHO growth chart, the Z scores for height and BMI were determined. Peak flow meters are used to measure the peak expiratory flow rate.

## Data collection method:

- **Height:** Standing height was measured in centimeters using standard portable stadiometer in barefoot. The child should stand erect with the feet close together and the heels, buttocks and back of head touching the stadiometer. The head was positioned in the Frankfurt plane, with the lower margin of the orbit in line with the external auditory meatus. Calculated height was converted into meters. Z score for height for age calculated using WHO growth chart
- **Weight:** The weight was measured in kilograms, without shoes by making the child stand still for one minute on a calibrated digital weighing scale.

- **Peak expiratory flow rate:** Peak expiratory flow rate was measured using the Peak Flow Meter. Before testing, the child was allowed to rest for a period of five minutes. The procedure was explained and demonstrated till the children understand the procedure fully. Each child was asked to form a good seal around the mouth-piece of the peak flow meter, take a deep breath and then blow into the peak flow meter as hard and fast as he/ she could. Three trials were given and the best of three were chosen for analysis.

Method of Result Analysis: Initially, MS Excel was used to compile the data, then SPSS software version 23.0 was

used for analysis. All information was summed up as frequency (percentages) for categorical variables and mean  $\pm$  standard deviations for continuous variables. For regularly distributed data, the difference between the two groups was compared using the Student's t test. The Mann-Whitney U test was used to evaluate the difference between those two groups for non-normally distributed data. The chi-square test was used to find the incidence of complications which varied throughout the groups. A value of  $P < 0.05$  was deemed statistically significant.

## RESULTS

**Table 1: Distribution of Gender, Age, BMI, PERF Score, and Height among study participants**

<b>Distribution of Gender among study participants (n=540)</b>			
<b>Gender</b>	<b>Frequency</b>	<b>Percentage (%)</b>	
Male	263	48.7	
Female	277	51.3	
Total	540	100	
<b>Distribution of Age among study participants (n=540)</b>			
<b>Age category</b>	<b>Frequency</b>	<b>Percentage (%)</b>	
10-12	141	26.1	
13-15	202	37.4	
16-18	197	36.5	
Total	540	100	
<b>Distribution of BMI for age (Z-Score) among study participants (n=540)</b>			
<b>Z-score</b>	<b>Frequency</b>	<b>Percentage (%)</b>	
-5 to -2.001 (Thinness)	205	38.0	
-2 to 0.999 (Normal)	265	49.1	
1 to 2 (Overweight)	46	8.3	
2.001 to 4 (Obesity)	24	4.6	
Total	540	100	
<b>Distribution of Peak Expiratory Flow Rate Score among study participants</b>			
<b>PEFR L/min</b>	<b>Frequency</b>	<b>Percentage (%)</b>	
150 - 250	298	55.2	
251 - 350	161	29.8	
351 - 450	81	15.0	
<b>Height for Age</b>	<b>Frequency</b>	<b>Percentage (%)</b>	
<b>Distribution of Height for age (Z-Score) among study participants (n=540)</b>			
Z –	< -3 (Severe stunting)	27	5.0

Score	-2.999 to -2.001 (Stunting)	84	15.6
	-2 to 2 (Normal)	429	79.4
	Total	540	100

The study sample included 540 individuals, with males comprising 263 (48.7%) and females 277 (51.3%). Age distribution was balanced across adolescence: 202 participants (37.4%) were aged 13–15, 197 (36.5%) were 16–18, and 141 (26.1%) were 10–12, reflecting a relatively even spread across early to late teenage years. Nutritional status varied, with 265 participants (49.1%) having normal BMI, 205 (38.0%) classified as thin, 45 (8.3%) overweight, and 25 (4.6%) obese, indicating a dual burden of malnutrition with undernutrition predominating. Pulmonary function assessment showed that 298

participants (55.2%) had low PEFR values (150–250 L/min), 161 (29.8%) fell in the mid-range (251–350), and 81 (15.0%) achieved higher values (351–450). Growth indicators revealed that 429 participants (79.4%) had normal height-for-age, while 84 (15.6%) were stunted and 27 (5.0%) severely stunted, meaning nearly one in five exhibited signs of chronic undernutrition (Table 1). This highlights that although most adolescents showed normal development, a significant proportion faced nutritional challenges with implications for long-term health and lung function.

