



## Evaluating Nutritional Status and Growth Hormone Deficiency in Iranian Children with Cystic Fibrosis

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### Abstract

**Background:** The relationship between nutritional status and growth hormone deficiency (GHD) in children with cystic fibrosis (CF) is complex. CF leads to malnutrition due to malabsorption and respiratory complications, which complicates growth. This study aims to evaluate the nutritional status and prevalence of GHD in Iranian children diagnosed with CF.

**Materials and Methods:** This cross-sectional study was conducted at the Children's Medical Center in Tehran, Iran, involving children under 19 years with CF diagnoses based on two positive sweat tests showing chloride levels above 60 mmol/L. A total of 127 patients were included in the study during a one-year period. Data collection encompassed demographic and anthropometric measurements, clinical evaluations, and growth hormone stimulation tests to assess nutritional status, respiratory function, and bone mineral density.

**Results:** The study included 125 patients with CF and a mean age of 8.3 years. The findings revealed that 30.4% were below the 5th height percentile, while 45.6% were below the 10th percentile. Males had a mean body mass index (BMI) Z-score of -0.88, whereas females had a Z-score of -1.06; 76.4% of males and 81.1% of females were below the 50th percentile for BMI ( $P > 0.05$ ). Short stature was more prevalent in older age groups, particularly among those aged 10-19, where it affected 40.5% of individuals ( $P = 0.03$ ). Significant correlations were found between height percentiles and lung function ( $P = 0.014$ ), as well as between height percentiles and bone mineral density (BMD) ( $P < 0.05$ ). Among those below the 5th height percentile, 32.3% had low growth hormone levels indicative of GHD, particularly in males ( $P = 0.31$ ).

**Conclusion:** This study reveals a high prevalence of short stature and low BMI among patients with cystic fibrosis, particularly in older children. Significant correlations between growth, lung function, and bone mineral density underscore the need for monitoring and early interventions to improve health outcomes.

**Key Words:** Cystic fibrosis, Growth hormone, Children, Iran, Nutrition.

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## 1- INTRODUCTION

Cystic fibrosis (CF) is a prevalent genetic metabolic disorder that significantly impacts the health and longevity of affected individuals. Caused by mutations in the CFTR gene (cystic fibrosis transmembrane conductance regulator), CF disrupts the normal functioning of chloride channels, leading to the accumulation of thick, sticky mucus in various organs, particularly the lungs, pancreas, and intestines. This mucus obstruction results in severe respiratory complications and digestive issues, making progressive lung disease the leading cause of mortality among CF patients (1-5). CF is recognized as the most common hereditary respiratory disorder in Western societies and ranks as the second most common genetic disease in the United States, with profound implications for life expectancy (6-8).

Despite significant advancements in treatment options and care strategies, children with CF often exhibit growth rates that lag behind their peers, underscoring growth as a critical indicator of disease progression and overall prognosis. Those with heights below the 5th percentile face a threefold increased risk of mortality compared to their counterparts above this threshold (9, 10).

Recent research indicates that growth hormone deficiency (GHD) is prevalent among CF patients, affecting approximately 6.6% of this population—substantially higher than the prevalence of less than 1% in the general pediatric population (11). GHD can exacerbate growth failure, leading to poor health outcomes and increased morbidity (12, 13). This highlights the necessity for routine screening for GHD in CF patients, particularly those showing signs of growth impairment. Furthermore, malnutrition is a widespread concern among children with CF, with nutritional status serving as a

vital prognostic factor independent of pulmonary function (14-17).

In a recent study involving 150 children with CF, 24 were identified as experiencing growth failure, with 10 diagnosed with GHD through standardized stimulation tests (11). This underscores the critical need for routine screening for GHD in CF patients, particularly those showing signs of growth impairment. Additionally, the multifactorial nature of growth issues in CF—often compounded by malnutrition, chronic inflammation, and pulmonary complications—demands a comprehensive management approach that integrates nutritional support and hormonal therapies (9, 10). Failure to adequately address these challenges can result in long-term detrimental effects on health, quality of life, and overall prognosis for children with CF (11, 18).

