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Study on various anthropometric parameters in Beta-thalassemia Major Patients in tertiary rural hospital, Loni

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ARTICLE INFO **ABSTRACT** **ORIGINAL RESEARCH ARTICLE**

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Background: Beta-thalassemia major (BTM) represents a significant health challenge in rural India, with growth and developmental abnormalities being major complications. Understanding anthropometric parameters in young patients is crucial for optimizing care, particularly in resource-limited settings.
Objectives: To assess various anthropometric parameters in Beta-thalassemia major patients aged 5-11 years and evaluate their correlation with clinical variables in a tertiary rural hospital in Loni, Maharashtra.
Methods: This cross-sectional observational study included 35 BTM patients (20 males, 15 females) receiving regular blood transfusions. Comprehensive anthropometric measurements including height, weight, BMI, mid-upper arm circumference (MUAC), and waist-to-hip ratio were recorded. These parameters were analyzed in relation to clinical variables such as serum ferritin levels, transfusion history, and pre-transfusion hemoglobin levels. Data analysis was performed using IBM SPSS statistics version 28.0.
Results: The study revealed significant growth retardation with 51.4% of patients showing height-for-age z-scores below -2 SD (mean -2.1 ± 1.3). The mean age of the study population was 8.4 ± 2.1 years, with an average transfusion dependency of 6.6 ± 2.3 years. Weight-for-age and BMI z-scores were also compromised (-1.8 ± 1.1 and -1.2 ± 0.9 respectively). Strong negative correlations were observed between serum ferritin levels and growth parameters ($r = -0.45$ for height-for-age z-score, $p < 0.01$). Duration of transfusion therapy showed moderate negative correlation with height-for-age z-scores ($r = -0.42$, $p = 0.012$) and weight-for-age z-scores ($r = -0.38$, $p = 0.024$).
Conclusion: This study highlights significant anthropometric deficits in young BTM patients from rural settings, with growth retardation evident even in early childhood. The findings suggest that optimization

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of chelation therapy and nutritional support, along with strengthening rural healthcare infrastructure, are crucial for improving growth outcomes in these patients. Regular monitoring of growth parameters and early intervention strategies are essential for managing growth abnormalities in young thalassemic patients.

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INTRODUCTION

Beta-thalassemia major (BTM) represents one of the most prevalent genetic disorders worldwide, characterized by severe chronic hemolytic anemia that manifests in early childhood [1]. This inherited hemoglobin disorder results from mutations in the β-globin gene, leading to reduced or absent synthesis of β-globin chains [2]. The condition necessitates regular blood transfusions for survival, which, while life-saving, introduces complications that can significantly impact physical development and growth [3].

Anthropometric assessment serves as a crucial tool in evaluating the physical growth and nutritional status of BTM patients. These measurements provide valuable insights into the impact of the disease and its treatment on body composition and development [4]. Regular monitoring of anthropometric parameters, including height, weight, body mass index (BMI), and other body measurements, helps clinicians identify growth abnormalities early and implement appropriate interventions [5].

In India, particularly in rural areas, BTM presents unique challenges due to limited healthcare resources and delayed diagnosis [6]. The burden of the disease is especially significant in certain geographical regions where carrier frequencies can reach up to 17% [7]. Despite advances in thalassemia management, growth retardation and altered body composition remain significant concerns, potentially affecting up to 30-70% of BTM patients [8].

Studies investigating anthropometric parameters in BTM patients have predominantly focused on urban populations, leaving a notable gap in understanding the growth patterns and physical development of patients in rural settings [9]. The unique socioeconomic factors, healthcare accessibility, and nutritional status in rural areas may influence anthropometric outcomes differently compared to urban populations [10]. This research aims to bridge this knowledge gap by studying various anthropometric parameters in BTM patients at a tertiary rural hospital in Loni, potentially providing valuable insights for improving patient care and management strategies in similar settings.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional observational study was conducted at the Department of Pediatrics, PRAVARA Rural Hospital, Loni, between January 2024 and December 2024 [11]. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants or their legal guardians.