**Table 2: Distribution of Mean and Standard deviation values among study participants (n=540)**

Variables	Mean	Standard Deviation (±)
Age	14.37	± 2.378
Height	155.347	± 12.6278
Weight	44.1850	± 13.67962
BMI	18.027	± 3.962
Z score (BMI for Age)	-0.985	± 1.687
PEFR	261.69	± 71.264
Z Score (Height for Age)	-1.001	± 1.184

The participants' average age is 14.37 years (±2.378). The group's overall physical growth is reflected in the average height of 155.35 cm (±12.63) and weight of 44.19 kg (±13.68). 18.03 (±3.96) is the average Body Mass Index (BMI). For height-for-age, the mean Z-score is -1.001 (±1.184), and for BMI-for-age, it is -0.985 (±1.687).

Participants here often fall just short of the anticipated development requirements, with some exhibiting mild to significant growth delays. The group's moderate lung function is shown by the mean Peak Expiratory Flow Rate (PEFR), which is 261.69 L/min (±71.26) (Table 2).

**Table 3: Association between Gender, Age, Thinness (Z-Score), Overweight & Obese (Z-Score), Height for Age (Z-Score) with Peak Expiratory Flow Rate among the study participants**

Association between Gender and Peak Expiratory Flow Rate among the study participants							
Gender and PEFR			PEFR (L/min)			Total	P-value
			150-250	251- 350	351-450		
Gender	Male	Count	81	101	81	263	<0.01
		Percentage	30.8%	38.4%	30.8%	100.0%	
	Female	Count	217	60	0	277	
		Percentage	78.3%	21.7%	0.0%	100.0%	
Total		Count	298	161	81	540	
		Percentage	55.2%	29.8%	15.0%	100.0%	
Association between age and Peak Expiratory Flow Rate among the study participants							
Age and PEFR			PEFR (L/min)			Total	P-Value
			150 - 250	251 - 350	351 - 450		
Age	10-12	Count	127	14	0	141	<0.01
		Percentage	90.1%	9.9%	0.0%	100.0%	

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13-15	Count	107	76	19	202		
	Percentage	53.0%	37.6%	9.4%	100.0%		
16-18	Count	64	71	62	197		
	Percentage	32.5%	36.0%	31.5%	100.0%		
Total	Count	298	161	81	540		
	Percentage	55.2%	29.8%	15.0%	100.0%		
Association between Thinness (Z-Score) and Peak Expiratory Flow Rate among the study participants							
<b>Z-Score (BMI for Age) and PEFR</b>		<b>PEFR (L/min)</b>			<b>Total</b>	<b>P-Value</b>	
		150 - 250	251 - 350	351 - 450			
Z-Score	-5 to -2.001 (Thinness)	Count	139	48	18	205	0.03
		Percentage	67.8%	23.4%	8.8%		
	-2 to 0.999 (Normal)	Count	126	94	45	265	
		Percentage	47.5%	35.5%	17.0%		
Total		Count	265	142	63	470	
		Percentage	56.3%	30.2%	13.4%	100.0%	
Association between overweight & Obese (Z-Score) and Peak Expiratory Flow Rate among the study participants							
<b>Z-Score (BMI for Age) and PEFR</b>		<b>PEFR (L/min)</b>			<b>Total</b>	<b>P-Value</b>	
		512	251 -350	351-450			
Z-Score	-2 to 0.999 (Normal)	Count	126	94	45	265	
		Percentage	47.5%	35.5%	17.0%		
	1 to 2 (Over weight)	Count	24	17	5	46	0.702
		Percentage	52%	37%	11%		
	2.001 to 4 (Obese)	Count	13	9	2	24	
		Percentage	48%	40%	2%		
Total		Count	163	120	52	335	
		Percentage	48.6%	35.8%	15.5%	100.0%	
Association between Height for Age (Z-Score) and Peak Expiratory Flow Rate among the study participants							
<b>Z-Score (Height for Age) and PEFR</b>		<b>PEFR (L/min)</b>			<b>Total</b>	<b>P-Value</b>	
		150 -250	251-350	351-450			
Z-Score	below -3 (Severe Stunting)	Count	21	6	0	27	<0.01
		Percentage	77.8%	22.2%	0.0%		
	-2.999 to -2.001 (Stunting)	Count	55	27	2	84	
		Percentage	65.5%	32.1%	2.4%		
	-2 to 2 (Normal)	Count	221	128	80	429	
		Percentage	51.5%	29.8%	18.7%		

