Research Article

Too Thin To Breathe Better? Exploring The Association Between Low Bmi and Pulmonary Function in Adolescents and Young Adults Aged 12–30 Years

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Abstract

Pulmonary function undergoes substantial development during childhood and adolescence, reaching near-maximal levels during young adulthood. Nutritional status may influence this process, yet research has traditionally focused more heavily on obesity-related respiratory impairment than on the potential consequences of low body weight. This article explores the association between low body mass index (BMI) and pulmonary function among adolescents and young adults aged 12–30 years, with emphasis on developmental differences between adolescents and adults. For individuals aged 12–19 years, nutritional status should be assessed using age- and sex-specific BMI-for-age criteria, whereas BMI <18.5 kg/m² is applicable for adults aged 20–30 years. Available evidence suggests that low BMI may be associated with reduced forced expiratory volume in one second (FEV1), forced vital capacity (FVC), peak expiratory flow and other measures of ventilatory performance, although evidence specifically involving adolescents remains limited and heterogeneous. Potential mechanisms include reduced respiratory and peripheral muscle mass, inadequate energy and protein intake, micronutrient deficiencies, impaired physical development, physical inactivity and underlying chronic disease. The association may also be bidirectional because respiratory and systemic diseases can contribute to weight loss. Comprehensive assessment of nutritional status, body composition, respiratory muscle strength and pulmonary function is therefore warranted in selected individuals with persistent low BMI.

Keywords: Low BMI, Underweight, Adolescents, Young Adults, Pulmonary Function, FEV1, FVC, Spirometry, Respiratory Muscle, Nutrition, Lung Development.

Introduction

The ability of the respiratory system to provide adequate ventilation depends on coordinated development of the lungs, airways, chest wall, respiratory muscles and cardiovascular system. During childhood and adolescence, lung dimensions and pulmonary function increase substantially as body size increases. This developmental process continues through adolescence and early adulthood, when many individuals reach their maximum lifetime pulmonary function. Consequently, factors that interfere with growth, nutritional status, physical development or respiratory health during these years may influence the level of pulmonary reserve achieved in early adulthood. Body mass index is one of the simplest anthropometric indicators used to characterize body size and nutritional status. In adults, BMI is calculated by dividing body weight in kilograms by height in meters squared, with BMI <18.5 kg/m² conventionally classified as underweight. However, this adult classification should not simply be transferred to adolescents. For individuals aged 5–19 years, the World Health Organization recommends BMI-for-age interpretation using age- and sex-specific z-scores, thinness is defined as a BMI-for-age z-score below −2 SD and severe thinness below −3 SD. This distinction is particularly important for a study covering the broad age range of 12–30 years because a single BMI cutoff cannot adequately represent nutritional status throughout adolescence and young adulthood. The figure 1 illustrates that lung growth occurs simultaneously with somatic growth. Low nutritional availability may influence muscle development, physical growth and respiratory reserve, while pulmonary disease may itself contribute to reduced appetite, increased metabolic demand and impaired growth.

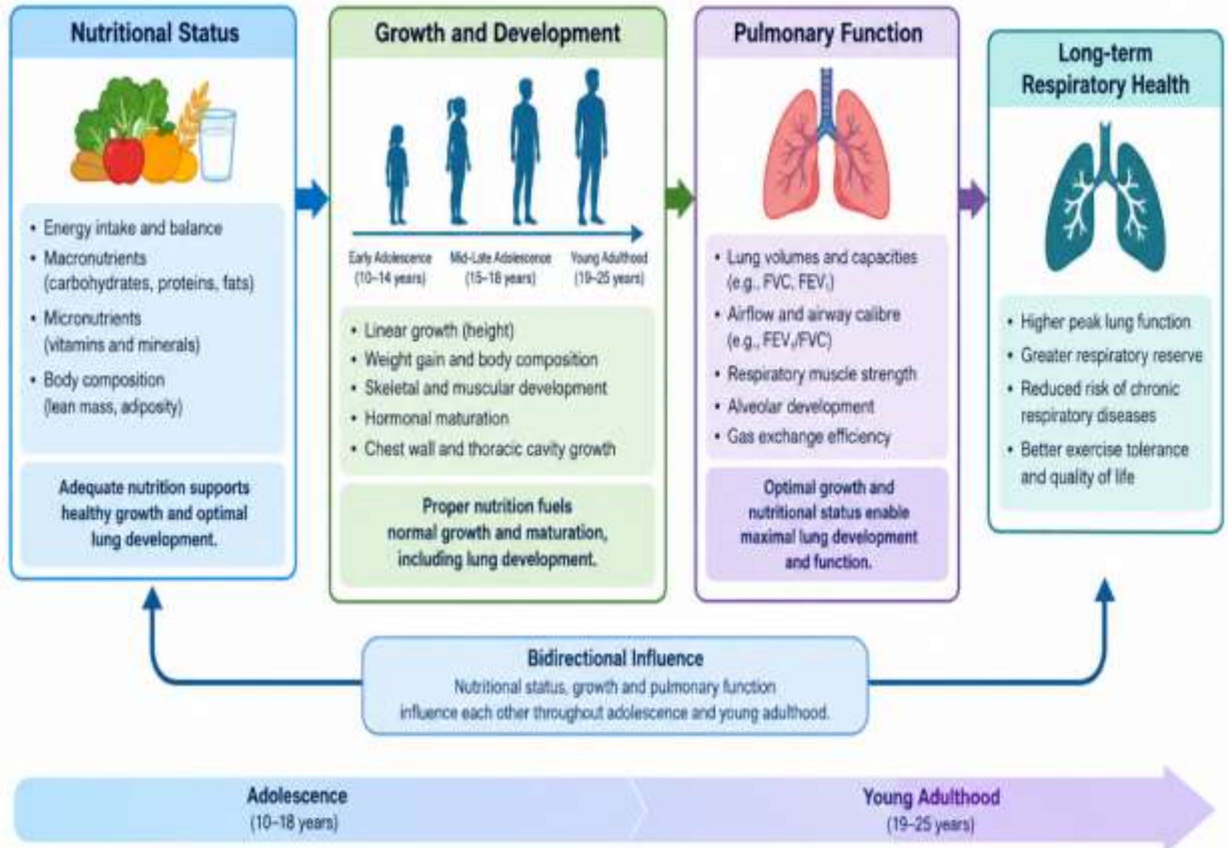

Figure 1. Developmental framework linking nutritional status, growth and pulmonary function from adolescence to young adulthood