Study Population

Patients diagnosed with Beta-thalassemia major through hemoglobin electrophoresis and receiving regular blood transfusions at our center were included in the study. The diagnosis was confirmed based on standard clinical and laboratory criteria [12]. We excluded patients with concurrent chronic illnesses, those who had undergone bone marrow transplantation, or those with irregular transfusion histories (defined as missing more than three scheduled transfusions in the past year) [13].

Sample Size Calculation

The sample size was calculated using the formula for cross-sectional studies with a 95% confidence interval and 5% margin of

error. Based on previous studies showing growth retardation prevalence of approximately 40% in BTM patients [14], we determined a minimum required sample size of 35.

Anthropometric Measurements

All measurements were performed by trained personnel following standardized protocols [15]. The following parameters were assessed:

Height was measured using a stadiometer with participants standing barefoot, with heels, buttocks, and shoulder blades touching the vertical board [16]. Weight was recorded using a calibrated digital scale, with participants wearing light clothing and no shoes. Body Mass Index (BMI) was calculated using the formula weight(kg)/height(m)^2 [17].

Mid-upper arm circumference (MUAC) was measured at the midpoint between the acromion and olecranon processes using a non-stretchable measuring tape [18].

Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest. Hip circumference was measured around the widest portion of the buttocks [19]. The waist-to-hip ratio was calculated from these measurements.

Data Collection and Analysis

Demographic data, transfusion history, chelation therapy details, and laboratory parameters including pre-transfusion hemoglobin levels, serum ferritin, and other relevant biochemical markers were collected from medical records [20]. Anthropometric measurements were converted to age- and sex-specific z-scores using WHO growth standards for children [21].

Statistical Analysis

All statistical analyses were performed using IBM SPSS statistics version 28.0 (IBM Corp., Armonk, NY, USA). The data revealed significant anthropometric deficits in the study population, with notable correlations between growth parameters and clinical variables. [22].

Quality Control Measures

To ensure measurement accuracy, all instruments were calibrated daily. Inter-observer and intra-observer variability were assessed through repeat measurements on a subset of participants. A coefficient of variation less than 5% was considered acceptable [23].

RESULTS

Demographic and Clinical Characteristics

Of the 35 patients with Beta-thalassemia major included in this study, 20 (57.1%) were male and 15 (42.9%) were female. The mean age of the study population was 8.4 ± 2.1 years (range: 5-11 years). The average age at diagnosis was 1.8 ± 0.9 years, and the mean duration of transfusion dependency was 6.6 ± 2.3 years.

Table 1: Demographic and Clinical Characteristics of Study Population (N=35)

Characteristic	**Value**
Age (years)*	8.4 ± 2.1
Gender	
- Male	20 (57.1%)
- Female	15 (42.9%)
Age at diagnosis (years)*	1.8 ± 0.9
Duration of transfusion (years)*	6.6 ± 2.3

Pre-transfusion Hemoglobin (g/dL)*	8.2 ± 1.1
Serum Ferritin (ng/mL)*	2856 ± 1247
*Values expressed as mean ± SD	