Total	Count	297	161	81	540
	Percentage	55.1%	29.9%	15.0%	100 %

The distribution of PEFR varied significantly by gender and age. Among males, values were fairly balanced across ranges: 30.8% in 150–250 L/min, 38.4% in 251–350, and 30.8% in 351–450. Females showed skewed results, with 78.3% in the lowest range, 21.7% in the mid-range, and none above 350, indicating lower pulmonary function. Chi-square analysis confirmed a significant correlation ( $p < 0.01$ ). Age also showed strong association with PEFR ( $p < 0.01$ ). Younger adolescents (10–12 years) had predominantly low values (90.1% in 150–250), while older groups demonstrated progressive improvement, with 31.5% of 16–18-year-olds reaching the highest range. Nutritional status influenced PEFR outcomes. Thin participants (67.8%) were more likely to fall in the lowest range compared to those with normal BMI, who showed better distribution across mid and high ranges. Chi-square testing confirmed a significant association ( $p = 0.03$ ).

Overweight and obese individuals displayed a declining trend in higher PEFR values, but the correlation was not statistically significant ( $p = 0.702$ ). This suggests undernutrition has a stronger impact on lung function than overnutrition, though excess weight may exert modest negative effects. Height-for-age was also strongly linked to PEFR. Severely stunted individuals had no values in the highest range, with 77.8% in the lowest. Moderately stunted participants showed similar patterns, while those with normal growth had better distribution, with 18.7% reaching the highest PEFR category. Chi-square testing confirmed a highly significant correlation ( $p < 0.01$ ), indicating that greater linear growth is associated with superior pulmonary function. Overall, gender, age, BMI, and height all demonstrated significant associations with PEFR, highlighting the multifactorial determinants of adolescent lung function. (Table 3)

**Table 4: Distribution of Prevalence of malnutrition status and combined Thinness and stunting in study participants**

Nutrition status	Frequency	Percentage (%)
<b>Distribution of Prevalence of malnutrition status among study participants (n= 540)</b>		
Severe Thinness	29	5.3
Thinness	144	26.6
Severe stunting	19	3.5
Stunting	59	10.9
Total (undernutrition)	251	46.4
Total study participants	540	100
<b>Distribution of combined Thinness and stunting among study participants</b>		
Variable	Frequency	Percentage (%)
Thinness and Stunting	33	6.1
Total study participants	540	100

Out of 540 participants, 251 (46.4%) were undernourished based on anthropometric measures. Severe thinness, indicating acute undernutrition and immediate health risks, was observed in 29 individuals (5.3%), while 144 (26.6%) showed thinness of a lesser degree. Severe stunting, a marker of chronic malnutrition, affected 19 participants (3.5%), and moderate stunting was present in 59 (10.9%). Overall, malnutrition impacted nearly half of the population, with thinness being the most prevalent form, underscoring the urgent need for nutritional interventions and policy-level strategies to address both acute and chronic undernutrition. Additionally, 33 individuals (6.1%) exhibited both thinness and stunting, reflecting a low to moderate prevalence of concurrent undernutrition conditions. This subgroup highlights potential chronic nutritional deficiencies requiring further investigation and targeted interventions to improve long-term health outcomes (Table 4).