The relationship between body weight and lung function is not necessarily linear. Obesity can impair pulmonary mechanics through excess adipose tissue, increased abdominal pressure and altered chest-wall compliance. At the opposite extreme, very low body weight may be associated with reduced muscle mass and nutritional reserve. Consequently, the relationship may resemble a U-shaped or reversed-U-shaped association, in which pulmonary function is comparatively preserved across an intermediate range and lower at the extremes. Population evidence supports this possibility. Do et al. (2019), in a large Korean population of 282,135 adults without apparent lung disease, reported that underweight individuals had lower FEV1, FVC, predicted FEV1, predicted FVC and peak expiratory flow than other BMI categories. Similarly, Zhang et al. (2021) found nonlinear associations between BMI and pulmonary function in a nationally representative U.S. population, with both underweight and obesity associated with reduced FEV1 and FVC. However, the adolescent literature requires greater caution. Adolescence is characterized by rapid changes in height, weight, body composition, sex hormones and respiratory-system dimensions. A lower absolute FVC in a smaller adolescent does not necessarily represent pathological restriction. Conversely, a chronically undernourished adolescent may have inadequate muscle development or impaired growth that could reduce expected pulmonary function. The purpose of this review is therefore to examine the available evidence regarding low BMI and pulmonary function in individuals aged 12–30 years, emphasizing developmental physiology, nutritional mechanisms, respiratory muscle function, spirometric findings, confounding factors, clinical assessment and future research.

Low BMI During Adolescence: Why the Definition Matters

The first methodological issue in studying adolescents is the definition of underweight. Applying BMI <18.5 kg/m² to a 12-year-old and a 29-year-old as if they represented the same biological condition would be inappropriate. During adolescence, BMI naturally changes with age. The same BMI can represent very different nutritional states in a 12-

year-old, a 16-year-old and a 19-year-old. Sex differences also become increasingly pronounced during puberty. Therefore, adolescent nutritional assessment should incorporate age, sex and developmental stage. The WHO 2007 growth reference provides BMI-for-age standards for individuals aged 5–19 years. Within this framework, thinness is defined as a BMI-for-age z-score below −2 SD, while severe thinness is below −3 SD. After the 19th birthday, adult BMI classifications become applicable. This distinction has direct implications for pulmonary-function research. If researchers classify adolescents using adult BMI thresholds, they may misclassify both nutritional status and its relationship with lung function. A 17-year-old classified as “normal” by an adult cutoff could actually have significant thinness when evaluated using BMI-for-age.

Table 1. Recommended interpretation of low BMI across the 12–30-year age range

Age group	**Preferred nutritional indicator**	**Low-weight interpretation**	**Important consideration**
12–14 years	BMI-for-age z-score	Thinness <−2 SD	Rapid growth and puberty influence BMI
15–17 years	BMI-for-age z-score	Thinness <−2 SD	Sex-specific maturation is important
18–19 years	BMI-for-age z-score, with transition toward adult assessment	Thinness <−2 SD	Transitional age group
20–30 years	Adult BMI	BMI <18.5 kg/m²	Adult BMI classification is appropriate
All ages	Weight trajectory and body composition	Context-dependent	BMI alone cannot diagnose malnutrition

The developmental context also explains why weight and lung function may appear correlated even when BMI is not the causal factor. Height is one of the strongest determinants of lung volume. Adolescents who are shorter because of delayed or impaired growth may have lower absolute FVC and FEV1. Thus, appropriate reference equations are essential. Figure 2 shows five interconnected pathways through which low nutritional status may influence pulmonary function during adolescence and young adulthood. Low energy intake, reduced protein availability, micronutrient deficiencies, low muscle mass and physical inactivity can interact to reduce respiratory reserve. At the same time, underlying disease may produce both low BMI and impaired pulmonary function.