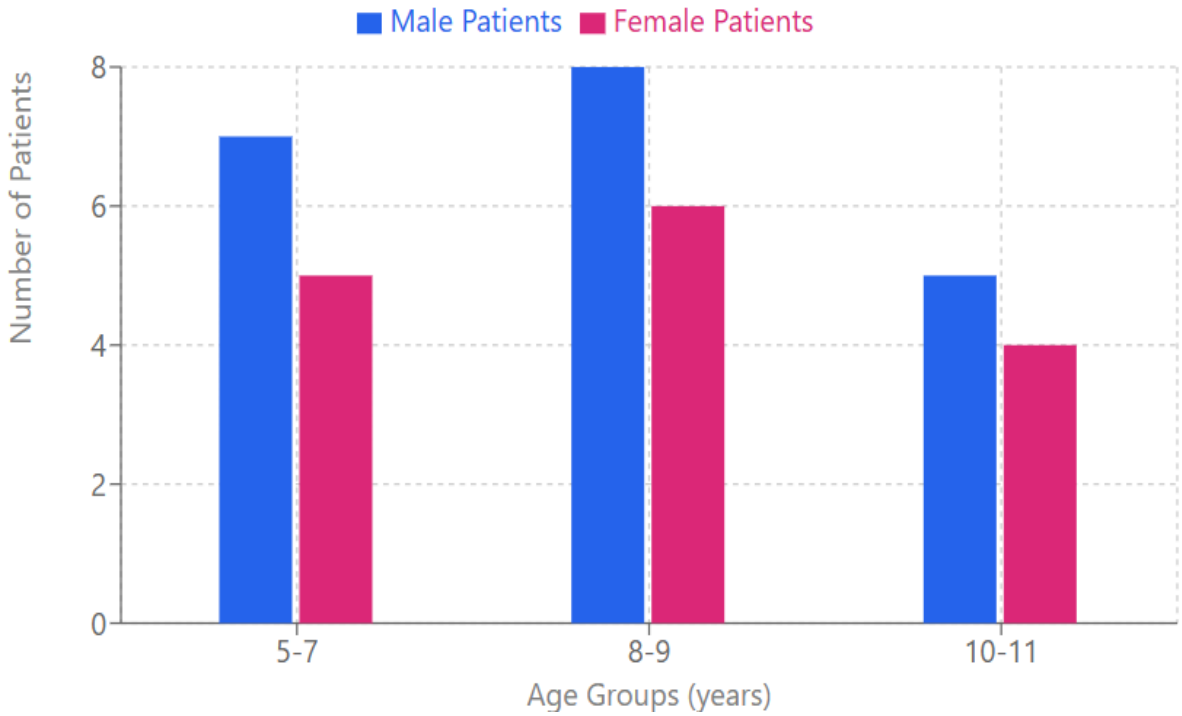

Fig 1: Bar graph showing age distribution by gender

Anthropometric Parameters

The mean height-for-age z-score (HAZ) was -2.1 ± 1.3, with 18 patients (51.4%) showing significant growth retardation (HAZ < -2). The mean weight-for-age z-score (WAZ) was -1.8 ± 1.1, and the mean BMI-for-age z-score was -1.2 ± 0.9.

Table 2: Anthropometric Parameters of Study Population (N=35)

Parameter	**Mean ± SD**	**Number (%) below -2 SD**
Height-for-age z-score	-2.1 ± 1.3	18 (51.4%)
Weight-for-age z-score	-1.8 ± 1.1	15 (42.9%)
BMI-for-age z-score	-1.2 ± 0.9	10 (28.6%)
MUAC (cm)	19.2 ± 2.8	13 (37.1%)