Given these factors, this study aimed to investigate the nutritional status and prevalence of growth hormone deficiency (GHD) in Iranian children and adolescents diagnosed with cystic fibrosis (CF). Understanding the interplay between nutritional deficiencies and hormonal imbalances will provide valuable insights for optimizing management strategies to improve growth outcomes and overall health in this vulnerable population.

## 2- MATERIALS AND METHODS

### 2-1. Study Design and Setting

This cross-sectional study was conducted at the Children's Medical Center affiliated with Tehran University of Medical Sciences in Tehran, Iran. The study population included children and adolescents with CF who were referred to the hospital and had a confirmed diagnosis based on at least two positive sweat tests showing chloride levels exceeding 60 mmol/L.

### 2-2. Inclusion and Exclusion Criteria

According to the World Health Organization (WHO), a "child" is defined as any person under the age of 18 years, with adolescents specifically categorized as those aged 10 to 19 years (19). All patients up to the age of 19 years diagnosed with CF and referred to the Children's Medical Center between June 2014 and June 2015 were included in the study, provided they had at least two positive sweat tests indicating chloride levels exceeding 60 mmol/L. Informed consent was obtained from all participants. The exclusion criteria encompassed children under the age of 2, as well as those with concurrent chronic diseases unrelated to CF, such as hypothyroidism, renal failure, or congenital heart disease.

### 2-3. Sample Size

To calculate the sample size, the following formula was used:

$$n = \frac{Z_{1-\alpha/2}^2 \cdot p(1-p)}{d^2}$$

- n: Sample size
- $Z_{1-\alpha/2}$ : Z-score corresponding to the desired confidence level
- p: Estimated prevalence of the disorders
- d: Margin of error

Based on a review of relevant literature and the prevalence of the identified disorders, a minimum sample size of 75 was determined, accounting for a potential loss of 5%. The study included all patients up to the age of 19 years who were diagnosed with CF and referred to the Children's Medical Center between June 2014 and June 2015. Eligible participants had to have at least two positive sweat tests indicating sweat chloride levels exceeding 60 mmol/L.

### 2-4. Measurement Tools

#### 2-4-1. Demographic and Anthropometric Data

The initial phase of data collection focused on key epidemiological factors, including age and gender, alongside anthropometric measurements such as weight (kg), and height (cm). These parameters were used to calculate body mass index (BMI, kg/m<sup>2</sup>) and were systematically recorded using a SECA model 220 scale. Additional pertinent information included:

- Parental height
- Number of hospitalizations in the past year
- History of bone fractures
- Dosage of vitamin D3 and calcium supplements
- Medications administered, including Creon and systemic steroids.

#### 2-4-2. Clinical Evaluations in Cystic Fibrosis Patients

##### 1. General Health Assessments

Clinical examinations involve comprehensive evaluations focusing on respiratory function, nutritional status, and growth metrics. Regular assessments are crucial for optimizing care and managing complications associated with CF.

##### 2. Nutritional and Growth Evaluations

- **Standard Deviation Scores (SDS):** Height, weight, and BMI calculations are performed using criteria from the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) (20). This standardized approach is vital for assessing growth and nutritional status.
- **Growth Hormone Stimulation Test:** The GH stimulation test was conducted on all patients whose height was below the 5th percentile, utilizing the clonidine test while the patients fasted. Each patient received 0.15 mg/m<sup>2</sup> of clonidine orally, and 5 mL blood

samples were taken at 0, 30, 60, and 90 minutes post-administration. A growth hormone level below 10 ng/mL indicates growth hormone deficiency (GHD) (21).

- **Insulin-like Growth Factor 1 (IGF-1) Measurement:** Serum IGF-1 levels were measured to screen children with growth failure for GHD. The ELISA method was used for quantification, employing a sandwich format with specific antibodies to capture and detect IGF-1 in serum samples. The IGF-1 Standard Deviation Score (SDS) was calculated using reference data from Diagnostic System Laboratories Inc., Webster, TX, adjusted for age and sex. Children were classified as IGF-1 deficient if their IGF-1 levels were below or equal to -2 SDS without concurrent growth hormone deficiency (22).

