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Evaluating the Nutritional and Growth Indicators Among Rural School-Aged Children Through Anthropometric Measurements

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Abstract
Malnutrition among school-aged children in rural areas remains a persistent public health challenge in rural areas of Jharkhand in India.

Objectives: The purpose of the present study was to evaluate the nutritional and growth indicators of rural school-aged children using anthropometric measurements of the rural children from Jharkhand.

Methodology: A cross-sectional survey was conducted among children aged 6 to 12 years from selected rural schools of Simdega district in Jharkhand. Height of the subjects was measured with the stadiometer. Body mass was assessed by using the portable weighing machine. Mid upper circumference was taken with the flexible steel tape. Skin fold thickness es were measured with the help of Herpenden skin fold calipers.

Results: The results revealed that the sample group have significantly lower Triceps skinfold thickness and MUAC values and significant prevalence of undernutrition and growth retardation among children. The linear regression of weight (dependent variable) on height (independent variable) showed statistical significance at age 6 ($F = 4.62$, $p = 0.041$) and a highly significant relationship at age 9 ($F = 26.61$, $p < 0.001$). These findings indicate that during these specific age periods, height was a strong predictor of weight. At other ages, however, the relationship was not statistically significant ($p > 0.05$), particularly at age 11 ($F = 0.03$, $p = 0.861$), where the relationship was negligible.

Conclusions: This study emphasizes the need for targeted nutritional interventions and regular growth monitoring to improve the overall health status of rural school children.

Keywords: School children, Body Mass Index, Malnutrition, Rural area, Anthropometric measurements

Introduction

Nutritional status during childhood plays a crucial role in determining the physical, cognitive, and social development of children. School-aged children (6–12 years) boys are in a critical period of growth and development, and any deviation from normal nutritional status during this stage can have long-term consequences on their health, academic performance, and future productivity. In rural India, the prevalence of malnutrition is particularly high due to factors such as poverty, ignorance, poor dietary intake, lack of health awareness, and limited access to healthcare services. Singh et al. (2021) observed 35% underweight. Mid upper Arm circumference and Triceps skin fold thickness were below WHO cut-offs among rural children. Kumar et al. (2015) reported that Body mass index and Mid upper arm circumference were reliable indicators for screening undernourished children of rural area. They

emphasized the importance of regular anthropometric assessments in schools. Anthropometric measurements serve as a reliable, non-invasive, and cost-effective tool for assessing the nutritional and growth status of children. These measurements help identify undernutrition (stunting, wasting, and underweight), overweight, and obesity. Key indicators such as height-for-age, weight-for-age, and BMI-for-age provide insights into both acute and chronic nutritional deficiencies. UNICEF (2019) has consistently reported that rural children in India face higher rates of malnutrition compared to their urban counterparts, necessitating focused interventions and better school health services. Bharati et al (2005) re¬ported better circumferences in the urban children from Raichur region of India. Eiben et al (2005) compared the Hungarian Children from rural and urban settings and reported that urban children had better diameters of body parts than their rural counterparts.Many studies have reported that physical parameters related to growth and development in urban children was at higher level than in rural children (ICMR, 1972; Phadake, 1968; Sahoo et al, 2011).
This study seeks to evaluate the nutritional and growth status of rural school-going boys by employing standard anthropometric techniques. The findings are expected to contribute to evidence-based planning and policy formulation for child nutrition programs in rural areas. These studies underscore the utility of anthropometric tools in understanding the health and nutrition landscape of children. However, there remains a gap in localized, current data from many rural regions, particularly in underserved areas. This study aims to fill that gap by generating anthropometric data for rural children.

Methodology

Study Design and Location

A cross-sectional exploratory cum descriptive study was conducted among boys (6–12 years) in selected rural villages of Simdega district in Jharkhand, India. The study area was purposefully selected on the basis of its remote location, limited accessibility, predominantly rural setting and cooperation from local and School authorities.

Sample Size and Sampling Technique

A total of 187 children (boys) were selected using simple random sampling method by age group (6-12 years).

Inclusion and Exclusion Criteria

- **Inclusion**: Children aged 6–12 years enrolled in selected rural schools and whose parents provided consent.
- **Exclusion**: Children with known chronic illnesses, physical deformities, or disabilities affecting growth measurements.