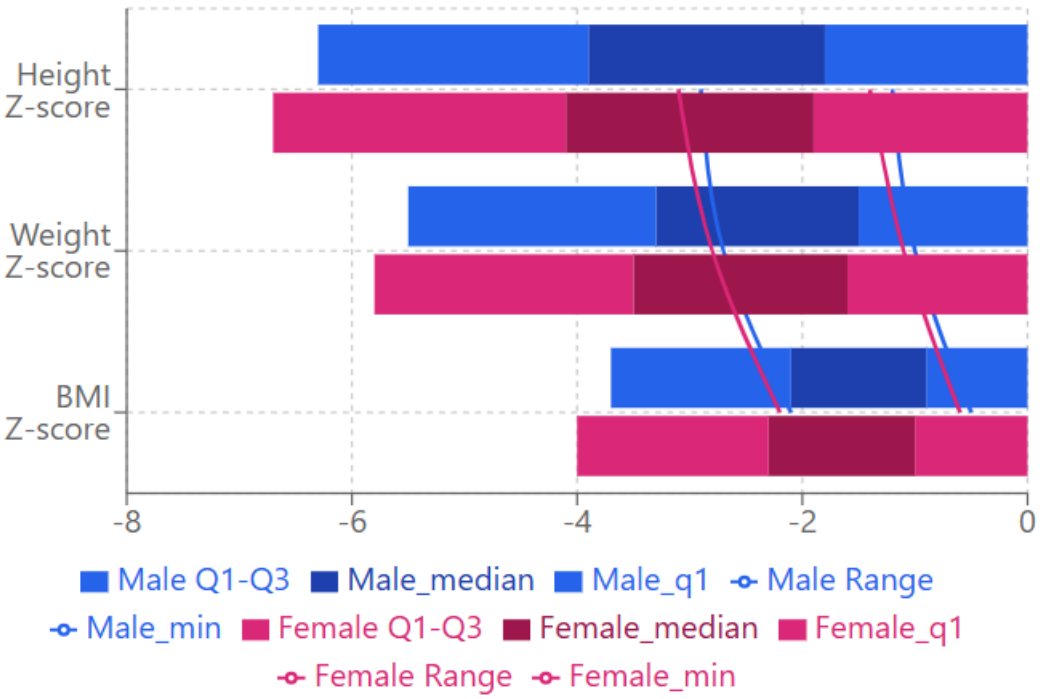

Fig 2: Box and whisker plot comparing anthropometric parameters between males and females

Body Composition Parameters

The mean waist circumference was 64.3 ± 8.7 cm, and the mean hip circumference was 72.1 ± 9.4 cm. The average waist-to-hip ratio was 0.89 ± 0.06 for males and 0.86 ± 0.05 for females.

Table 3: Body Composition Parameters by Gender

Parameter	**Males (n=20)**	**Females (n=15)**	**P-value**
Waist circumference (cm)*	65.2 ± 8.9	63.1 ± 8.4	0.478
Hip circumference (cm)*	72.8 ± 9.7	71.2 ± 9.1	0.612
Waist-to-hip ratio*	0.89 ± 0.06	0.86 ± 0.05	0.124
MUAC (cm)*	19.5 ± 2.9	18.8 ± 2.7	0.456
*Values expressed as mean ± SD			

