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Anthropometric indicators as measures of nutritional vulnerability and determinants of anthropometric failure among tribal school children in Anaikatti, Coimbatore district Tamil Nadu

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Abstract: Malnutrition is an emerging health problem that has challenged healthcare authorities worldwide. This study aims to determine anthropometric measurements and the malnutrition status children of Anaikatti tribal area of Coimbatore district. A cross-sectional study was conducted among 97 tribal school children (48 boys and 49 girls) aged 5–14 years in Anaikatti village. Socioeconomic data were collected using a structured questionnaire; anthropometric measurements were assessed using standard WHO procedures. All participants belonged to the lower middle-income group. Among boys aged 5–9 years, 8% exhibited thinness, 24% were overweight, 4% were obese and 64% belongs to normal anthropometric status. In the 10–14-year group, 35% were with normal anthropometrics, 13% showed severe thinness, 26.1% thinness, 27.1% overweight, and 8.7% obesity. Among girls aged 5–9 years, 7.7% were thin, 61.6% with normal anthropometrics, 26.9% overweight, and 3.8% obese, while in the 10–14-year group, only 17.4% were with normal anthropometrics, 26.1% had severe thinness, 43.5% thinness, and 8.7% overweight, and 4.3% obesity. Despite belonging to the same socioeconomic group, both under-nutrition and over-nutrition coexisted, indicating a double burden of malnutrition. Personalized nutrition education and counseling sessions were conducted for all participants and their parents to improve awareness and promote healthy eating practices. The study highlights a significant coexistence of thinness and overweight among tribal school children in Anaikatti, emphasizing the need for school based targeted nutritional interventions and continuous community-based education.

Keywords: anthropometry, nutrition education, obesity, thinness, Tribal children, nutrition education

I. INTRODUCTION

Malnutrition among children remains a significant public health concern. India bears about one-third of the global malnutrition burden, according to the World Health Organization. Tribal children are particularly vulnerable as they exist in conditions of poverty, unsanitary environments, and inadequate education and health care, resulting in heavy morbidity and mortality rates (NFHS-5, 2021).

The school age (5–14 years) is also referred to as a period of latent development, important for development and storage of nutrients. Malnutrition at this phase negatively impacts cognitive function, capacity to learn, and school enrollment, and usually carries on into adulthood, affecting health and productivity (Black et al. (2013); Mukherjee et al. (2020).683 Scheduled tribes have been enumerated in Coimbatore district, namely the Irular, Pataka, Thoda, Kota, and Kurumba, who are listed as Particularly Vulnerable Tribal Groups (PVTGs). Irula people are particularly famous in the Western Ghats foothills Vijayaraghavan et al. (2017).

A double burden of malnutrition (DBM) was recently discovered in Indian schoolchildren, wherein under-nutrition coexists with increasing overweight and obesity. Food transition, decreased physical activity, and socioeconomic inequality are the reasons for this change (Daga et al. (2020); Popkin et al. (2020). Tribal communities are also being impacted by these changes, necessitating a comprehensive assessment and selective intervention. The present study thus

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also tries to assess the anthropometric measures and nutritional vulnerability of tribal school children in Anaikatti, Coimbatore district, Tamil Nadu, to determine the emerging trends of malnutrition among this marginalized population.

II. MATERIAL AND METHODS

The study was community based cross sectional study. Data on body weight, height, and BMI were collected through survey and observation to assess nutritional status. Parental consent was obtained before participation, and all procedures adhered to ethical research guidelines. The current research was conducted at the Aniakatti tribal area of Periyanaikan block, Coimbatore. Simple random sampling method was used for the selection of study subjects. A total of 97 tribal children comprising 48 boys and 49 girls aged 5-14 were selected for the study.