### 3. Respiratory Function Assessments

- **Respiratory Function Assessment:** Mean forced expiratory volume in one second (FEV1) is a critical measure for evaluating lung function in CF patients aged 6 years and older (23). This data is obtained from respiratory tests conducted over the previous year, providing essential insights into lung health and disease progression.

### 4. Bone Health Evaluations

- **Bone Mineral Density (BMD):** In this study, we evaluated bone mineral density (BMD), a measure of the mineral content in bone, primarily calcium and phosphorus, which serves as a key indicator of bone strength and fracture risk. For patients aged 6 years and older, BMD assessments were performed using dual-energy X-ray absorptiometry (DEXA) scans with Hologic devices. The results were recorded as Z-scores, which compare an individual's BMD to age-appropriate

norms, focusing on key sites such as the lumbar spine and femur. A Z-score below -2.0 indicates lower than expected bone density for the individual's age and sex (24).

### 2-5. Ethical Considerations

The study on children and adolescents with cystic fibrosis (CF) was approved by the Research Ethics Committee of Tehran University of Medical Sciences (approved code: T-1392-06), adhering to the Helsinki Declaration (25) and pediatric research guidelines. This adherence aligns with the Belmont Report principles (26): Respect for Persons was upheld through voluntary participation based on informed consent from parents or guardians, alongside age-appropriate assent from children, ensuring that vulnerable populations like minors received extra protection. Beneficence was ensured by maximizing benefits while minimizing risks; participants received comprehensive assessments without undue harm, and all tests were provided free of charge. The principle of Justice ensured fair participant selection based on inclusion criteria rather than vulnerability or ease of access, distributing risks equitably among those involved. To further enhance ethical considerations, strict confidentiality was maintained during data collection, and parents were fully informed about the study's objectives, potential risks, and post-study care. The results were presented in a way that protected participant identities by extracting data in general terms.

### 2-6. Data Analysis

Data analysis was conducted using SPSS Version 18 software. For qualitative variables, prevalence and frequency estimates were calculated, while quantitative variables were summarized using means and standard deviations. A 95% confidence interval was applied to all estimates. Differences in frequencies across groups were assessed using the Chi-

square test, and mean differences among two or more groups were evaluated using the independent t-test. A p-value of less than 0.05 was considered statistically significant

### 3- RESULTS

#### 3-1. Patient Demographics

In this study, 127 patients were initially considered; however, two were excluded due to hypothyroidism and

congenital heart disease, resulting in a final analysis of 125 patients with cystic fibrosis (CF). The results indicated a slight male majority among the participants. The mean age of the participants was 8.3 years, with no statistically significant difference between the ages of males and females ( $P=0.151$ ).

**Table 1** summarizes the demographic characteristics of the study population.

**Table 1:** Demographic Characteristics of Patients with Cystic Fibrosis.

Demographic Variable	Total	Male, Number (%)	Female, Number (%)	P-value*
Number of Patients	125	72 (57.6%)	53 (42.4%)	-
Mean Age (year)	8.3 (2-19.4)	8.9 (2-19.3)	7.66 (2-19.4)	0.151

\* Independent samples t-test.

#### 3-2. Growth Metrics

**Table 2** summarizes the BMI, height, and weight Z-scores for male and female patients, reflecting their nutritional status. Males have a mean BMI Z-score of -0.88, while females have a lower mean of -1.06; however, the differences were not statistically significant ( $p > 0.05$ ), indicating potential nutritional deficiencies

in both groups. The overall mean BMI Z-score for all patients was -0.96, highlighting widespread concerns about below-average nutritional health. The p-values for BMI (0.47), height (0.59), and weight (0.70) indicate no statistically significant differences between genders in these measurements (**Table 2**).