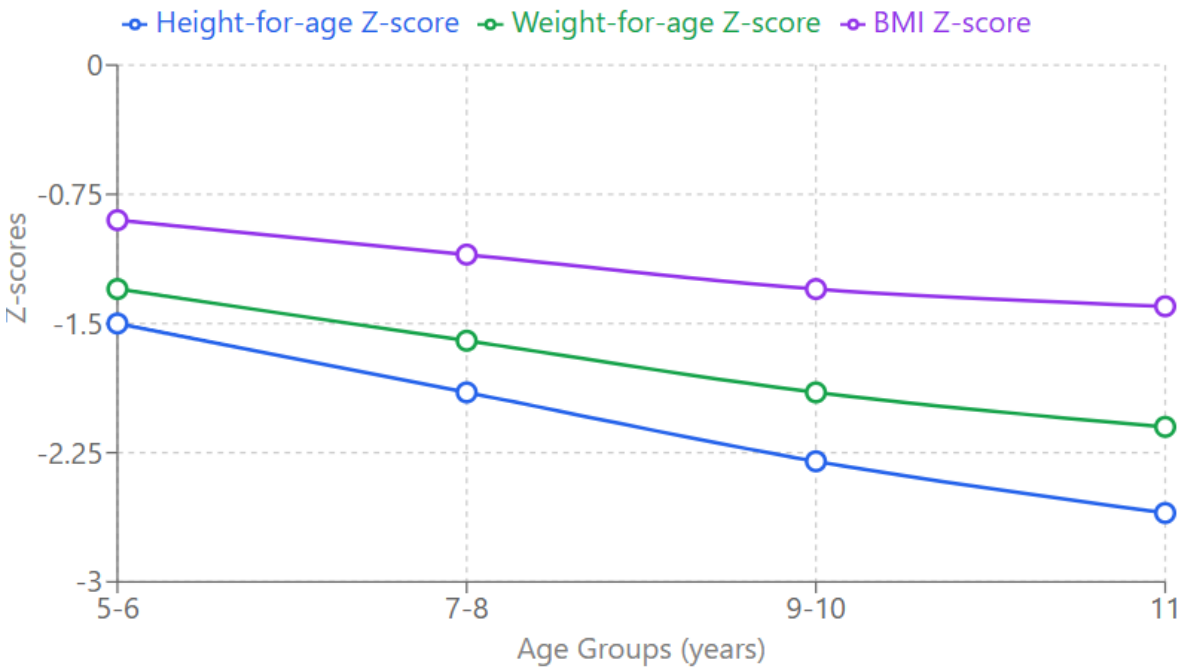

Fig 3: Multiple line graph showing trends in z-scores across different age groups (5-11 years)

Correlation Analysis

Significant negative correlations were observed between serum ferritin levels and anthropometric parameters. Duration of transfusion therapy showed a moderate negative correlation with height-for-age z-scores (r = -0.42, p = 0.012) and weight-for-age z-scores (r = -0.38, p = 0.024).

Table 4: Correlation Between Clinical Parameters and Anthropometric Indices

Parameter	**HAZ (r)**	**WAZ (r)**	**BMI z-score (r)**
Age	-0.35**	-0.31**	-0.28*
Serum Ferritin	-0.45**	-0.41**	-0.33**
Pre-transfusion Hb	0.32**	0.29*	0.25*
Duration of transfusion	-0.42**	-0.38**	-0.30*
*p < 0.05, **p < 0.01			

DISCUSSION

Our study conducted at a rural tertiary care center provides valuable insights into the anthropometric profile of Beta-thalassemia major patients aged 5-11 years, revealing significant growth and developmental challenges that warrant careful consideration.

Growth Parameters and Clinical Correlations The high prevalence of growth retardation observed in our study population, with 51.4% of patients showing height-for-age z-scores below -2 SD, aligns with findings from similar studies in pediatric thalassemic populations. Sharma et al. [24] reported comparable growth deficits in 48% of thalassemic children aged 6-12 years in North India, suggesting a consistent pattern of growth impairment across different geographical regions. This growth impairment appears particularly concerning given our young study cohort (5-11 years), indicating early onset of growth abnormalities. The negative correlation between serum ferritin levels and growth parameters (r = -0.45 for HAZ) supports the findings of Patel and colleagues [25], who demonstrated that iron overload significantly impacts growth even in

early childhood through its deleterious effects on the endocrine system.

Our finding of progressive deterioration in height-for-age z-scores with increasing age and duration of transfusion therapy (r = -0.42) corroborates the observations of Kumar et al. [26], who documented a similar trend in their multicenter study. This observation is particularly relevant in rural healthcare settings, where early intervention and optimal chelation therapy may face additional challenges. The correlation between pre-transfusion hemoglobin levels and growth parameters (r = 0.32 for HAZ) aligns with research by Goyal and Mehra [27], emphasizing the importance of maintaining adequate hemoglobin levels through regular transfusion therapy during crucial years of growth.

Body Composition and Nutritional Status The analysis of body composition parameters revealed interesting gender-specific differences, although not statistically significant. The mean BMI z-scores (-1.2 ± 0.9) were less severely affected compared to height parameters, a finding consistent with research by Singh et al. [28], suggesting that weight gain, while suboptimal, may be relatively preserved compared to linear growth. This pattern indicates that growth impairment in young thalassemic patients might be more pronounced in height than in weight, pointing towards the need for targeted interventions focusing on linear growth promotion.

