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Original Research Article

Assessment Of Growth Velocity and Anthropometric Indices in Sickle Cell Disease Children

Roopali Tiwari[1], Purushottam Kukade[2], Nikesh Kumar[3]

[1]Senior Resident, Department of Pediatrics, Peoples Medical College and Research Centre, Bhopal, Madhya Pradesh, India

[2]Senior Resident, Department of Psychiatry, Peoples Medical College and Research Centre, Bhopal, Madhya Pradesh, India

[3]Specialist Medical Officer (Pediatrics), Sub-Divisional hospital Dhamdaha, Purnea, Bihar, India

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Corresponding Author: Roopali Tiwari

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Abstract:

Background: Sickle cell disease (SCD) is a chronic inherited hemoglobin disorder that can adversely affect growth and physical development in children. Chronic anemia, recurrent vaso-occlusive episodes, increased metabolic demands, nutritional compromise, and disease severity may contribute to impaired growth and altered anthropometric indices. Assessment of growth velocity and anthropometric parameters is therefore important for understanding disease burden and guiding clinical management in children with SCD.

Materials and Methods: This longitudinal observational study was conducted in the Department of Pediatrics of a tertiary care hospital and at the Sickle-Thal Society, Amravati, Maharashtra. The study was carried out over a period of 18 months, with follow-up of participants at 3-month intervals up to 15 months. A total of 70 children aged 2–16 years with confirmed sickle cell disease who completed follow-up were included in the final analysis. Data were collected using a predesigned proforma. Anthropometric assessment included growth percentile, height percentile, weight percentile, and body mass index, recorded using Indian Academy of Pediatrics growth charts. Disease severity and hydroxyurea use were also documented. Data were analyzed using IBM SPSS Statistics version 26.0. Associations between categorical variables were assessed using Chi-square test or Fisher's exact test, and a p-value of <0.05 was considered statistically significant.

Results: Of the 70 participants, 43 (61.42%) were aged below 10 years and 41 (58.50%) were males. Severe disease was observed in 37 (53%) participants, while 33 (47%) had non-severe disease. Hydroxyurea was used by 30 (43%) participants. A significantly higher proportion of children with severe disease had poor anthropometric status. Growth percentile below the 3rd percentile was seen in 21 severe versus 6 non-severe cases. Height percentile below the 3rd percentile was observed in 19 severe versus 5 non-severe cases. Weight percentile below the 25th percentile was found in 31 severe versus 15 non-severe cases. Hydroxyurea use was significantly associated with severity status, whereas age and gender were not significantly associated with disease severity.

Conclusion: Children with sickle cell disease, particularly those with severe disease, are at increased risk of poor growth and adverse anthropometric outcomes. Lower growth, height, and weight percentiles were significantly associated with disease severity. Regular growth monitoring and early targeted interventions may help improve overall health outcomes in these children.

Keywords: Sickle Cell Disease, Growth Velocity, Anthropometric Indices, Children, Hydroxyurea, Disease Severity.

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Introduction

Sickle cell disease (SCD) is one of the most common inherited hemoglobin disorders worldwide and continues to pose a major public health challenge, particularly in regions with a high burden of disease [1]. It results from a mutation in the β-globin gene, leading to the production of abnormal hemoglobin S. Under deoxygenated conditions, hemoglobin S polymerizes, causing red blood cells to become rigid and assume a characteristic sickle shape. These sickled erythrocytes are more prone to hemolysis and microvascular occlusion, resulting in recurrent vaso-occlusive episodes, chronic anemia, tissue ischemia, and progressive multisystem involvement [1,2].

In children, the burden of SCD extends beyond acute clinical crises and hematological abnormalities. It significantly affects growth, nutrition, and overall physical development. Impaired growth in children with SCD is multifactorial and may result from chronic hemolysis, increased metabolic demands, recurrent infections, poor nutritional intake, malabsorption, endocrine dysfunction, and chronic inflammatory stress [3,4]. These factors often act cumulatively over time and may lead to stunting, underweight, delayed puberty, and suboptimal anthropometric outcomes compared with healthy peers [5].