Inclusion criteria: Children who were (i) Age group of 5-14 years ii) Permanent residents at anaikatti tribal area iii) Without any severe chronic disease and disability iv) willing to participate in this study
Exclusion criteria: Children who were (i) Age group below 5 and above 14 years, (ii) Nonresidents in selected tribal area (iii) With any severe chronic diseases and disabilities (iv) Not willing to participate in this study
Questionnaire: A validated questionnaire was designed to collect data on background characteristics and anthropometric parameters.
Background information: Demographic information such as name, age, gender, ethnicity, and socioeconomic status (SES) was assembled through a pre-tested and validated questionnaire administered to the study participants.
Anthropometric parameters: The height (cm) of each participant was measured using a calibrated stadiometer, and weight (kg) was recorded using a calibrated weighing scale. The measurements were compared with the WHO AnthroPlus (2007) reference standards for assessing BMI-for-age.
Assessment of Malnutrition Status: The anthropometric measurements obtained from the study participants were entered and analyzed using the WHO AnthroPlus software, which applies the WHO 2007 Growth Reference for children and adolescents aged 5–19 years. This software was utilized to calculate the Body Mass Index-for-Age Z-scores (BAZ), enabling the assessment of the malnutritional status of school-aged children. According to the WHO BMI-for-age classification, children were categorized as severely thin (< -3 SD), thin (< -2 SD), normal (≥ -2 SD to $\leq +1$ SD), overweight ($> +1$ SD, equivalent to BMI 25 kg/m² at 19 years), and obese ($> +2$ SD, equivalent to BMI 30 kg/m² at 19 years). These classifications were used to evaluate the prevalence of malnutrition.
Nutrition education: Personalized nutrition education and counseling sessions were conducted for all participants and their parents to enhance awareness and encourage the adoption of healthy eating practices.
Ethical approval: The study was approved by the Institutional human Ethics Committee, PSG IMS&R, and Coimbatore with the Ref.No:PSG/IHEC/2025/Appr/FB/042

III. RESULTS AND DISCUSSION

1. Socioeconomic profile of the study population

The table summarizes the socio-economic profile of the study population, including variables such as parent's educational status, occupation, and family income. It provides an overview of the demographic profile of the participants, which helps in understanding the context of their nutritional and health outcomes.

Table 1: Socioeconomic profile of the study population

Socioeconomic Parameters	Criteria	No of Subjects (n=97)	
		Frequency (n=97)	Percentage (100%)
Parental Education	Illiterate	56	57.7
	Primary/Middle	41	42.3
	Total	**97**	**100**
Parental Occupation	Daily wage labor	32	33
	Private sector	29	29.9
	Unemployed	36	37.1
	Total	**97**	**100**
Monthly Family Income (₹)	< 5,000	24	24.7
	5,001–10,000	73	75.3
	Total	**97**	**100**

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The table 1 demonstrates the socioeconomic profile of the study population showed that most parents had low education, limited income, and unstable jobs. Among the 97 tribal school children surveyed, 57.7% of parents were illiterate. Meanwhile, 42.3% had completed primary or middle school. This indicates that more than half of the families came from a low educational background. Low education levels among parents may directly affect their understanding of nutritional needs and health practices for their children. In terms of income, 75.3% of families earned between ₹5,001 and ₹10,000 per month. About 24.7% had an income below ₹5,000. This suggests financial difficulties that could limit access to sufficient and varied foods. As for jobs, 33% of parents were daily wage workers, 29.9% were in the private sector, and 37.1% were unemployed. This reflects the unstable economic conditions many tribal families face. Overall, these findings indicate that families in Anaikatti deal with significant socioeconomic challenges. These challenges can negatively affect household food security, living conditions, and ultimately, the nutritional status of their children.

2. BMI-for-Age Classification Based on WHO Anthro plus (2007) Standards among Anikatti tribal Children

The below table represents BMI-for-age classification of the tribal schoolchildren was assessed using the WHO AnthroPlus (2007) growth reference standards. The results were categorized according to gender (boys and girls) and age group (5–14 years).