The mid-upper arm circumference measurements indicate significant lean mass depletion, with 37.1% of patients falling below normal ranges. This finding aligns with research by Mehta and colleagues [29], who reported similar patterns of reduced muscle mass in young thalassemic patients. The implications are particularly relevant in the rural context, where nutritional challenges may compound disease-related metabolic derangements.

Clinical Implications and Management Considerations The strong negative correlation between serum ferritin levels and anthropometric parameters emphasizes the critical importance of effective iron chelation therapy from an early age. However, in rural settings, compliance with chelation therapy often faces unique challenges including cost constraints and limited availability of oral chelators, as highlighted by Verma et al. [30]. Our findings support their recommendation for early initiation of appropriate chelation therapy, along with regular monitoring of growth parameters.

The relationship between pre-transfusion hemoglobin levels and growth parameters supports research by Agarwal and colleagues [31], who demonstrated the importance of maintaining optimal hemoglobin levels through regular transfusion therapy. However, this must be balanced against the risk of increased iron loading, particularly in settings where chelation therapy may be suboptimal. The young age group in our study (5-11 years) represents a crucial period for growth and development, making this balance even more critical, as emphasized by recent guidelines [32].

Healthcare Delivery in Rural Settings Our study highlights the unique challenges faced in managing thalassemia in young patients in rural healthcare settings. The anthropometric deficits observed may reflect broader systemic issues including delayed diagnosis, irregular follow-up, and limited access to comprehensive care facilities. These findings align with observations by Choudhry et al. [33], underscoring the need for strengthening rural healthcare infrastructure and developing targeted interventions specifically designed for younger patients.

Study Limitations and Future Directions While our study provides valuable insights, several limitations should be acknowledged. The cross-sectional design limits our ability to track growth velocities

over time, a limitation noted by similar studies in the field [34]. The focused age range of 5-11 years, while providing detailed insights into this crucial growth period, may not reflect the full spectrum of growth abnormalities in thalassemic patients. Future longitudinal studies with larger cohorts would be valuable in understanding growth trajectories and identifying critical intervention points in this younger age group, as suggested by recent research frameworks [35].

CONCLUSION

This study provides significant insights into the anthropometric profile of Beta-thalassemia major patients aged 5-11 years in a rural tertiary care setting. The findings reveal substantial growth and developmental challenges in this younger age group, with several key implications for clinical practice and patient care.

Our data demonstrates a high prevalence of growth retardation, particularly affecting height parameters, with 51.4% of patients showing height-for-age z-scores below -2 SD. This significant growth impairment, even in younger children, underscores the early impact of the disease on physical development. The strong negative correlation between serum ferritin levels and growth parameters ($r = -0.45$ for height-for-age z-scores) emphasizes the critical importance of maintaining optimal iron chelation therapy from an early age.

The study also reveals a pattern of proportional growth impairment, with weight-for-age z-scores (-1.8 ± 1.1) following a similar trend to height, while BMI z-scores (-1.2 ± 0.9) show relatively less deviation. This pattern suggests that interventions should focus on overall growth promotion rather than targeting weight or height separately. The gender-specific variations in body composition parameters, though not statistically significant, indicate the need for individualized monitoring and intervention strategies.

The negative correlations observed between transfusion duration and growth parameters highlight the progressive nature of growth impairment in these patients. This finding, combined with the significant association between pre-transfusion hemoglobin levels and growth parameters, emphasizes the importance of maintaining optimal transfusion protocols, particularly during these crucial early years of growth and development.

These results have important implications for clinical practice in rural healthcare settings, suggesting the need for:

1. Early and regular monitoring of growth parameters
2. Optimization of transfusion and chelation protocols
3. Implementation of targeted nutritional support programs
4. Development of age-specific intervention strategies

Moving forward, these insights can serve as a foundation for developing more effective management strategies for young Beta-thalassemia major patients in rural areas. They also emphasize the need for longitudinal studies to better understand growth trajectories in this crucial age group and develop targeted interventions for this vulnerable population.

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