Anthropometric Measurements

The following measurements were taken using standard WHO procedures:
Height: Measured using a stadiometer to the nearest 0.1 cm. **Weight**: Measured using a digital weighing scale to the nearest 0.1 kg.**BMI**: Calculated using the formula: weight (kg)/height (m^2). **MUAC**: Measured at the midpoint of the left upper arm using a non-stretchable measuring tape.**Triceps Skinfold Thickness (TSFT)**: Measured using slide callipers for subcutaneous fat estimation. Data were entered and analysed using SPSS. Nutritional status indicators were classified based on WHO growth standards and ICMR

reference values. Statistical analysis included means, standard deviations, percentiles, and linear regression analysis between height, weight, and age.

Result And Discussions

Table No. 1: Mean Weight (in Kg) of Boys (N=187) in Comparison with ICMR Standards

Age (in years)	Observed Mean Weight (Kg)	ICMR Standard	Difference	Interpretation
6	17.6 (±1.5)	20.3	-2.7 kg	Below Standard
7	21.0 (±1.1)	22.4	-1.4 kg	Slightly Below
8	22.0 (±1.1)	24.5	-2.5 kg	Below Standard
9	26.0 (±1.9)	27	-1.0 kg	Slightly Below
10	27.7 (±2.6)	29.5	-1.8 kg	Below Standard
11	30.3 (±1.4)	32.5	-2.2 kg	Below Standard
12	32.8 (±1.9)	35.9	-3.1 kg	Significantly Below

(Figures in parentheses are S.D.)

The table provides the mean weight of boys aged 6 to 12 years (N=187), along with their standard deviations. These values are compared against the **ICMR (Indian Council of Medical Research) standards** to assess the growth status of the boys. All age groups show **lower mean weight** compared to ICMR standards. The deviation ranges from **-1.0 kg to -3.1 kg**, indicating a consistent trend of underweight among the boys. The greatest deviation is observed in the **12 years.**

Table-2: Mean Height (in cm) of Boys (N=187) in Comparison with ICMR Standards

Age (in years)	Observed Mean Height (cm)	ICMR Standard	Difference	Interpretation
6	113.6 (±4.1)	115.5	-1.9 cm	Slightly Below
7	119.7 (±1.1)	120.6	-0.9 cm	Nearly Normal
8	123.1 (±1.8)	125.8	-2.7 cm	Below Standard
9	126.6 (±1.6)	130.9	-4.3 cm	Significantly Below
10	133.5 (±1.4)	136.0	-2.5 cm	Below Standard
11	141.3 (±2.7)	141.5	-0.2 cm	Near Standard
12	146.7 (±3.4)	147.1	-0.4 cm	Nearly Normal

(Figures in parentheses are S.D.)

Observation:

The mean height of boys was **slightly below** the ICMR standards in most age groups.The **greatest shortfall** is seen in the **9–10 years** age group (-4.3 cm). For older boys (11–12 years), the height values approach ICMR norms, showing improvement. The consistent underweight trend suggests **chronic undernutrition or poor dietary intake**. Height deficits, though not as severe as weight, point to **mild**

stunting in younger age groups. Height tends to normalize as age increases, while weight lags behind, indicating **catch-up growth in height**, but **delayed weight gain**. Nutritional interventions are essential, especially for children aged **6 to 10 years**, who show maximum deviations from ICMR norms. The findings reflect socio-economic constraints, dietary inadequacies, or health access issues in the study population.

Table 3: BMI Calculation & Nutritional Status of Boys (Age 6–12 Years)

Age (Years)	Mean Weight (kg)	Mean Height (cm)	Height (m)	BMI (kg/m²)	Nutritional Status (WHO BMI-for-age Percentile)	Interpretation
6	17.6	113.6	1.136	13.63	<5th percentile	Severely Underweight
7	21.0	119.7	1.197	14.65	5th–15th percentile	Underweight
8	22.0	123.1	1.231	14.52	5th–15th percentile	Underweight
9	26.0	126.6	1.266	16.23	15th–50th percentile	Normal
10	27.7	133.5	1.335	15.55	15th–25th percentile	Normal (lower end)
11	30.3	141.3	1.413	15.17	10th–15th percentile	Underweight
12	32.8	146.7	1.467	15.17	10th–15th percentile	Underweight