**Table 2:** Growth Metrics and Z-Scores in Patients with Cystic Fibrosis.

Group	BMI Z Score, Mean $\pm$ SD	Height Z Score, Mean $\pm$ SD	Weight Z Score, Mean $\pm$ SD	Total
Male	-0.88 $\pm$ 1.47 (-7.4 - 1.47)	-1.17 $\pm$ 1.20 (-4.8 - 1.4)	-1.39 $\pm$ 1.60 (-9.4 - 1.13)	72
Female	-1.06 $\pm$ 1.41 (-5.0 - 1.23)	-1.06 $\pm$ 1.23 (-4.7 - 1.0)	-1.49 $\pm$ 1.46 (-5.9 - 1.21)	53
Total	-0.96 $\pm$ 1.44 (-7.4 - 1.47)	-1.12 $\pm$ 1.21 (-4.8 - 1.4)	-1.43 $\pm$ 1.55 (-9.4 - 1.21)	125
P-value*	0.47	0.59	0.70	

\* Independent samples t-test. BMI: Body Mass Index, SD: Standard Deviation.

**Table 3** displays the prevalence of patients below specific BMI and height percentiles across male and female groups. It indicates that 76.4% of males and 81.1% of females fall below the 50th percentile for BMI, while 25% of males and 34% of females are below the 10th percentile for BMI, suggesting a significant risk of underweight. Regarding height, 45.6% of cases (47.2% of males and 43.4% of

females) are below the 10th percentile, while 30.4% of cases (29.2% of males and 32.1% of females) fall below the 5th percentile. The p-values, which range from 0.27 to 0.73, indicate no statistically significant differences between genders for any of the metrics assessed. This suggests a common concern regarding nutritional status and growth among these patients.

**Table 3:** Comparison of BMI and Height Percentiles in Male and Female Cystic Fibrosis Patients.

Group	BMI <50%, Number (%)	BMI <10%, Number (%)	Height <10%, Number (%)	Height <5%, Number (%)	Total
Male	55 (76.4%)	18 (25%)	34 (47.2%)	21 (29.2%)	72
Female	43 (81.1%)	18 (34%)	23 (43.4%)	17 (32.1%)	53
Total	98 (78.4%)	36 (28.8%)	57 (45.6%)	38 (30.4%)	125
P-value*	0.52	0.27	0.67	0.73	

\*Chi-square test. BMI: Body Mass Index.

The analysis of BMI and height percentiles in CF patients reveals significant trends across age groups (**Table 4**). The prevalence of patients with a BMI below the 50th percentile increases with age, rising from 64.9% in those under 5 years to 90.5% in the 10-19 year age group. The highest prevalence of BMI below the 10th percentile is also observed in the 10-19 year age group, at 35.7%.

Height data shows a similar pattern, with the percentage of patients below the 10th percentile increasing from 35.1% to 61.9%, and those below the 5th percentile rising from 18.9% to 40.5%. Significant

differences were found between age groups for BMI <50% ( $P = 0.022$ ) and height <10% ( $P = 0.03$ ), while no significant differences were observed for BMI <10% ( $P = 0.47$ ) or height <5% ( $P = 0.12$ ).

Overall, 30.4% of patients had a height below the 5th percentile ( $P = 0.73$ ), and 45.6% were below the 10th percentile for height ( $P = 0.67$ ). These findings highlight the nutritional challenges and growth failure faced by children with cystic fibrosis, underscoring the need for targeted interventions.

**Table 4:** Comparison of BMI and Height Percentiles by Age Group in Cystic Fibrosis Patients.

Age Group (year)	BMI <50%, Number (%)	BMI <10%, Number (%)	Height <10%, Number (%)	Height <5%, Number (%)	Total
< 5	24 (64.9%)	9 (24.3%)	13 (35.1%)	7 (18.9%)	37
5 - 9	36 (78.3%)	12 (26.1%)	18 (39.1%)	14 (30.4%)	46
10 - 19	38 (90.5%)	15 (35.7%)	26 (61.9%)	17 (40.5%)	42
Total	98 (78.4%)	36 (28.8%)	57 (45.6%)	38 (30.4%)	125
P-value*	0.022	0.47	0.03	0.12	

\*Chi-square test. BMI: Body Mass Index.