Table 2. BMI-for-Age Classification Based on WHO Anthro plus (2007) Standards among Anikatti tribal Children by Gender and Age Group

Subjects	N	Normal %	< −3SD (Severe thinness)	< −2SD (Thinness)	> +1SD (overweight)	> +2SD (Obese)	> +3SD (Severe obese)	Mean ± SD
Boys (5–14)	48	41.6	6.3 (3)	16.7 (8)	22.9 (11)	10.4 (5)	2.1 (1)	-0.55± 1.68
Boys (5–9)	25	60.0	0 (0)	8 (2)	24 (6)	12 (3)	4 (1)	-0.24± 1.44
Boys (10–14)	23	30.4	13 (3)	26.1 (6)	21.7 (5)	8.7 (2)	0 (0)	-0.9± 1.52
Girls (5–14)	49	40.8	12.2 (6)	24.5 (12)	18.4 (9)	4.1 (2)	0 (0)	-0.77± 1.56
Girls (5–9)	26	61.5	0 (0)	7.7 (2)	26.9 (7)	3.8 (1)	0 (0)	-0.09± 1.24
Girls (10–14)	23	17.4	26.1 (6)	43.5 (10)	8.7 (2)	4.3 (1)	0 (0)	-1.55± 1.50
Overall	97	41.3	9.3% (9)	20.6% (20)	20.6% (20)	7.2% (7)	1.0% (1)	−0.66 ± 1.68

The above table 2 showed the BMI-for-age by WHO anthroplus software categorization of the 97 tribal school children aged between 5–14 years, 41.3% of participants had normal nutritional status (−2SD to +1SD), 20.6% were thin, 20.6% were overweight, and 7.2% were obese. Severe thinness (<−3SD) was found in 9.3% of children, showing under nutrition as a persistent problem in this tribal population. The mean BMI-for-age Z-score (BAZ) was −0.66 ± 1.68, indicating a mild negative deviation from the WHO standards.

Gender comparison indicated that the nutritional status of boys (5–14 years) was marginally better, with 42.0% being in the normal category compared to 40.8% in girls. Thinness was higher in girls (24.5%) compared to boys (16.7%). Interestingly, overweight and obesity were higher in boys (22.9% and 10.4%, respectively) than in girls (18.4% and 4.1%), suggesting potential variations in physical activity levels and food intake. Age-related patterns showed a clear nutritional shift. The younger boys (5–9 years) had 60% of normal BMI status, with 24% being overweight and 12%

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obese, indicative of improved nutrition in early childhood but potential early initiation of high-calorie food. In contrast, adolescent boys (10–14 years) indicated decreasing normal status (30.4%) and rising thinness (26.1%) and severe thinness (13%). Such trends were also seen in girls, where 61.5% of the 5–9 years category were normal while just 17.4% were in the age group 10–14 year. Thinness and severe thinness combined to make up close to 70% of adolescent girls with a mean BAZ of −1.55 ± 1.50, showing increased vulnerability in early ages of puberty.

The results are in agreement with previous reports from tribal children in Tamil Nadu and central India that have experienced chronic under nutrition alongside increasing overweight and obesity as a result of lifestyle and dietary changes Talapalliwar (2014) Evidence that both under nutrition and over nutrition occur in the same population is an indication of the double burden of malnutrition, which is evident during the nutrition transition period Popkin et al. (2020). The findings support the necessity of specific nutrition interventions, especially for girls above 10years, targeting diet diversity, micronutrient consumption, and health education. School-based nutrition surveillance and culturally sensitive physical activity programs may also address the increasing trend towards overweight and obesity in younger boys.

A cross-sectional survey by Pujara et al (2025) reported that among 137 children (5-10 years) from 122 Koraga tribal households in rural villages of Udupi District. Malnutrition was assessed through anthropometric measurements, including height and weight assessments of the children. Height-for-age (HAZ), Weight-for-age (WAZ) and BMI-for-age (BAZ) Z-scores were calculated using WHO growth standards 2007. Anaemia was evaluated by measuring haemoglobin levels, and stool samples were examined microscopically for worm infestation.

3. Percentage of selected Tribal Schoolchildren in Different BMI-for-Age Categories (Bar Chart, WHO AnthroPlus 2007

The below Bar chart shows the percentage distribution of BMI-for-age categories among selected tribal schoolchildren based on WHO AnthroPlus (2007) growth reference standards. The results are displayed by gender (boys and girls) and age group (5–14 years), illustrating the proportion of children classified as severely thin, thin, normal, overweight or obese.