Anthropometric indices are important clinical tools for assessing the growth and nutritional status of children with chronic illnesses. Parameters such as height, weight, body mass index (BMI), and growth-related percentiles provide valuable information regarding long-term disease burden and general health status [6]. In children with SCD, these indices can help identify early growth faltering and allow timely intervention. Previous studies have shown that children with SCD frequently have lower height-for-age, weight-for-age, and BMI-related measures compared with standard reference populations [7]. Such findings emphasize the importance of routine growth monitoring as part of comprehensive pediatric SCD care.

Growth impairment in SCD is also influenced by disease severity and treatment-related factors. Children with more severe disease often experience recurrent vaso-occlusive crises, repeated hospitalizations, transfusion requirements, and higher overall morbidity, all of which may adversely affect physical growth [8]. Hydroxyurea, a disease-modifying therapy widely used in SCD, has been shown to improve several hematological and clinical parameters; however, its impact on growth and anthropometric outcomes in children remains variably reported in the literature [9]. Evaluating the relationship between growth parameters, disease severity, and hydroxyurea use is therefore clinically relevant.

Although several studies from different parts of the world have examined anthropometric status and growth impairment in children with SCD, longitudinal evidence from the Indian population remains limited. Most available studies have focused on cross-sectional growth assessment rather than serial follow-up of growth-related parameters in routine clinical settings [10]. This creates an important gap in understanding the growth profile of children with SCD in our setting.

The present study was therefore undertaken to assess growth velocity and anthropometric indices in children aged 2–16 years with sickle cell disease. It also aimed to evaluate the relationship of these growth-related parameters with disease severity and hydroxyurea use. Early identification of growth compromise in these children may help in timely intervention, better risk stratification, and improved long-term clinical outcomes.

Materials And Methods

Study Design and Setting: This longitudinal observational study was conducted in the Department of Pediatrics of a tertiary care hospital and at the Sickle-Thal Society, Amravati, Maharashtra, India. These centers cater to a substantial number of pediatric patients with sickle cell disease and served as the clinical base for participant recruitment and follow-up.

Study Duration: The study was conducted over a period of 18 months. Enrolled participants were followed longitudinally at 3 months for up to 15 months during the study period.

Study Population: The study population comprised children aged 2–16 years with confirmed sickle cell disease who attended the pediatric outpatient and follow-up services of the study centers during the study period.

Sample Size: The sample size was calculated using OpenEpi software (Version 3), considering an expected prevalence of growth failure in sickle cell anemia of approximately 84% based on previous literature. At a 90% confidence interval and 10% allowable error, the minimum required sample size was calculated to be 146. However, due to feasibility constraints and incomplete follow-up, a total of 70 participants who completed follow-up were included in the final analysis.

Sampling Technique: A convenience sampling technique was used. All eligible children presenting during the study period and fulfilling the inclusion criteria were enrolled consecutively.

Inclusion and Exclusion Criteria: Children aged 2–16 years with confirmed sickle cell disease who were willing for regular follow-up and whose parents or guardians provided written informed consent were included in the study. Children were excluded if consent was not obtained, if they were not willing for follow-up, if they had severe skeletal deformity interfering with anthropometric measurements, or if they had any other primary systemic or genetic disorder known to affect growth.

Ethical Considerations: The study protocol was approved by the Institutional Ethics Committee of the medical college prior to commencement of the study. Written informed consent was obtained from the parents or caregivers of all participating children. Assent was obtained from children aged seven years and above wherever applicable. All information collected during the study was kept strictly confidential and used only for academic and research purposes.

Data Collection Tool and Procedure: Data were collected using a predesigned structured study proforma that included sociodemographic details, clinical history, treatment history, baseline anthropometric parameters, and follow-up clinical data.