## DISCUSSION

Men comprised 48.7% of participants and women 51.3%, allowing balanced comparison of PEFR outcomes. Male PEFR distribution was broad: 30.8% in the 150–250 L/min range, 38.4% in 251–350, and 30.8% above 350. In contrast, 78.3% of females fell in the 150–250 range, 21.7% in 251–350, with none exceeding 350. This indicates significantly higher PEFR in males, consistent with studies by Mohammadzadeh et al., Pande et al., Islam et al. and Chen et al. (18,19, 20, 21), though Rahman et al., (22) reported higher female values in some groups. Male advantage is attributed to stronger respiratory muscles, enhanced protein synthesis from androgens, larger chest dimensions, greater alveolar size and compliance, and testosterone-driven thoracic changes during puberty (23). These physiological and hormonal differences explain

superior male pulmonary function and reinforce sex as an independent predictor of PEFr (24).

The study sample was balanced across adolescence: 13–15 years (37.4%), 16–18 years (36.5%), and 10–12 years (26.1%), with a mean age of 14.37 ( $\pm 2.378$ ). PEFr rose significantly with age ( $p < 0.01$ ). Most younger participants (90.1% of 10–12 years) had low PEFr (150–250 L/min), while 31.5% of late teens reached higher values (351–450 L/min). The overall mean PEFr was 261.69 L/min ( $\pm 71.26$ ), comparable to Parikh et al.'s findings (25). Age consistently emerged as an independent predictor of PEFr in studies by Bharadwaj et al., Mohammadzadeh et al., and Pande et al., (26, 18, 19). Kumar et al., and Nairn et al., similarly reported peak values in 17–19-year-olds, reflecting airway expansion and increased muscularity (27, 28). Dikshit et al. noted linear PEFr growth, peaking in males at 20–25 and in females just before 20, with later declines (29).

The study participants had an average weight of 44.19 kg ( $\pm 13.68$ ) and BMI of 18.03 ( $\pm 3.96$ ), with a mean BMI-for-age Z-score of  $-0.985$  ( $\pm 1.687$ ), indicating mild undernutrition. Thinness was prevalent in 38% of participants, higher than India's national average of 24% (CNNS, 2019) by National Report (30). Nearly half (49.1%) had normal BMI, while 8.3% were overweight and 4.6% obese—slightly above national average. These findings highlight a dual burden of malnutrition, with thinness remaining the predominant concern among adolescents.

Among thin participants (BMI Z-score  $< -2$ ), 67.8% recorded low PEFr values (150–250 L/min), 23.4% fell in the 251–350 range, and only 8.8% reached 351–450. In contrast, those with normal BMI showed better distribution: 47.5% in the lowest range, 35.5% mid-range, and 17% in the highest. This statistically significant difference underscores the impact of nutritional status on pulmonary function. Primhak et al. (31) similarly reported malnutrition's effect on PEFr, linked to reduced muscle power and voluntary lung inflation. Ijaz et al. (32) found positive correlations between PEFr and BMI/WHR, especially in underweight and normal-weight groups. Kuti et al. (33) observed significantly lower PEFr in underweight Nigerian schoolchildren compared to normal-weight peers, with indoor air pollution also contributing. Kaur et al. (34) demonstrated that wasted or stunted children had markedly reduced expiratory flow rates and lung volumes (FVC, FEV1, FEV3). Faridi et al. (16) and Senevirathna et al. (17) noted that malnutrition affected FVC and FEV1 more than PEFr, though PEFr was still reduced. Mechanistically, Faridi et al. (16) attributed declines to weakened respiratory muscles and thoracic cage limitations, as muscle protein serves as a reserve during nutritional shortage, leading to atrophy. Nair

et al. (35) further showed malnutrition causes atrophy of diaphragm fibers (type II  $>$  type I), reducing force generation and impairing inspiratory capacity more than expiratory. Collectively, these findings highlight that thinness compromises overall lung function and respiratory efficiency, with PEFr serving as a useful, non-invasive indicator of nutritional impact on adolescent respiratory health.