All age groups have a lower BMI than expected norms; most fall in the underweight or severely underweight category. Ages 6, 7, 8, 11, and 12 show BMI <15.5, which is below the 15th percentile. Only 9–10 years age group approaches a more normal BMI range but still remains on the lower side of the healthy spectrum. This trend aligns with your weight and height observations – suggesting chronic undernutrition and possibly insufficient calorie or nutrient intake.Children aged 6–12 years exhibit lower weight and height compared to ICMR standards, indicating chronic undernutrition. BMI analysis further confirms that most of these children fall into underweight or severely underweight categories. Table No. 4: Distribution of Mean Tricep and MUAC of Boys (n = 187) in Comparison with ICMR Standards

Table 4: Comparison of observed value with ICMR standard value of Tricep and mid Upper arm circumference of Boys (Age 6–12 Year)

Age (years)	Tricep (mm) means ± S.D.	ICMR Standard Mean ± SD	Interpretation	MUAC (cm) means ± S.D.	ICMR Standard Mean ± SD	Inter-pretation
6	5.6 (± 0.859)	9.8 (± 2.5)	Markedly lower	15.04 (± 1.028)	17.0 (± 1.2)	Much lower

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Age (years)	Tricep (mm) means ± S.D.	ICMR Standard Mean ± SD	Interpretation	MUAC (cm) means ± S.D.	ICMR Standard Mean ± SD	Inter-pretation
7	6.5 (± 0.759)	10.3 (± 2.7)	Lower	15.25(± 1.140)	17.5 (± 1.3)	Lower
8	6.8 (± 0.669)	10.8 (± 2.9)	Lower	16.00 (± 1.699)	18.0 (± 1.4)	Slightly lower
9	6.8 (± 0.704)	11.3 (± 3.1)	Lower	15.79 (± 1.464)	18.6 (± 1.4)	Lower
10	7.2 (± 0.813)	11.8 (± 3.3)	Lower	16.84 (± 1.230)	19.2 (± 1.5)	Lower
11	7.2 (± 0.829)	12.3 (± 3.5)	Lower	16.97 (± 1.442)	19.8 (± 1.6)	Lower
12	7.5 (± 0.745)	12.8 (± 3.7)	Lower	18.07 (± 2.025)	20.3 (± 1.7)	Slightly lower

(Figures in parentheses are S.D.)

Triceps skinfold thickness (in mm)

This table compares the **mean Triceps skinfold thickness (in mm)** and **Mid-Upper Arm Circumference (in cm)** among boys aged **6 to 12 years** with the **ICMR (Indian Council of Medical Research) standard values** for the same age group. The values include mean ±standard deviation (SD), offering a statistical view of nutritional status and growth indicators in children. Across all age groups, the observed Triceps skinfold thickness is consistently lower than ICMR standards, indicating reduced subcutaneous fat. A possible sign of chronic undernutrition or poor energy reserves among the children surveyed.

Mid-Upper Arm Circumference (in cm)

Observation: Mid Upper Arm Circumference values were also consistently below ICMR standards, although the gap slightly narrows in the older age group (12 years). This suggests moderate levels of undernutrition and potential muscle mass deficiency, especially in early age groups (6–9 years).

Statistical Interpretation: The **standard deviations** in the observed values are relatively **lower** than those of ICMR standards, suggesting **less variability** in this specific sample group. However, despite this consistency, the **mean values fall short** of the recommended norms across all age groups. The **mean triceps skinfold** is approximately **2.5 to 5 mm lower** than standard, which is significant in anthropometric assessments. The **MUAC difference** ranges from **~2 cm at age 6 to ~1.2 cm at age 12**, which can affect the interpretation of protein-energy status. These deviations indicate **chronic energy deficiency** common in nutritionally insecure populations. MUAC and Triceps skinfolds are indicators of body fat and muscle mass, which reflect both protein and energy intake adequacy. The values below standard thresholds imply the boys are **at risk of malnutrition**, which could impact physical growth, immunity, and cognitive development. The comparative analysis with ICMR standards reveals that the children in this sample group have **significantly lower Triceps skinfold thickness and MUAC values**, suggesting **widespread undernutrition**. when compared to **ICMR growth and MUAC references**, these values would likely fall **below the recommended ranges** for healthy growth, especially for **school-aged children**. Targeted interventions are essential to address this nutritional deficit and improve child health outcomes in the population.