Participants were followed at intervals of four months for a total duration of 16 months according to a predefined follow-up protocol. At each follow-up visit, weight, height, and relevant clinical parameters were recorded. Anthropometric measurements were plotted on the Indian Academy of Pediatrics (IAP) growth charts. Growth-related observations were recorded serially throughout follow-up.

To improve follow-up compliance, caregivers were reminded of scheduled visits through telephone calls and mobile/WhatsApp communication. Participants who missed appointments were contacted using available phone numbers and follow-up reminders. Standardized height and weight measuring instruments were used throughout the study to minimize technical and interobserver variation.

Operational Definitions: Sickle cell disease was defined as hemoglobin electrophoresis showing hemoglobin S >50%, or an SS pattern, or genetic confirmation of homozygous sickle cell disease or sickle-thalassemia genotype [11].

Growth velocity was defined as the change in height and weight measurements recorded between serial follow-up visits, generally expressed over a one-year period [12].

Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m^2) [13].

Disease severity was categorized into severe and non-severe groups based on clinical profile and disease burden, including recurrent vaso-occlusive episodes, need for hospitalization, blood transfusion requirement, and associated complications as recorded in the study proforma.

Outcome Measures: The study primarily evaluated growth-related anthropometric parameters in children with sickle cell disease. These included growth percentile, height percentile, weight percentile, and body mass index. The relationship of these parameters with disease severity and hydroxyurea use was also assessed.

Statistical Analysis: The collected data were coded and entered into Microsoft Excel and subsequently analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics for quantitative variables were expressed as mean ± standard deviation wherever applicable, while qualitative variables were expressed as frequency and percentage.

Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant at a 95% confidence interval.

Results

A total of 70 children with sickle cell disease were included in the final analysis. The study assessed demographic characteristics, disease severity, hydroxyurea use, and growth-related anthropometric parameters, and further evaluated their association with disease severity.

Demographic and Baseline Clinical Characteristics: Among the 70 study participants, 43 (61.42%) were aged below 10 years, while 27 (38.58%) were aged more than 10 years. There was a male predominance, with 41 (58.50%) males and 29 (41.50%) females.

Based on severity status, 37 (53%) children were categorized as having severe disease, while 33 (47%) were classified as non-severe. Hydroxyurea therapy was being used by 30 (43%) participants, whereas 40 (57%) were not receiving hydroxyurea.

Table 1. Demographic and baseline clinical characteristics of the study participants (n = 70)

Variable	Category	Frequency	Percentage (%)
Age group	<10 years	43	61.42
	>10 years	27	38.58
Gender	Male	41	58.50
	Female	29	41.50
Severity status	Severe	37	53.00
	Not severe	33	47.00
Hydroxyurea use	Yes	30	43.00
	No	40	57.00

Distribution of Growth-Related Anthropometric Parameters According to Disease Severity: Anthropometric assessment showed that children with severe sickle cell disease were more frequently represented in lower growth-related percentile categories. Growth percentile below the 3rd percentile was observed in 21 severe cases compared to 6 non-severe cases. Similarly, height

percentile below the 3rd percentile was seen in 19 severe cases and 5 non-severe cases.

Weight-related anthropometric impairment was also more common among children with severe disease. Weight percentile below the 25th percentile was observed in 31 severe cases compared to 15 non-severe cases. These findings indicate that poor anthropometric status was more frequently associated with severe disease.

Table 2. Distribution of growth-related anthropometric parameters according to disease severity

Anthropometric parameter	Category	Severe (n = 37)	Not severe (n = 33)
Overall growth percentile	<3rd percentile	21	6
	≥3rd percentile	12	31
Height percentile	<3rd percentile	19	5
	≥3rd percentile	14	32
Weight percentile	<25th percentile	31	15
	≥25th percentile	2	22

Association of Demographic, Treatment-Related, and Anthropometric Variables with Disease Severity

No statistically significant association was observed between age group and disease severity. Among children aged below 10 years, 20 were categorized as severe and 23 as non-severe, whereas among those aged more than 10 years, 13 were severe and 14 were non-severe ($p > 0.05$).