### 3-3. Growth Hormone Levels

The results indicate that a clonidine stimulation test was conducted to evaluate serum growth hormone levels in 34 of the 38 patients with CF whose height percentile was less than 5%. Among those tested, 11 patients (32.3%) had growth hormone levels below 10 ng/mL, indicating potential growth hormone

deficiency. Of these patients, 8 were male (38%) and 3 were female (23%), with no statistically significant difference between genders ( $P = 0.31$ ). Additionally, 12 patients (35.3%) had serum GH levels of  $\geq 10$  ng/mL and IGF-1 levels less than -2 SD, indicating growth hormone insensitivity (**Table 5**).

**Table 5:** Prevalence of Growth Hormone Levels in Patients with Short Stature.

Cases	Number (%)	GH<10 ng/ml Number (%)	GH ≥10 ng/ml	
			IGF-1 > -2SD	IGF-1 <-2SD
Male	21	8 (38.1%)	5 (23.8%)	8 (38.1%)
Female	13	3 (23.1%)	6 (46.1%)	4 (30.8%)
Total	34	11 (32.3%)	11 (32.3%)	12 (35.3%)
P-value*		0.31		

\*Chi-square test. GH: Growth Hormone, IGF-1: Insulin-like Growth Factor-1, SD: Standard deviation.

### 3-4. Relationship between Height and Lung Function

**Table 6** shows the distribution of patients across height percentiles and their corresponding FEV1 groups. In the >90% FEV1 group, 5 patients (27.8%) have a height percentile < 5%, while 13 patients (72.2%) have a height percentile ≥ 5%. In the 40-69% FEV1 group, 16 patients

(53.3%) fall below the 5th height percentile.

With a total of 74 patients assessed, the p-value of 0.014 indicates a statistically significant relationship between height percentiles and lung function (**Table 6**). This suggests that individuals with greater height tend to have better lung function compared to those who are shorter.

**Table 6:** Relationship between Height Percentiles and FEV1 Groups in Patients with Cystic Fibrosis.

FEV1 Group	Height Percentile	Number	% within Height Percentile	% within FEV1 Group
> 90%	< 5%	5	19.2%	27.8%
	≥ 5%	13	27.1%	72.2%
70-89%	< 5%	4	15.4%	16.0%
	≥ 5%	21	43.8%	84.0%
40-69%	< 5%	16	61.5%	53.3%
	≥ 5%	14	29.2%	46.7%
< 40%	< 5%	1	3.8%	100.0%
	≥ 5%	0	.0%	.0%
Total		74		
P-value*				0.014

\*Chi-square test. FEV1: Forced Expiratory Volume in 1 second.

### 3-5. Relationship between BMD and Lung Function

**Table 7** shows the relationship between FEV1 groups and BMD in the spine and femur. In the >90% FEV1 group, 1 patient (5.9%) has a spine BMD < -2, while 16 patients (94.1%) have a BMD ≥ -2. For the

femur, 2 patients (11.8%) fall below -2, and 15 patients (88.2%) are at or above -2.

Overall, there are 22 patients with spine BMD < -2 and 20 with femur BMD < -2. The p-values of 0.000 for spine BMD and 0.004 for femur BMD indicate a significant relationship between lung function and bone density (**Table 7**).

**Table 7:** Relationship between BMD and FEV1 Groups in Patients with Cystic Fibrosis.

FEV1 Group	Spine BMD	Total	% within Spine BMD	Femur BMD	Total	% within Femur BMD
> 90%	<-2	1	5.9%	<-2	2	11.8%
	≥-2	16	94.1%	≥-2	15	88.2%
70-89%	<-2	2	8.0%	<-2	3	12.0%
	≥-2	23	92.0%	≥-2	22	88.0%
40-69%	<-2	18	60.0%	<-2	14	46.7%
	≥-2	12	40.0%	≥-2	16	53.3%
< 40%	<-2	1	100.0%	<-2	1	100.0%
	≥-2	0	.0%	≥-2	0	.0%
Total		22			20	
P-value*	0.000			0.004		

\*Chi-square test. FEV1: Forced Expiratory Volume in 1 second, BMD: Bone Mineral Density.