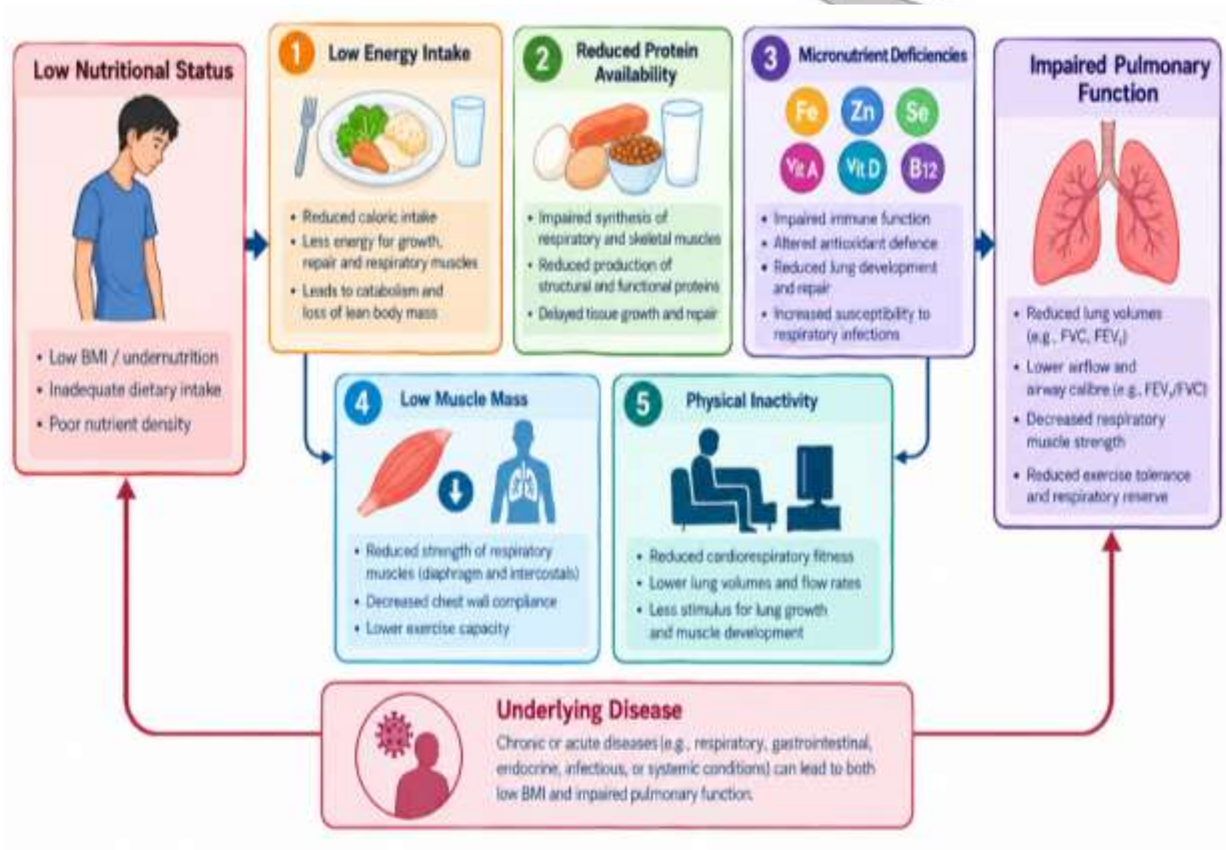

Figure 2. Interconnected pathways linking low nutritional status with impaired pulmonary function during adolescence and young adulthood

Adolescent Growth and Lung Development

Lung development is closely linked to overall body growth. During adolescence, increases in standing height are accompanied by increases in thoracic dimensions and lung volumes. Pulmonary function therefore changes considerably with age and body size. The relationship between anthropometry and lung function has been demonstrated in pediatric populations. In a large cohort of school-age children, BMI status was associated with subsequent lung-function patterns, although the direction and magnitude of associations differed according to BMI category and sex. In the BAMSE cohort, persistent overweight and obesity were associated with lower FEV1/FVC ratios, indicating that body composition can influence airway function during childhood and adolescence. Studies also show that body size, socioeconomic conditions and environmental exposure influence lung function among children. Indian data from the Size and Lung Function in Children study demonstrated differences in FEV1 and FVC across urban, semiurban and rural populations, with BMI, socioeconomic conditions, tobacco exposure and biomass exposure contributing to variation in lung-function measurements. These observations are important because low BMI can be a marker of several different biological circumstances. An adolescent with a low BMI due to constitutional thinness and normal growth may have entirely normal pulmonary function. Another adolescent with low BMI caused by chronic nutritional deprivation may have impaired growth, reduced muscle mass and reduced physical fitness. Therefore, the question should not simply be: “Does low BMI reduce lung function?” A more appropriate question is: “Does inadequate nutritional status or reduced body composition during a critical period of lung development contribute to failure to achieve expected pulmonary function?” This distinction is essential for future longitudinal research.

Evidence From Adolescents

Evidence specifically linking low BMI with pulmonary function in adolescents is less extensive than evidence involving obesity. Much of the pediatric respiratory literature has focused on obesity because of its established association with airway obstruction and reduced lung volumes. Nevertheless, pediatric studies provide indirect evidence that the lower end of the body-size spectrum may also be relevant. A study examining healthy children and adolescents found that underweight participants had lower percent-predicted FVC and vital capacity than other groups. Although the study predates the preferred 10-year reference period for this review, its findings provide biological context for more recent research. More recent pediatric studies have demonstrated that anthropometric measurements, body composition and growth trajectories are associated with FEV1 and FVC. The direction of the relationship is not necessarily identical across the entire BMI range. The 2018 BAMSE population-based cohort, for example, demonstrated that persistent overweight and obesity were associated with lower FEV1/FVC during adolescence, emphasizing that BMI can affect airway physiology. However, the study was primarily informative regarding higher BMI rather than severe thinness. The absence of large adolescent studies specifically examining severe thinness should not be interpreted as evidence that low nutritional status has no effect. Instead, it represents a major research gap. Figure 3 illustrates Hypothesized relationship between BMI-for-age and pulmonary function during adolescence. The proposed model emphasizes that pulmonary function may be reduced at both extremes of nutritional status, although the mechanisms differ. At low BMI-for-age, reduced muscle mass, impaired growth and nutritional deficiency may predominate, at high BMI-for-age, mechanical loading and airway dysfunction may become more prominent. This conceptual model should not be interpreted as establishing a universal U-shaped relationship in adolescents. The actual curve may differ according to age, sex, ethnicity, pubertal development, height, physical activity, environmental exposure and disease status.