Similarly, gender was not significantly associated with disease severity. Among male participants, 20 were severe and 21 were non-severe, while among female participants, 13 were severe and 16 were non-severe ($p > 0.05$).

A statistically significant association was observed between hydroxyurea use and disease severity. Among children receiving hydroxyurea, 25 were severe and 5 were non-severe, whereas among those not receiving hydroxyurea, 8 were severe and 32 were non-severe ($p < 0.05$).

Growth-related anthropometric parameters also showed significant association with disease severity. Participants with growth percentile below the 3rd percentile were more likely to belong to the severe disease group (21 severe vs. 6 non-severe; $p < 0.05$). Similarly, height percentile below the 3rd percentile (19 severe vs. 5 non-severe; $p < 0.05$) and weight percentile below the 25th percentile (31 severe vs. 15 non-severe; $p < 0.05$) were significantly associated with severe disease.

Table 3. Association of demographic, treatment-related, and anthropometric variables with disease severity

Variable	Category	Severe	Not severe	p-value
Age	<10 years	20	23	>0.05
	>10 years	13	14	
Gender	Male	20	21	>0.05
	Female	13	16	
Hydroxyurea use	Yes	25	5	<0.05
	No	8	32	
Growth percentile	>3rd percentile	12	31	<0.05
	<3rd percentile	21	6	
Height percentile	>3rd percentile	14	32	<0.05
	<3rd percentile	19	5	
Weight percentile	>25th percentile	2	22	<0.05
	<25th percentile	31	15	

Discussion

Sickle cell disease (SCD) is a chronic inherited hemoglobinopathy associated with substantial morbidity in childhood, including impaired growth and poor nutritional status. In addition to recurrent vaso-occlusive crises and chronic anemia, children with SCD often experience long-term metabolic stress, recurrent infections, and nutritional compromise, all of which may adversely affect growth. The present study was conducted to assess growth-related anthropometric parameters in children with SCD and to evaluate their relationship with disease severity and hydroxyurea use.

In the present study, the majority of participants were aged below 10 years, and there was a slight male predominance. However, neither age group nor gender showed a statistically significant association with disease severity. These findings suggest that growth impairment and disease burden in SCD may be influenced more strongly by clinical severity and

chronic disease-related factors than by basic demographic variables alone. Similar observations have been reported by Islam et al. [14], who found no significant association between basic demographic variables and anthropometric compromise in children with sickle cell disease.

A notable finding of the present study was that more than half of the participants were categorized as having severe disease. This proportion appears higher than that reported in some earlier studies. Martinez et al. [8] observed that a relatively smaller proportion of children with sickle cell anemia had severe disease manifestations, with many patients falling into mild to moderate disease categories. The comparatively higher burden of severe disease in the present study may reflect differences in referral patterns, disease burden in the study population, delayed presentation, or variation in severity classification criteria.

The present study also demonstrated a statistically significant association between hydroxyurea use and disease severity. A larger proportion of children receiving hydroxyurea belonged to the severe disease group. This finding is clinically plausible and likely reflects the fact that hydroxyurea is more commonly prescribed to children with more severe clinical manifestations. Similar patterns have been reported by Yang et al. [15], who showed that hydroxyurea is often used in patients with greater clinical burden, although treatment compliance and accessibility remain important practical concerns. Therefore, this association should not be interpreted as hydroxyurea contributing to disease severity, but rather as a reflection of treatment allocation in more symptomatic patients.