Table No.: 5 Analysis of Linear Regression of Weight on Height for Different Ages of Boys (N=187)

Age (Years)	Mean Weight (kg)	Mean Height (cm)	F-ratio	p-value	Interpretation
6	17.6	113.6	4.62	0.041	Significant
7	21.0	119.7	3.36	0.080	Not significant
8	22.0	123.1	0.71	0.407	Not significant
9	26.0	126.6	26.61	0.001	Highly significant
10	27.7	133.5	3.54	0.064	Borderline significant
11	30.3	141.3	0.03	0.861	Not significant
12	32.8	146.7	1.30	0.263	Not significant

The table presents the results of a linear regression analysis assessing the relationship between weight and height across different age groups of boys (6 to 12 years). The key statistical parameters include the mean weight (kg), mean height (cm), F-ratio, p-value, and interpretation of significance.

The regression analysis suggests that the association between height and weight is strongest and most predictable around age 9, followed by age 6. As boys grow older, particularly beyond 10 years, the relationship becomes more variable and statistically insignificant. This variability could be due to the onset of puberty, differences in body composition, and other environmental or genetic factors. These findings imply that growth monitoring and nutritional interventions may be most impactful in early to mid-childhood (ages 6–9), where linear growth shows a stronger association with weight gain. This supports the importance of targeted interventions during critical growth windows in childhood. The table presents the results of a linear regression analysis to assess the relationship between weight (dependent variable) and height (independent variable) among boys aged 6 to 12 years. At **age 6 (p=0.041)** and **age 9 (p=0.001)**, the relationship between height and weight is statistically **significant**, especially age 9 where the **F-ratio is highest (26.61).** Borderline significance is seen at age 10 (p=0.064). Other age groups (7, 8, 11, and 12) show **non-significant** associations, indicating less predictability of weight from height at those ages.

Conclusion

The analysis revealed that both height and weight from age 6 to 12 years, aligning with ICMR standards. However, the predictive power of height on weight varies with age, with stronger associations at younger ages (6, 9 years). The fluctuating F-ratios and p-values suggest that other factors such as nutrition, socioeconomic status . At ages where significance is low, interventions may be needed to monitor health, especially around puberty. There is a progressive increase in both mean height and weight with advancing age. The average height increased from 115.64 cm at age 6 to 146.71 cm at age 12+, while the average weight increased from 17.66 kg to 38.77 kg over the same period. These trends are consistent with expected patterns of physical growth during childhood and early adolescence.The regression of weight on height was statistically significant at **age 6 (p = 0.041)** and **age 9 (p = 0.000)**, indicating a meaningful linear relationship between these two variables during these stages of growth. The **highest F-ratio (26.61)** observed at age 9 suggests a **strong predictive relationship** between height and weight at this age, possibly reflecting a period of accelerated linear and weight growth (pre-pubertal growth spurt). For other age groups (7, 8, 10, 11, 12+ years), the relationship between weight and height was not statistically significant ($p > 0.05$), indicating that the predictive power of height for determining weight varied by age. Age 11 displayed the **least significant relationship (p = 0.861)**, with almost no correlation between the two variables, possibly due to hormonal fluctuations or variations in pubertal onset. The results indicate that while both height and weight increase with age, the strength of the linear relationship between these two variables is not uniform throughout childhood. Significant correlations at ages 6 and 9 suggest specific periods where height can effectively predict weight, possibly due to synchronized growth patterns. These findings underline the importance of age-specific growth assessments in pediatric health monitoring, and caution against applying a single linear model across all developmental stages.

Recommendations

- **Regular Growth Monitoring:** Periodic anthropometric assessments is essential to identify undernourished children early. Inclusion of local, seasonal prebiotic and probiotic foods in daily diets can improve overall nutritional status.
- **Community Nutrition Education:** Educate parents, especially mothers, on balanced diets, hygiene, and child feeding practices.
- **Link Schools with Health Services:** Integrate health checkups, deworming, and supplementation programs with school curricula.

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