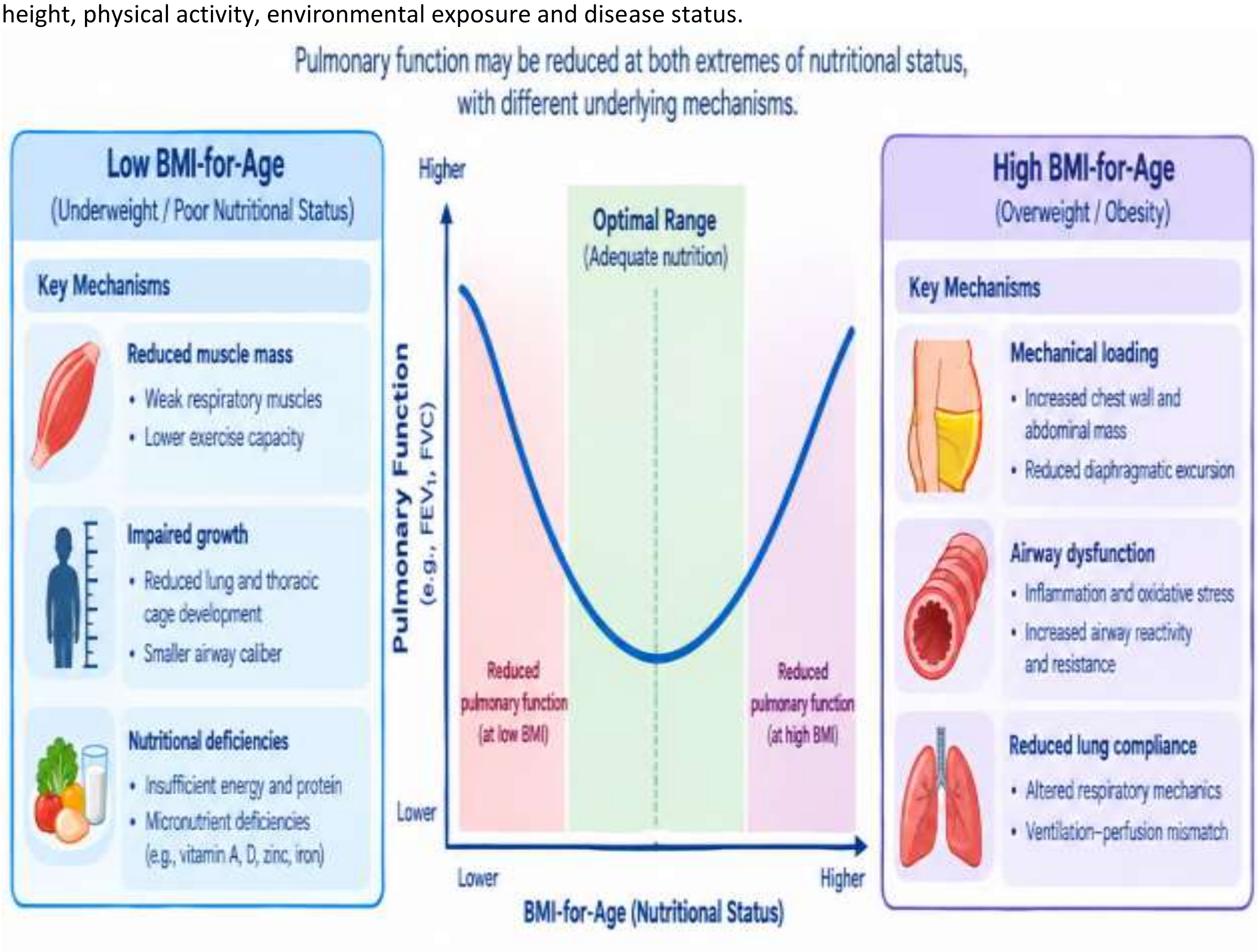

Figure 3. Hypothesized U-shaped relationship between BMI-for-age and pulmonary function during adolescence, with distinct mechanisms contributing to impairment at low and high BMI-for-age

Low BMI and Pulmonary Function in Young Adults

The evidence becomes stronger after adolescence. A major Korean study by Do et al. (2019) examined 282,135 adults and found significantly lower FEV1, predicted FEV1, FVC, predicted FVC and peak expiratory flow in underweight individuals after adjustment for age, sex, height, smoking, vigorous exercise, diabetes and high-sensitivity C-reactive protein. This study is especially relevant to young adults because it demonstrates that low BMI can be associated with reduced pulmonary function even in individuals without obvious lung disease. Importantly, the association was not simply attributable to smoking or overt respiratory disease. The same general pattern was supported by Zhang et al. (2021), who analyzed 7,346 participants from a nationally representative U.S. cohort. After adjustment for age, race, education, smoking and physical activity, both underweight and obesity were associated with reduced FEV1 and FVC. The investigators identified reversed-U-shaped relationships between BMI and pulmonary function. A more recent study of healthy nonobese young adults aged 18–25 years, however, reported a different result: BMI itself was not significantly associated with spirometric parameters after adjustment, whereas height and sex were important independent predictors of FVC and FEV1. This finding is valuable because it demonstrates that the association between BMI and lung function is not universal. The contrast between these studies illustrates the importance of population characteristics. In healthy young adults without obesity, BMI may have relatively little independent explanatory value once height, sex and other determinants of lung size are considered. Conversely, in larger population samples containing individuals with nutritional deficiency and chronic disease, low BMI may identify people with reduced muscle mass or systemic illness. Thus, low BMI should be considered a potential marker of reduced pulmonary reserve rather than a direct determinant of lung function in every individual.

BMI, Body Composition and the Respiratory Muscles

One of the strongest biological explanations for a relationship between low BMI and pulmonary function involves skeletal muscle. The respiratory system is dependent on the diaphragm, intercostal muscles, abdominal muscles and accessory muscles. These muscles require adequate protein, energy and micronutrients for normal development and function. During adolescence, skeletal muscle mass increases substantially, particularly during puberty. Nutritional insufficiency during this period could theoretically limit the development of both peripheral and respiratory muscle reserve. This concept is supported by research in chronic respiratory disease. Studies of COPD have repeatedly demonstrated relationships between fat-free mass, sarcopenia, respiratory muscle strength and pulmonary function. Although COPD populations are much older than the 12–30-year age range considered here, the physiological principles provide insight into possible mechanisms. Respiratory muscle strength can be assessed using maximal inspiratory pressure and maximal expiratory pressure. The European Respiratory Society statement on respiratory muscle testing emphasizes standardized measurement of respiratory muscle function. In young people with low BMI and unexplained reduction in FVC or exercise capacity, respiratory muscle testing may therefore provide information beyond conventional spirometry.

Low BMI and Respiratory Muscle Strength

A reduction in respiratory muscle strength can affect pulmonary function in several ways. During forced expiration, adequate expiratory muscle force is required to generate high expiratory flow. Reduced muscle strength may therefore decrease peak expiratory flow and potentially limit FEV1.

Similarly, inadequate inspiratory muscle strength may prevent achievement of maximal inspiratory volume before forced expiration. This can reduce the starting lung volume and contribute to a lower FVC. The effect is particularly important when low BMI reflects sarcopenia rather than constitutional thinness. However, it is important not to assume that every underweight adolescent has respiratory muscle weakness. Some individuals with low BMI are highly physically active and may have excellent cardiorespiratory fitness and muscle function.

This reinforces the need to distinguish:

- Low BMI,
- Low fat-free mass,
- Sarcopenia,
- Malnutrition, and
- Constitutional thinness.

These are related but not interchangeable conditions. Figure 4 shows relationship between body composition, respiratory muscle strength and spirometric performance.

