RESEARCH PAPER

Nutritional status and its determinants among school-going adolescents in Ambala district, Haryana: a cross-sectional study

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Abstract

Background: Adolescence is a nutritionally sensitive stage of rapid growth, and changing food environments in North India may be reshaping adolescent nutrition. This study assessed the nutritional status of school-going adolescents in Ambala district, Haryana, and examined socio-demographic and lifestyle factors associated with body mass index (BMI)-for-age.

Methods: A school-based cross-sectional study was conducted among 1,300 adolescents aged 10–16 years selected from urban and rural schools by non-probability convenience sampling. Weight, height and waist circumference were measured; BMI was classified using Indian Academy of Pediatrics (IAP) charts, and BMI-for-age Z-scores (BAZ) were derived from the WHO 2007 growth reference. Associations with sex, age, residence, socioeconomic status and lifestyle factors were tested using the chi-square test, one-way ANOVA and Pearson correlation, with $p<0.05$ considered significant.

Results: By IAP BMI classification, 52.5% of adolescents had normal weight, 36.2% were underweight, 8.5% were overweight and 2.8% were obese. By WHO BAZ, 32.2% were thin and 26.9% severely thin, with a mean BAZ of −1.619, indicating a population skewed toward undernutrition. Sex was the only socio-demographic factor significantly associated with nutritional status (ANOVA $F=6.409$, $p<0.001$; chi-square $p=0.001$). Nutritional status did not differ significantly by residence, family type, socioeconomic class, physical activity, junk-food intake, screen time or sleep duration (all $p>0.05$). BAZ correlated strongly with BMI ($r=0.824$) and weight ($r=0.473$), negatively with height ($r=-0.628$), and showed no significant correlation with waist circumference ($r=0.042$, $p=0.133$).

Conclusion: Undernutrition is highly prevalent among school-going adolescents in Ambala, with a large proportion near the clinical threshold of thinness. Biological sex was a more important determinant of nutritional status than residence or household-level factors, suggesting regional convergence of adolescent lifestyles. Gender-sensitive nutrition support and routine school-based anthropometric screening are warranted.

Keywords: Adolescents; Nutritional status; BMI-for-age Z-score; Underweight; Thinness; Haryana; India

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Introduction

Adolescence is a period of transformative physical, cognitive and emotional development during which nutritional requirements are high yet dietary intake is frequently inadequate. Nutrition in this window shapes the timing and pattern of puberty, adult height, muscle and fat accrual, and later risk of non-communicable disease, with effects that extend across generations [1]. The current generation of adolescents is growing up amid rapid change in food environments, in which persisting micronutrient deficiency and food insecurity coexist with rising overweight and obesity [1,2].

Despite the size and importance of this age group, adolescent nutrition has been comparatively neglected in research and policy [2]. In low- and middle-income countries, school-age children and adolescents experience a double burden of malnutrition, with stunting, thinness and micronutrient deficiencies alongside increasing overweight, driven by transitions toward energy-dense, micronutrient-poor diets [3]. In India, thinness and stunting remain highly prevalent among adolescents and are patterned by age, sex and household socioeconomic position [4].

Haryana is an agriculturally prosperous but rapidly urbanising state where dietary and lifestyle patterns are shifting. Ambala district, situated at the intersection of urban and rural zones and bordering Punjab and Himachal Pradesh, offers a setting to examine adolescent nutrition across a dietary transition. Prior work among adolescent girls in Ambala reported a high burden of malnutrition, with more rural than urban girls affected [5]. However, most regional studies have focused on girls, leaving the nutritional status of adolescent boys comparatively under-studied.

The choice of growth reference also matters: adult BMI cut-offs can misclassify adolescent nutritional status relative to age- and sex-specific BMI-for-age Z-scores (BAZ), and international growth charts differ in accuracy across populations [6,7]. Against this background, the present study aimed to assess the nutritional status of school-going adolescents aged 10–16 years in Ambala district using both IAP BMI classification and WHO BAZ, and to examine the socio-demographic and lifestyle factors associated with BMI-for-age.

Materials and Methods

Study design and setting

A school-based cross-sectional study was conducted over 18 months in government and private schools located in urban and rural areas of Ambala district, Haryana, India, by the Department of Paediatrics, MMIMSR, Mullana.

Participants

School-going adolescents of either sex studying in classes 6 to 12 (aged 10–16 years) were eligible. Adolescents whose consent/assent was not available and those with a known chronic medical disorder (cardiac, renal, gastrointestinal or endocrine) were excluded.

Sample size and sampling

The sample size was calculated using $N = Z^2P(1-P)/d^2$, with Z=1.96 (95% confidence), an assumed prevalence P=16% and absolute error d=5%, yielding approximately 1,290 and rounded to 1,300. Participants were recruited from accessible schools using non-probability convenience sampling within the data-collection period.