### 3-6. Relationship between BMI and Lung Function

**Table 8** shows the relationship between FEV1 groups and BMI percentiles. In the >90% FEV1 group, 1 patient (5.6%) has a BMI percentile below 10, while 17 patients (94.4%) have a BMI percentile of 10 or higher. In the 70-89% FEV1 group, 5 patients (20.0%) fall below the 10th percentile, whereas 20 patients (80.0%) are

at or above this threshold. In the 40-69% FEV1 group, 17 patients (56.7%) have a BMI percentile below 10.

In total, there are 24 patients with a BMI percentile below 10 and 50 patients with a BMI percentile of 10 or higher, resulting in a total of 74 patients. The p-value of <0.001 indicates a significant relationship between FEV1 groups and BMI percentiles (**Table 8**).

**Table 8:** Relationship between BMI and FEV1 Groups in Patients with Cystic Fibrosis.

FEV1 Group	BMI Percentile < 10	BMI Percentile ≥ 10	Total	% within FEV1 Group
> 90%	1	17	18	5.6% (<10) 94.4% (≥10)
70-89%	5	20	25	20.0% (<10) 80.0% (≥10)
40-69%	17	13	30	56.7% (<10) 43.3% (≥10)
< 40%	1	0	1	100.0% (<10) .0% (≥10)
Total	24	50	74	32.4% (<10) 67.6% (≥10)
P-value*				<0.001

\*Chi-square test. FEV1: Forced Expiratory Volume in 1 second, BMI: Body Mass Index.

### 3-7. Relationship between BMI and BMD

**Table 9** shows the relationship between BMI percentiles and spine bone mineral density (BMD). Among individuals with a BMI percentile < 10%, 12 patients (54.5% of those within the spine BMD group) have a spine BMD < -2, while another 12

patients (23.5% of those within the spine BMD group) have a BMD ≥ -2, totaling 24 patients. In the >10% BMI group, 10 patients (45.5% of those within the spine BMD group) have a spine BMD < -2, and 39 patients (76.5% of those within the spine BMD group) have a BMD ≥ -2, totaling 49 patients.

Overall, there are 22 patients with spine BMD  $< -2$  and 51 patients with spine BMD  $\geq -2$  across all groups, comprising a total of 73 patients. The p-value of 0.014

indicates a significant relationship between BMI percentiles and spine BMD (Table 9).

**Table 9:** Relationship between BMI and BMD in Patients with Cystic Fibrosis.

BMI Percentile	Spine BMD $< -2$	Spine BMD $\geq -2$	Total	% within Spine BMD
$< 10\%$	12	12	24	54.5% ( $< -2$ ) 23.5% ( $\geq -2$ )
$> 10\%$	10	39	49	45.5% ( $< -2$ ) 76.5% ( $\geq -2$ )
Total	22	51	73	100.0%
P-value*			0.014	

\*Chi-square test. BMD: Bone Mineral Density.

#### 4- DISCUSSION

This study investigated the nutritional status and prevalence of growth hormone deficiency (GHD) in Iranian children and adolescents diagnosed with cystic fibrosis (CF). The results indicated that 30.4% of the participants were below the 5th height percentile, while 45.6% fell below the 10th percentile. Short stature was more prevalent among older age groups, with 40.5% of those aged 10-19 affected ( $P=0.03$ ). Significant correlations were found between height percentiles and lung function ( $P = 0.014$ ) as well as bone mineral density (BMD) ( $P < 0.05$ ). Among those below the 5th height percentile, 32.3% exhibited low growth hormone levels, indicating GHD, particularly in males ( $P = 0.31$ ).