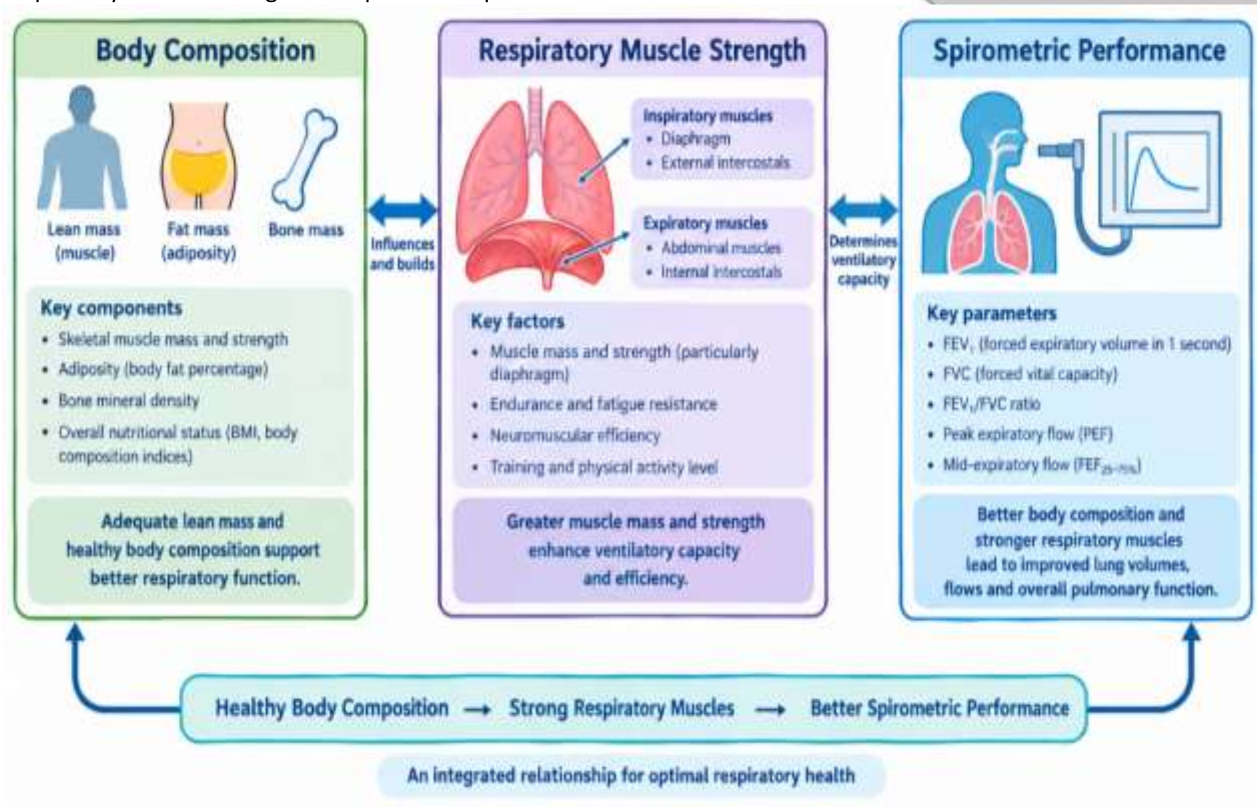

Figure 4. Relationship between body composition, respiratory muscle strength and spirometric performance
Protein-Energy Availability During Adolescence

Adolescence is characterized by increased nutritional requirements because of rapid physical growth. Energy requirements vary with age, sex, pubertal stage and physical activity. Inadequate energy availability can interfere with normal growth and may contribute to reduced body mass. In athletes, particularly those involved in high-volume endurance or aesthetic sports, insufficient energy intake may occur even when food availability is adequate. Low energy availability may affect bone health, reproductive function, endocrine regulation, immune function and skeletal muscle development. These systemic effects can indirectly influence exercise capacity and respiratory performance. Christian and Smith (2018) emphasized that adolescent undernutrition is an important global health issue and can affect growth and development during a period of increased nutrient demand. Therefore, an adolescent with low BMI and reduced pulmonary function should be assessed for dietary adequacy, recent weight loss, excessive exercise, gastrointestinal symptoms and other signs of nutritional insufficiency.

Micronutrients and Pulmonary Function

Micronutrients may also contribute to the relationship between nutritional status and respiratory health. Iron deficiency is particularly important in adolescents, especially menstruating females. Iron deficiency and anemia can reduce oxygen transport and exercise tolerance. Although anemia does not necessarily reduce spirometric volumes directly, it can significantly influence functional respiratory symptoms and exercise performance. Vitamin D deficiency has also been investigated in relation to muscle performance and respiratory health. Vitamin D plays roles in skeletal muscle function, bone metabolism and immune regulation. Other nutrients, including zinc, vitamin A, vitamin B12 and folate, are important for normal growth and immune function. Thus, a low-BMI adolescent reporting fatigue, breathlessness or reduced exercise tolerance should not automatically be assumed to have a primary pulmonary disorder. Nutritional and hematological contributors should also be considered.

Physical Fitness as a Major Confounder

Physical fitness is one of the most important variables when examining BMI and pulmonary function. Two individuals may have the same BMI but markedly different aerobic capacity and skeletal muscle strength. A physically active adolescent with BMI below the population average may have excellent pulmonary function. Conversely, a sedentary individual with low BMI may have low muscle mass and poor functional capacity. Studies in children and young people have demonstrated associations between cardiorespiratory fitness and FEV1/FVC and between fitness and absolute lung volumes. Therefore, future studies should include objective measures of physical fitness, such as:

- Peak oxygen uptake,
- Six-minute walk distance,
- Shuttle-walk performance,
- Handgrip strength,
- Sit-to-stand performance,
- Maximal workload,
- Physical activity monitoring and
- Respiratory muscle strength.

This would help determine whether the relationship between low BMI and pulmonary function is mediated partly through physical fitness.