Measurements and definitions

Weight was measured to the nearest 100 g using a calibrated electronic weighing scale, and height to the nearest 0.5 cm using a stadiometer with the participant barefoot and the head in the Frankfurt plane. BMI was calculated as weight (kg) divided by height (m) squared. Nutritional status was classified in two ways: (i) using IAP BMI-for-age charts (thinness, normal, overweight, obese class 1, obese class 2); and (ii) using BMI-for-age Z-scores based on the WHO 2007 growth reference (severe thinness $Z<-3$ SD; thinness -3 to <-2 SD; normal -2 to $\leq+1$ SD; overweight $>+1$ to $\leq+2$ SD; obese $>+2$ SD). Waist circumference was measured with a non-elastic tape at the iliac crest and dichotomised using the IAP 70th centile cut-off. Screen time (≤2 vs >2 h/day), physical activity (≤1 vs >1 h/day), sleep duration (<7 vs ≥7 h/day), junk-food consumption and family history of chronic disease (diabetes/hypertension) were recorded by structured proforma. Socioeconomic status was classified using the Modified B.G. Prasad scale for rural participants and the Modified Kuppuswamy scale for urban participants.

Statistical analysis

Data were entered in Microsoft Excel and analysed using SPSS version 23.0. Frequencies and cross-tabulations were computed; the chi-square test was used to test associations between categorical variables and BAZ category, one-way ANOVA to compare socio-demographic variables across BAZ categories, and Pearson correlation to assess relationships between BAZ and anthropometric measures. A p-value <0.05 was considered statistically significant.

Ethical considerations

Informed consent was obtained prior to data collection, and confidentiality and privacy of participants were maintained throughout the study.

Results

Participant characteristics

A total of 1,300 adolescents were studied. The mean age was 12.63 ±1.33 years; 738 (56.8%) were female and 562 (43.2%) male. Urban participants numbered 697 (53.6%) and rural 603 (46.4%). Most belonged to nuclear families (72.3%), reported >1 h/day of physical activity (79.5%), ≥7 h/day of sleep (79.1%) and consumed junk food (85.6%); 47.2% reported >2 h/day of screen time and 23.3% had a positive family history of chronic disease. The demographic profile is summarised in Table 1.

Table 1. Demographic and lifestyle profile of participants (N=1,300).

Characteristic	Category	n	%
Sex	Male	562	43.2
	Female	738	56.8
Residence	Urban	697	53.6

	Rural	603	46.4
Family type	Nuclear	940	72.3
	Joint	360	27.7
Physical activity	>1 h/day	1034	79.5
	≤1 h/day	266	20.5
Junk-food intake	Yes	1113	85.6
	No	187	14.4
Screen time	>2 h/day	613	47.2
	≤2 h/day	687	52.8
Sleep duration	≥7 h/day	1028	79.1
	<7 h/day	272	20.9
Family history of chronic disease	Positive	303	23.3
	Negative	997	76.7
Socioeconomic class	Class I	121	9.3
	Class II	141	10.8
	Class III	417	32.1
	Class IV	483	37.2
	Class V	138	10.6

Nutritional status

By IAP BMI classification, 682 adolescents (52.5%) had normal weight, 470 (36.2%) were underweight, 111 (8.5%) overweight, 34 (2.6%) obese class 1 and 3 (0.2%) obese class 2 (Table 2). When BMI-for-age Z-scores were applied using the WHO 2007 reference, the burden of undernutrition was higher: 419 (32.2%) were classified as thin and 350 (26.9%) as severely thin, while 350 (26.9%) were normal, 112 (8.6%) overweight and 69 (5.3%) obese. The mean BAZ was −1.619, which lies within the normal band but close to the −2 SD thinness threshold, indicating a population skewed toward undernutrition (Table 2).

Table 2. Nutritional status by IAP BMI classification and WHO 2007 BMI-for-age Z-score (BAZ) (N=1,300).

IAP BMI category	n (%)	WHO BAZ category	n (%)
Underweight	470 (36.2)	Severe thinness (Z<−3)	350 (26.9)
Normal	682 (52.5)	Thinness (−3 to <−2)	419 (32.2)
Overweight	111 (8.5)	Normal (−2 to ≤+1)	350 (26.9)
Obese class 1	34 (2.6)	Overweight (>+1 to ≤+2)	112 (8.6)
Obese class 2	3 (0.2)	Obese (>+2)	69 (5.3)
—	—	Mean BAZ	−1.619

Factors associated with nutritional status

On one-way ANOVA comparing socio-demographic variables across BAZ categories, sex was the only variable that differed significantly (F=6.409, p<0.001), while age (F=0.771, p=0.544), family type (F=0.371, p=0.829), number of siblings (F=2.253, p=0.061), family history of chronic disease (F=0.942, p=0.439) and socioeconomic class (F=0.906, p=0.459) did not.