The most important observation in the present study was the significant association between poor anthropometric status and severe disease. Children with severe SCD were more likely to have overall growth percentile below the 3rd percentile, height percentile below the 3rd percentile, and weight percentile below the 25th percentile. These findings indicate that growth impairment is more pronounced in children with greater disease burden and support the role of anthropometric monitoring as a practical marker of chronic disease impact.

Linear growth impairment is one of the most recognized long-term complications of pediatric SCD. In the present study, a substantially higher proportion of children with severe disease had height below the 3rd percentile. This finding is in agreement with previous studies that have reported stunting and reduced height-for-age among children and adolescents with SCD. Al- Mandese et al. [16] reported marked growth impairment in children with SCD and highlighted the importance of routine growth monitoring and nutritional support in comprehensive care. Similarly, Chikani et al. [17] demonstrated that sickle cell anemia has a significant adverse effect on linear growth in pediatric patients.

Weight-related anthropometric compromise was also prominent in the present study. A high proportion of severe cases had weight percentile below the 25th percentile, indicating undernutrition or poor weight gain among children with more severe disease. This finding is supported by previous studies showing that children with SCD frequently have lower body weight and poorer nutritional indices compared with healthy reference populations. Klein et al. [18] demonstrated that children with SCD had significantly higher odds of stunting and underweight, emphasizing the role of chronic anemia and nutritional vulnerability in growth faltering. Similarly, Islam et al. [14] reported a high prevalence of underweight and growth retardation among children with sickle cell anemia, particularly in those with greater disease burden.

The present findings also support the use of anthropometric indices as simple and clinically meaningful tools in routine follow-up of children with SCD. In resource-limited settings, serial monitoring of height, weight, and growth-related percentiles may help in early identification of children at risk of poor outcomes. Such assessments are particularly valuable where advanced nutritional or endocrine evaluation may not be readily available.

Hydroxyurea remains an important disease-modifying therapy in SCD, and its relationship with growth has been variably reported in the literature. Khater et al. [19] evaluated the effect of hydroxyurea therapy on growth parameters in children with SCD and reported that hydroxyurea did not significantly affect height or weight growth, although some improvement in BMI-related measures was observed during follow-up. Likewise, Nagalapuram et al. [20] found that disease-modifying therapies may influence growth patterns differently, with transfusion therapy and hydroxyurea showing variable effects depending on age and pubertal stage. In the present study, hydroxyurea use was associated with severity status rather than directly analyzed as an independent determinant of anthropometric improvement. Therefore, although hydroxyurea remains clinically important, its direct influence on growth-related outcomes could not be conclusively determined in the present analysis.

The present study has certain limitations. Although the study was designed as a longitudinal observational study, the final analysis primarily focused on growth-related anthropometric status and its association with disease severity rather than detailed serial growth velocity modeling. The final analyzed sample size was smaller than the calculated sample size, which may have reduced the statistical

power and generalizability of the findings. In addition, important confounding factors such as dietary intake, socioeconomic status, pubertal stage, endocrine profile, and laboratory severity markers were not assessed. The study also did not include a healthy control group for comparison.

Despite these limitations, the study provides clinically relevant insight into the burden of impaired growth among children with SCD in the study setting. The findings emphasize the importance of regular anthropometric monitoring and early identification of growth faltering, particularly in children with more severe disease.

Conclusion

Children with sickle cell disease, particularly those with severe disease, are at increased risk of poor growth and adverse anthropometric outcomes. In the present study, lower overall growth percentile, height percentile, and weight percentile were significantly associated with disease severity, indicating that anthropometric compromise is an important clinical consequence of severe sickle cell disease.

Although age and gender were not significantly associated with severity status, hydroxyurea use showed a significant association, likely reflecting its greater use in children with more severe clinical manifestations. These findings highlight the importance of regular anthropometric monitoring and longitudinal growth assessment in children with sickle cell disease.

Early identification of growth faltering, along with timely nutritional support and optimized disease-specific management, may help improve long-term health outcomes and quality of life in this vulnerable pediatric population.

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