Table 2. Major factors that may modify the relationship between low BMI and pulmonary function in individuals aged 12–30 years

Factor	Possible effect on pulmonary function	Importance in interpretation
Age	Lung volumes increase during adolescence	Must use age-appropriate reference values
Height	Strong determinant of FEV1 and FVC	Essential for prediction equations
Sex	Pubertal growth produces sex-specific differences	Sex-specific reference equations required
Pubertal stage	Influences body composition and lung development	Particularly important at 12–18 years
Smoking/vaping	May impair airway function	Important confounder
Asthma	Can cause variable airflow obstruction	Should be assessed separately
Physical activity	Can improve respiratory and muscle performance	Potential mediator/confounder
Socioeconomic status	Influences nutrition and environmental exposure	Important population-level confounder
Air pollution	May impair lung development	Relevant in urban and rural settings
Biomass exposure	Can impair respiratory health	Particularly important in some regions
Anemia	Reduces oxygen-carrying capacity	Influences exercise tolerance
Sarcopenia	Reduces respiratory muscle reserve	Potential mediator
Chronic disease	Can cause weight loss and lung impairment	Raises reverse-causality concerns
Dietary intake	Determines energy/protein availability	Important for nutritional assessment

Low BMI and Asthma

Asthma is common during adolescence and young adulthood and can complicate the interpretation of the BMI–pulmonary-function relationship. Asthma can reduce FEV1 and FEV1/FVC during symptomatic periods. Conversely, some adolescents with asthma may have low physical activity because of exercise-related symptoms, potentially contributing to lower body mass or reduced fitness. Population studies have demonstrated relationships between BMI and asthma-related pulmonary outcomes, but the direction of association is complex. Therefore, a low-BMI adolescent with reduced FEV1 should undergo appropriate clinical evaluation for asthma rather than having the spirometric abnormality attributed solely to nutritional status. Bronchodilator responsiveness, symptom variability, wheeze, nocturnal symptoms, exercise-related symptoms and family history can provide important contextual information.

Smoking, Vaping and Environmental Exposure

Smoking remains an important determinant of pulmonary function in young adults. Even relatively short periods of tobacco exposure can affect airway inflammation and respiratory symptoms. Electronic-cigarette and vaping exposure also deserves attention in contemporary adolescent and young-adult respiratory research. Because vaping patterns are rapidly evolving, future BMI–lung function studies should collect detailed information about both conventional smoking and electronic nicotine product use. Environmental exposure represents another important confounder. Air pollution, second-hand smoke and biomass fuel exposure can influence lung development and pulmonary function during childhood and adolescence. This is particularly relevant in low-resource settings, where low BMI may coexist with environmental respiratory exposures.

Socioeconomic Conditions and the Low BMI–Lung Function Relationship

Socioeconomic circumstances can influence both nutritional status and respiratory health. Poor socioeconomic conditions may increase the likelihood of inadequate dietary intake, infectious disease, environmental pollution exposure and limited access to healthcare. These same factors may influence pulmonary development. Research among Indian children has demonstrated that residence, socioeconomic conditions, BMI and tobacco or biomass exposure are associated with variation in lung function. Therefore, a study examining low BMI and pulmonary function should ideally adjust for socioeconomic status, environmental exposure and nutritional access. Failure to do so may produce an apparent association between BMI and lung function that actually reflects broader social and environmental determinants.

Low BMI and the FEV1/FVC Ratio

The FEV1/FVC ratio is particularly useful when assessing low-BMI individuals. A reduction in FEV1 accompanied by a disproportionately reduced FVC can produce a preserved or elevated FEV1/FVC ratio. This pattern may suggest reduced lung volume rather than classic airflow obstruction. In contrast, a disproportionately reduced FEV1 with a low FEV1/FVC ratio suggests airflow obstruction. However, spirometry alone cannot confirm restriction. A low FVC with preserved FEV1/FVC should generally prompt consideration of lung-volume measurement when clinically appropriate. The 2022 ERS/ATS interpretive standard emphasizes the use of reference populations, limits of normal and integrated clinical interpretation. The 2023 ERS/ATS technical standard also provides updated guidance for lung-volume measurement.