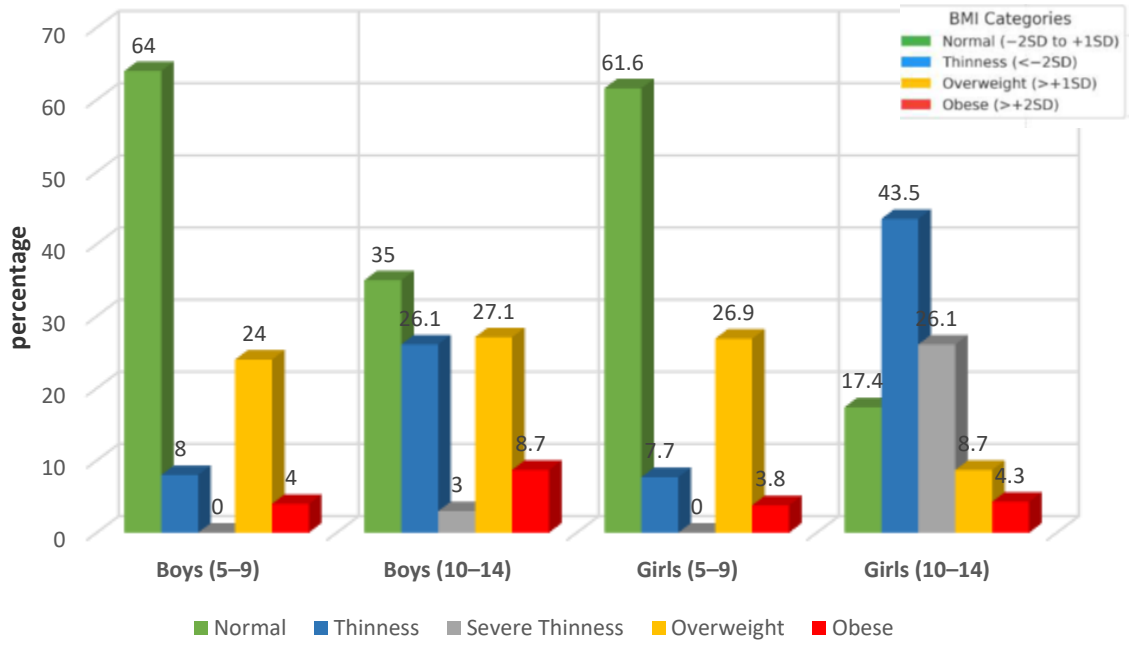

Figure1 BMI -for- Age categories among tribal school children by age and gender group

The above figure 1 clearly depicts the overall BMI- for age percentage distribution among the 97 children, for the younger boys aged 5–9 years, the most (64%) had normal anthropometric status, whereas 8% were thin, 24% were overweight, and 4% were obese. However, boys 10–14 years had a reduction in normal BMI (35%) and an increased prevalence of thinness (26.1%) and overweight (27.1%), with 8.7% obese. In the Among girls aged 5–9 years, 61.6% were in the normal range, 7.7% thin, 26.9% overweight, and 3.8% obese. Girls aged 10–14 years showed a significant increase in under nutrition and were 43.5% thin and 26.1% severely thin, while only 17.4% were in the normal range. In

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general, the trend reveals that younger girls between 10-14yers are more susceptible to under nutrition than boys, while overweight and obesity are more common among younger children of both genders.

4. Comparison of BMI- for- age Z- score distribution of selected tribal school children with WHO child growth standard (2007)

The figure below illustrates the distribution and prevalence of various categories of malnutrition among the selected tribal children (n = 97). The curve pattern further depicts a comparative assessment of the children's nutritional status based on their WHO Z-scores in relation to the standard WHO growth reference curves."