##### 4-1. Prevalence of Malnutrition

The present study found 30.4% of participants below the 5th height percentile and 45.6% below the 10th percentile. These findings align with Iranian research reporting malnutrition prevalence of 21-42% among CF patients (27). International studies from high-resource settings demonstrate significantly better nutritional outcomes, highlighting disparities in healthcare access (28).

##### 4-2. Gender Differences in Nutritional Status

Males exhibited a BMI Z-score of -0.88 compared to -1.06 in females ( $P > 0.05$ ), indicating no statistically significant gender difference. This finding aligns with systematic reviews demonstrating comparable malnutrition patterns across genders in cystic fibrosis, although adolescent females frequently show marginally lower Z-scores attributable to elevated energy requirements during puberty and growth spurts (29).

##### 4-3. Growth Hormone Deficiency (GHD)

GHD was detected in 32.3% of CF patients below the 5th height percentile—substantially exceeding general population prevalence ( $<1\%$ ). This prevalence aligns closely with endocrine research documenting growth impairment in 22-35% of short-stature CF patients, highlighting its clinical significance in this high-risk subgroup (11, 30).

##### 4-4. Age-Related Trends

The present study observed an increase in BMI  $<50$ th percentile prevalence with age, reaching 90.5% among adolescents (10-19 years). This trend is corroborated by multicenter research showing older CF children face greater malnutrition risk due to progressive pancreatic insufficiency, chronic inflammation, and escalating energy demands (31, 32).

#### **4-5. Correlations with Lung Function**

The significant correlation between height percentiles and lung function ( $P = 0.014$ ) observed in this study aligns with previous research demonstrating that better growth is associated with improved lung function in CF patients (33). Studies have consistently shown that adequate nutrition is crucial for maintaining lung function and overall survival rates in this population (34, 35).

#### **4-6. Bone Mineral Density (BMD)**

The relationship between lung function and BMD found in this study echoes findings from other research indicating that poor nutrition adversely affects both lung health and bone density in CF patients (36). For example, recent studies document reduced BMD in children with CF due to nutritional deficiencies, vitamin D insufficiency, and chronic inflammation (37, 38).

In summary, this study reinforces earlier evidence of persistent nutritional and growth challenges in children with cystic fibrosis, highlighting the need for integrated nutritional and endocrine interventions to improve growth and overall health outcomes.

#### **4-7. Study Limitations**

This cross-sectional study has several limitations that may affect the interpretation of its findings. First, the design prevents establishing causality between cystic fibrosis characteristics and outcomes, as data were collected at a single point in time. The sample size of 125 patients may not adequately represent the broader CF population, limiting generalizability. Additionally, excluding children under 2 years old and those with concurrent chronic diseases could introduce bias.

Reliance on self-reported data may also lead to inaccuracies due to recall bias, and variations in measurement techniques

could create inconsistencies. Furthermore, potential confounding factors such as dietary habits and physical activity levels may not have been fully controlled. These limitations underscore the need for further research using longitudinal designs and larger, more diverse samples to validate these findings and enhance our understanding of CF outcomes.

### **5- CONCLUSION**

This study highlights a concerning prevalence of short stature and low BMI among children and adolescents with cystic fibrosis (CF), particularly in older age groups, where the rates of underweight and growth deficiencies significantly increase. Notably, 30.4% of participants were below the 5th height percentile, with a marked rise in short stature observed among adolescents. The findings also demonstrate significant associations between growth parameters, lung function, and bone mineral density, indicating that impaired growth may adversely influence overall health outcomes.

The detection of low growth hormone levels in 32.3% of patients below the 5th height percentile, especially among males, underscores the need for careful monitoring and management of nutritional status and growth in this population. These results reinforce the importance of early, targeted interventions to optimize growth and pulmonary health, thereby improving quality of life and long-term outcomes for individuals with CF. Through proactive multidisciplinary care, healthcare providers can better support the developmental and physiological needs of children with CF.

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**7- CONFLICT OF INTEREST:** None.

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