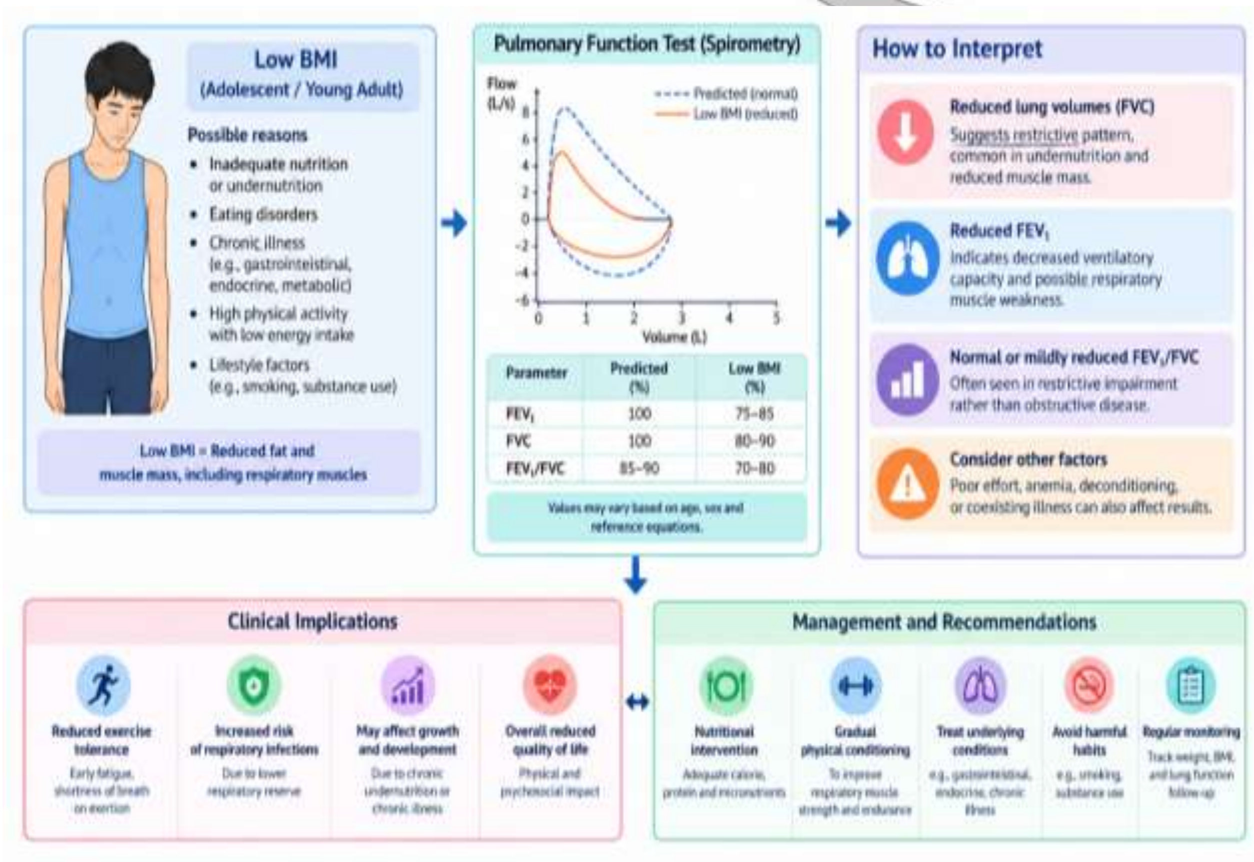

Figure 5. Practical interpretation of reduced pulmonary function in a low-BMI adolescent or young adult

Reverse Causality: Does Lung Disease Cause Low BMI?

The association between low BMI and reduced pulmonary function may operate in both directions. Chronic respiratory disease can cause weight loss through several mechanisms. Dyspnea may make eating difficult. Increased respiratory work increases energy expenditure. Chronic inflammation can promote catabolism. Physical inactivity can reduce skeletal muscle mass. This creates a potential vicious cycle:

Respiratory disease → reduced activity → muscle loss → lower BMI → respiratory muscle weakness → reduced exercise tolerance → further inactivity

Although this cycle is particularly well described in chronic respiratory diseases such as COPD, similar mechanisms may be relevant in adolescents with chronic lung disease, neuromuscular disorders, congenital conditions or recurrent respiratory infections. This is why cross-sectional studies cannot determine causality. Longitudinal research is required to establish whether low BMI precedes reductions in pulmonary function, whether pulmonary impairment precedes weight loss, or whether both develop from a common underlying factor.

Low BMI and Chronic Respiratory Disease in Young People

Although COPD is uncommon in the 12–30-year age group, other chronic respiratory conditions may be relevant. These include:

- Asthma,
- Bronchiectasis,
- Cystic fibrosis,
- Interstitial lung disease,
- Congenital pulmonary disorders,
- Neuromuscular disorders,
- Chronic respiratory infections,

- Post-infectious lung disease and
- Structural chest-wall abnormalities.

Cystic fibrosis provides an important example of the interaction between nutrition and lung function. Maintaining adequate nutritional status has long been recognized as an important component of clinical management because nutritional depletion can be associated with poorer pulmonary outcomes. Bronchiectasis can similarly involve recurrent infection, inflammation, increased metabolic demands and nutritional compromise. Thus, low BMI should sometimes be regarded as a potential clinical signal rather than simply an anthropometric measurement.

Table 3. Suggested clinical/research assessment of a low-BMI adolescent or young adult with reduced pulmonary function

Assessment domain	Recommended variables	Purpose
Anthropometry	BMI/BMI-for-age, height, weight trajectory	Determine nutritional status
Growth	Height velocity, pubertal development	Assess developmental status
Nutrition	Dietary intake, appetite, weight loss	Identify nutritional deficiency
Body composition	BIA, DXA, FFMI where available	Determine lean-mass status
Muscle strength	Handgrip, sit-to-stand	Identify peripheral weakness
Respiratory muscle	MIP/PImax, MEP/PEmax	Assess respiratory muscle strength
Spirometry	FEV1, FVC, FEV1/FVC, PEF	Characterize ventilatory function
Lung volumes	TLC, RV	Evaluate suspected restriction
Gas transfer	DLCO where clinically indicated	Evaluate gas-exchange abnormalities
Fitness	VO_2 peak, 6MWD, shuttle test	Assess functional capacity
Nutrition-related labs	Hemoglobin, iron indices, selected micronutrients	Identify contributors to fatigue
Respiratory history	Asthma, infection, chronic symptoms	Identify underlying disease
Exposure history	Smoking, vaping, biomass, pollution	Identify respiratory risk factors
Psychosocial assessment	Food insecurity, excessive exercise, eating concerns	Identify causes of low BMI

Nutritional Rehabilitation

If low BMI is accompanied by evidence of nutritional deficiency, intervention should focus on restoring adequate energy and protein availability rather than simply increasing body weight. For adolescents, nutritional intervention must support ongoing growth and development. The goal should therefore be individualized and age appropriate. For young adults, nutritional intervention may include adequate protein intake, sufficient total energy, correction of micronutrient deficiencies and progressive resistance exercise. Nutritional rehabilitation should be particularly cautious in individuals with suspected eating disorders. Rapid nutritional intervention without appropriate clinical supervision may not be appropriate in severe malnutrition.

Exercise and Pulmonary Rehabilitation

Exercise training may provide benefits beyond nutritional supplementation because muscle adaptation depends on both adequate substrate and mechanical stimulus. Resistance training can increase muscle strength and potentially improve fat-free mass. Aerobic exercise can improve cardiorespiratory fitness and functional capacity. Respiratory muscle training may be considered in selected individuals with demonstrable respiratory muscle weakness. However, exercise prescriptions for severely underweight adolescents should be individualized. The presence of dizziness, syncope, significant anemia, cardiac abnormalities, severe malnutrition or active systemic disease requires appropriate medical evaluation before vigorous training. For otherwise healthy underweight young adults, regular physical activity may help preserve muscle mass and respiratory reserve.