In our study, 17% of participants with normal BMI reached the highest PEFr range (351–450 L/min), compared to 11% of overweight and only 2% of obese individuals, suggesting a decline in PEFr with increasing BMI, though not statistically significant. Similar negative associations between obesity and PEFr were reported by Aggarwal, Chinnaiyan, Sarala, and Athmanada (36–39). Borse et al. (40) explained that obesity impairs PEFr through abdominal fat restricting lung expansion, reduced diaphragmatic mobility, airway remodeling from pro-inflammatory adipokines, and cytokine-mediated inflammation (IL-6, TNF- $\alpha$ ), alongside decreased adiponectin. Our findings show undernutrition had a more pronounced effect on PEFr than overnutrition, likely due to loss of respiratory muscle mass. While obesity may impose mechanical and inflammatory loads, its impact was less evident. Chakravathy et al. similarly found undernutrition more detrimental to PEFr than obesity (41). In the present study, 429 participants (79.4%) had normal height-for-age Z-scores ( $-2$  to  $+2$ ), while 27 (5.0%) were severely stunted ( $< -3$ ) and 84 (15.6%) stunted ( $-3$  to  $-2$ ). Thus, 20.6% were stunted overall, lower than the national average of 30% reported by the CNNS (2019) (29). Although reduced compared to national data, this prevalence still reflects a substantial burden of chronic undernutrition.

Since adolescence is a second critical growth period before epiphyseal closure, stunting at this stage may result in permanent short stature and long-term health risks.

PEFr values were significantly lower among stunted individuals. Of those severely stunted, 77.8% fell into the lowest PEFr range (150–250 L/min), with none reaching the highest (351–450). Similarly, 65.5% of stunted participants had low PEFr, while only 2.8% achieved the highest range. In contrast, 18.7% of participants with normal height reached the highest category, confirming a linear correlation between height and PEFr.

Height has consistently been shown to be the strongest predictor of PEFr. Kyejo et al. (42) reported the largest correlation ( $r = 0.745$ ), while Durairaj et al. (43) found height to be the primary determinant of pulmonary function, with lung volumes scaling proportionately. Studies by Rao, Dhungel (44, 45) further support this association. Zverev et al. (46) demonstrated that stunted Malawian children had reduced PEFr proportional to

delayed growth, though stature remained a robust predictor, suggesting isotropic impairment of lung and body growth. Neve et al. (47) highlighted that thoracic growth, rather than overall height, is the more direct determinant of pulmonary capacity, as lung volumes continue to expand even after adult height is reached. Chronic malnutrition thus compromises both linear and thoracic development, leading to impaired lung function. Overall, height and thoracic growth emerge as critical determinants of adolescent pulmonary capacity.

In the present study, stunting was less common than thinness but had a stronger impact on PEFR: only 2.4% of stunted individuals reached the highest PEFR range compared to 8.8% of thin participants. Primhak et al. (30) noted chronic malnutrition affects growth more than PEFR, while acute malnutrition reduces PEFR modestly. Thinness, driven by respiratory muscle wasting, is largely reversible with nutritional rehabilitation. Garrido et al. (48) showed anorexia nervosa patients regained PEFR and muscle strength after five weeks of recovery. Stunting, however, is more persistent. Himaz et al. (49) emphasized that growth faltering can occur or partially reverse during adolescence, while Mauch et al. (50) found early intervention improves lung function and reduces infection risk. Without management, stunting leads to irreversible impairment of lung development. Thus, adolescence is a critical window for targeted nutritional strategies and ongoing monitoring.

## CONCLUSION

From the present study it is evident that,

- PEFR correlates positively with age and gender – PEFR increases with age and consistently higher in males.
- Under nutrition (stunting and thinness) has a significant negative impact on PEFR, indicating that nutritional deficiencies adversely affect lung function.
- Over nutrition also shows a negative association with PEFR, though not statistically significant indicating a possible role of the double burden of malnutrition on respiratory health.
- Stunting has a greater negative impact on PEFR than thinness, highlighting more persistent and profound effect of chronic malnutrition compared to acute malnutrition on respiratory health.
- Acute malnutrition, typically due to muscle wasting, reduces strength of respiratory muscle and is potentially reversible, while chronic malnutrition causes impairment of

thoracic and lung development, making its impact more likely irreversible. Therefore, timely diagnosis and intervention is crucial in stunting before the cessation of growth, to enable catch-up growth and attain lung function comparable to healthy peers.

- Periodic nutritional assessment during adolescence is essential for early detection of malnutrition particularly stunting to prevent long-term pulmonary complications.
- Undernourished adolescents presenting with respiratory illness must receive utmost clinical care to reduce associated morbidity and mortality

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