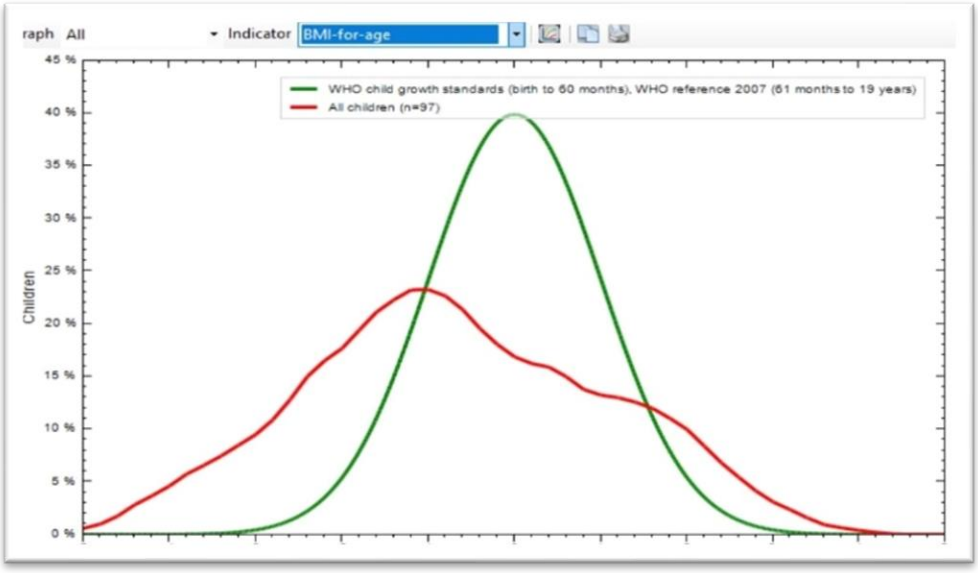

Figure 2 Sample Population BMI-for-Age Distribution Compared to WHO Reference

Figure 2 shows that the comparison of the study subjects Body Mass Index-for-age distribution (red line) with the World Health Organization (WHO) growth standard (green line), the standard for healthy. The key finding was that the sample group has a large negative deviation from the healthy standard, as it implies a widespread nutritional deficiency. The WHO standard (green curve) is aligned at a Z-score of 0 (the 50th percentile), which is the median of the healthy BMI. The sample population (red curve) is decidedly to the left of the WHO standard, with its peak at a negative Z-score (of about −1). This indicates that the children in the sample are thinner, on average, than the healthy international reference. In addition, the red curve presents significantly more children in the negative Z-score intervals (below −2 and −3 Z-scores), validating a high prevalence of thinness and severe thinness (being underweight) among the sample group. This indicates that under nutrition or malnutrition is the predominant public health issue among the population studied.

5. Association between Anthropometic and parental education of the selected tribal school children

The socioeconomic profile of the study population emerged as an important determinant of children nutritional status. The table below demonstrates a statistically significant association between parental education levels and the BMI-for-age categories among the study participants. These findings also highlight the crucial influence of parental nutrition and education on the overall nutritional status of children.

Table 3: Association between Parents Education and BMI-for-Age Categories

Socioeconomic Variable	Category	Severe Thinness (<−3SD) %	Thinness (<−2SD)%	Normal (−2SD to +1SD)%	Overweight (>+1SD)%	Obese (>+2SD)%	χ^2 value	p-value
Parental Education	Illiterate	10.5	45	36	8	1	7.1	0.029
	Primary/Middle educated	2.5	21	71	6	3		

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Values represent percentage distribution of BMI-for-age categories according to parental education levels. Statistical test: Chi-square (χ^2); $p < 0.05$ considered statistically significant.

The above table 3 illustrates a strong relationship between BMI-for-age and parental education ($\chi^2 = 7.12$, $p = 0.029$). Among the 97 tribal school children, the ones whose parents lacked formal education had a higher incidence of undernutrition, with 10.5% showing severe thinness and 45% being classified as thin. In contrast, children from families with parents holding primary or middle-level education had lower rates of severe (>2.5%) and thinness (21%). On the contrary, obesity and overweight were more prevalent among children of educated parents (6% overweight and 2.5% obese) than among those of illiterate parents (8% overweight and 1% obese). The implications of the study findings are that nutrition education and awareness programs are paramount to the illiterate and primary-educated parents.

5. Association between Anthropometic and family income of the selected tribal school children

Family income represents a key socioeconomic factor affecting the nutritional status of the study population. The table under demonstrates a significant association between parental income and the BMI-for-age categories among the study participants. These findings highlight the critical role of economic status in determining nutritional outcomes across both low- and middle-income families.