Clinical Implications for Physiotherapists

Physiotherapists frequently encounter adolescents and young adults with reduced exercise tolerance, fatigue or respiratory symptoms. BMI can provide a useful initial clue but should never be used as a standalone measure of pulmonary health. A physiotherapy assessment may include:

1. Height and weight,
2. BMI or BMI-for-age,
3. Posture and thoracic mobility,
4. Respiratory rate and breathing pattern,
5. Chest expansion,
6. Respiratory muscle strength,
7. Peripheral muscle strength,
8. Exercise tolerance,
9. Dyspnea assessment,
10. Physical activity level and
11. Spirometry when available and clinically appropriate.

For patients with low BMI and reduced functional capacity, the physiotherapist should consider whether muscle weakness, deconditioning, nutritional deficiency or respiratory disease is the predominant limitation. This multidimensional approach is more clinically informative than assuming that a low BMI automatically indicates poor pulmonary function.

Research Methodological Considerations

Future research investigating the association between low BMI and pulmonary function in adolescents and young adults should address several methodological problems.

1. Investigators should separate adolescents from adults rather than treating ages 12–30 years as a homogeneous population.
2. Adolescent nutritional status should be defined using BMI-for-age z-scores rather than adult BMI thresholds.
3. Studies should incorporate height, sex and pubertal development.
4. Body composition should be assessed whenever feasible.
5. Pulmonary-function testing should follow standardized ATS/ERS procedures.
6. Investigators should use contemporary reference equations and interpret values using z-scores and lower limits of normal rather than relying exclusively on 80% predicted.
7. Smoking, vaping, asthma, physical activity, environmental exposure and socioeconomic status should be incorporated into multivariable models.
8. Longitudinal studies are needed.
9. Studies should examine whether nutritional rehabilitation changes pulmonary-function trajectories.
10. Researchers should investigate whether low BMI affects the peak pulmonary function achieved in early adulthood, rather than simply examining cross-sectional spirometric differences.

Potential Long-Term Significance

Peak lung function achieved during early adulthood is an important determinant of later respiratory health. Individuals who attain a lower maximal lung-function level may have less respiratory reserve later in life. This concept raises an important possibility: if chronic undernutrition or insufficient muscle development during adolescence contributes to reduced pulmonary function, interventions during adolescence could theoretically influence respiratory health decades later. However, this hypothesis currently requires stronger longitudinal evidence. It would be premature to conclude that every thin adolescent is destined to have reduced lung function. Genetic factors, height, pubertal timing, environmental exposure, physical activity and socioeconomic circumstances all influence pulmonary development. The clinically relevant message is instead that persistent or clinically significant thinness accompanied by reduced growth, poor muscle development, respiratory symptoms or low exercise capacity deserves attention.

Current Evidence: What We Know and What Remains Uncertain

The evidence can be summarized into several broad conclusions.

1. Low BMI and pulmonary function can be associated in population studies.
2. The strongest direct evidence for reduced FEV1 and FVC among underweight individuals comes from large adult populations.
3. Adolescent studies demonstrate important relationships between body size, growth, BMI, physical fitness and pulmonary function, but specifically low-BMI adolescent populations remain understudied.
4. Body composition may be more biologically informative than BMI alone.
5. Respiratory muscle weakness represents a plausible pathway connecting nutritional depletion with pulmonary impairment.
6. The relationship is probably bidirectional.
7. Low BMI does not automatically indicate abnormal pulmonary function.
8. Appropriate age-specific nutritional and pulmonary reference standards are essential.

Future Research Priorities

Future investigations should ideally use prospective cohort designs beginning before adolescence and continuing through young adulthood. A useful study design could recruit adolescents aged 12–14 years and follow them through age 25–30 years. Participants could undergo annual assessment of:

- BMI-for-age,
- Height,
- Pubertal stage,
- Dietary intake,
- Body composition,
- Handgrip strength,
- Respiratory muscle strength,
- FEV1,
- FVC,
- FEV1/FVC,
- DLCO,
- Physical activity,
- Cardiorespiratory fitness,
- Smoking/vaping exposure and
- Socioeconomic variables.

Such a study could determine whether persistent thinness predicts reduced peak lung function. Randomized nutritional and exercise interventions could then determine whether improving lean mass during adolescence produces measurable changes in pulmonary function. Research should also examine sex-specific pathways because adolescent boys and girls experience different patterns of muscle development, puberty and body composition.

Conclusion

The question posed by the title “Too thin to breathe better?” does not have a simple yes-or-no answer. The available evidence suggests that low BMI can be associated with reduced pulmonary function, but the relationship is strongly influenced by age, growth, body composition, physical fitness, nutritional status, environmental exposure and underlying disease. Among adolescents aged 12–19 years, low BMI should be defined using BMI-for-age rather than the adult threshold of <18.5 kg/m². Thinness during adolescence may reflect inadequate nutritional intake, delayed growth, chronic disease, excessive exercise, socioeconomic disadvantage or constitutional body habitus. These conditions have very different implications for pulmonary function. Among young adults aged 20–30 years, BMI <18.5 kg/m² is a more appropriate definition of underweight. Population-level evidence indicates that underweight adults may have lower FEV1, FVC and peak expiratory flow. However, other studies in healthy young adults indicate that height and sex may explain substantially more variation in pulmonary volumes than BMI itself. The most plausible biological pathway involves reduced fat-free mass and respiratory muscle reserve. Nutritional deficiency can impair skeletal muscle development, while low physical activity can further reduce muscle strength. At the same time, chronic respiratory disease can cause weight loss, creating a bidirectional relationship. Consequently, BMI should be regarded as a screening marker rather than a direct measure of respiratory health. A low-BMI adolescent or young adult with reduced pulmonary function should receive a comprehensive assessment incorporating growth, nutritional status, body composition, muscle strength, physical fitness, respiratory symptoms, environmental exposure and standardized pulmonary-function testing. The most important research question for the future is not merely whether low BMI is associated with lower FEV1 or FVC. Rather, researchers should determine whether persistent nutritional deficiency and low lean mass during adolescence prevent young people from achieving their genetically and developmentally expected peak pulmonary function. Longitudinal cohort studies and carefully designed nutritional-exercise interventions will be required to answer that question. Until such evidence becomes available, the available literature supports a balanced interpretation: being thin does not inherently mean having poor lungs, but clinically significant or persistent undernutrition may coexist with reduced pulmonary and muscular reserve and should not be overlooked during adolescence and young adulthood.

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