Table 4: Association between Family income and BMI-for-Age Categories

Socioeconomic Variable	Category	Severe Thinness (<−3SD) %	Thinness (<−2SD) %	Normal (−2SD to +1SD) %	Overweight (>+1SD) %	Obese (>+2SD) %	χ^2 value	p-value
	< 5,000	13	50	38	8	0	6.1	0.048
Family Income (₹)	5,001–10,000	7	26	60	11	6		

Values represent percentage distribution of BMI-for-age categories according to parental family income levels. Statistical test: Chi-square (χ^2); $p < 0.05$ considered statistically significant.

From the above Table 4 it was observed that there was a significant association between parental income and BMI ($\chi^2 = 6.1$, $p = 0.048$), the children in the ₹5,000/month family income group showed more cases of malnutrition (13% severe thinness and 50% thinness) when compared to the people in the ₹5,001-10,000 group (7% and 26%, respectively), while the higher-income categories had just a bit more overweight and obesity (11% overweight and 6% obese) the general interpretation of the results is that even small rises in income lead to better nutrition, but proper nutrition knowledge is still essential to get rid of malnutrition problems.

5. Association between Anthropometic and parental occupation status of the selected tribal school children

Parental occupation represents an important determinant of nutritional status among children. The table below demonstrates the association between BMI-for-age categories and parental occupation within the study participants

Table 5: Association between Parents occupation and BMI-for-Age Categories

Socioeconomic Variable	Category	Severe Thinness (<−3SD) %	Thinness (<−2SD) %	Normal (−2SD to +1SD) %	Overweight (>+1SD) %	Obese (>+2SD) %	χ^2 value	p-value
Parental Occupation	Daily wage labor	9	44	41	6	0	6.5	0.038
Parental Occupation	Private sector	3	21	55	17	3		
Parental Occupation	Unemployed	11	39	42	6	3		

Values represent percentage distribution of BMI-for-age categories according to parental occupation levels. Statistical test: Chi-square (χ^2); $p < 0.05$ considered statistically significant.

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The analysis of data presented in Table 6 reveals a strong correlation between income of the parents and Body Mass Index (BMI) ($\chi^2 = 6.54$, $p = 0.038$). The condition of under nutrition was most severe among children of daily wage laborers (9% with severe thinness and 44% with thinness) and unemployed parents (11% and 39%) when compared to the private sector (3% children with severe thinness and 21% children with thinness), while overweight and obesity were more frequent among the latter group (17% overweight and 3% obese). These observations underline the existence of a dual burden of malnutrition; under nutrition still prevails among the poorest while over nutrition has developed in the families of slightly better-off. Even in the same lower middle-income category, communities suffered from both undernourishment and over nourishment. All the participants and their parents received personalized nutrition education and counseling aimed at raising dietary awareness and encouraging the adoption of healthy food habits. Jeyakumar et al. (2021) in their study reported that as per Z score, prevalence of stunting, wasting, and underweight were 48%, 13%, and 43%, respectively. The high prevalence of anthropometric failure among tribal children highlights the urgent need for immediate interventions to address existing undernutrition, along with long-term strategies aimed at enhancing maternal literacy and nutritional awareness to prevent and manage child malnutrition.

V. CONCLUSION

Annaikatti represents a community where both under nutrition and over nutrition occur simultaneously. Thinness and severe thinness appeared more frequently among girls aged 10–14 years, while excess weight and obesity were more prevalent among younger boys (ages 5 to 9 years). Lower levels of parental education, restricted income, and precarious jobs were associated with increased under nutrition, whereas improved socioeconomic standing correlated with excessive nutrition. Nutrition Educational initiatives were implemented to inform children and parents about well-rounded regional diets, hygiene, and nutritious eating habits. Despite government school meal programs, problems such as insufficient monitoring, food wastage, picky eating, and inactivity contribute to nutritional imbalance. The BMI-for-age distribution showed a leftward shift from WHO standards, suggesting continued susceptibility. Enhancing school-based nutrition monitoring, dietary recommendations, and implementing lifestyle interventions is crucial for boosting the health and development of tribal children.

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