Chi-square analyses of individual factors against BAZ category (Table 3) confirmed a significant association for sex (p=0.001): overweight and obesity were more frequent among females, and thinness slightly more frequent among males. Age was also significantly associated with BAZ category on chi-square testing (p=0.001). No significant association was found for residence, family type, number of siblings, socioeconomic class, physical activity, junk-food intake, screen time, sleep duration, family history of chronic disease or waist circumference (all $p>0.05$).

Table 3. Association of socio-demographic and lifestyle factors with WHO BMI-for-age Z-score category (chi-square test).

Factor	p-value	Association
Sex	0.001	Significant
Age	0.001	Significant
Residence (urban/rural)	0.150	Not significant
Family type	0.829	Not significant
Number of siblings	0.309	Not significant
Socioeconomic class	0.438	Not significant
Physical activity	0.775	Not significant
Junk-food intake	0.965	Not significant
Screen time	0.289	Not significant
Sleep duration	0.289	Not significant
Family history of chronic disease	0.438	Not significant
Waist circumference	0.296	Not significant

Correlation with anthropometric parameters

BMI-for-age Z-scores correlated strongly and positively with BMI ($r=0.824$, $p<0.001$) and moderately with weight ($r=0.473$, $p<0.001$), and strongly negatively with height ($r=-0.628$, $p<0.001$). No significant correlation was observed between BAZ and waist circumference ($r=0.042$, $p=0.133$) (Table 4).

Table 4. Pearson correlation of WHO BMI-for-age Z-score with anthropometric parameters (N=1,300).

Parameter	r	p-value
BMI	0.824	<0.001
Weight	0.473	<0.001
Height	−0.628	<0.001
Waist circumference	0.042	0.133

Discussion

In this cross-sectional study of 1,300 school-going adolescents in Ambala district, more than half had a normal BMI by IAP classification, but undernutrition remained the dominant deviation: over one-third were underweight, and by WHO BAZ nearly three in five were thin or severely thin. The mean BAZ of −1.619, close to the −2 SD threshold, indicates a population at high risk of tipping into clinical thinness. The higher undernutrition burden captured by BAZ than by adult-derived BMI cut-offs is consistent with reports that BMI-based classification can underestimate adolescent thinness relative to age- and sex-specific Z-scores [6], reinforcing the value of BAZ for adolescent screening [7].

The persistence of thinness in an agriculturally prosperous state echoes the wider double burden of malnutrition described across low- and middle-income countries, where undernutrition coexists with emerging overweight amid dietary transition [3]. A smaller but clinically relevant proportion of adolescents were overweight or obese, indicating that schools in the district face both ends of the nutrition spectrum simultaneously.

Biological sex was the strongest determinant of nutritional status, significant on both ANOVA and chi-square testing, with a higher proportion of overweight/obesity among girls and of thinness among boys. Sex differences in physiology, pubertal timing, physical activity and food preferences plausibly underlie this pattern, and sex-patterned adolescent undernutrition has been reported elsewhere in India [4]. In contrast, residence, family type, number of siblings, socioeconomic class and family history of chronic disease were not significantly associated with nutritional status. The near-identical urban and rural distributions suggest convergence of adolescent diets and lifestyles across the rural–urban divide in this region.

Lifestyle factors—physical activity, junk-food intake, screen time and sleep duration—were not significantly associated with BAZ. This may reflect a saturation of exposure: behaviours such as frequent junk-food consumption (85.6%) and adequate reported sleep and activity were near-universal in the sample, limiting the variation needed to detect associations. These findings are consistent with school-based work from North India documenting widespread dietary risk factors alongside a coexistence of thinness and obesity [9].

BAZ correlated strongly with BMI and weight and negatively with height, the latter consistent with early-adolescent growth in which linear growth can outpace weight gain, producing relatively lower weight-for-height among taller students. The absence of a significant correlation between BAZ and waist circumference suggests that overall nutritional status and central adiposity are not interchangeable in this age group, in keeping with evidence that BMI-based indices do not fully capture body-fat distribution during adolescence [8]. Incorporating measures such as waist-to-height ratio may add value in identifying central adiposity that BAZ alone can miss.

Strengths of this study include a large sample drawn from both urban and rural schools and the parallel use of IAP and WHO references. Several limitations should be noted. The cross-sectional design precludes causal inference. Convenience sampling and restriction to school-going adolescents in a single district limit generalisability, particularly to out-of-school adolescents. Lifestyle exposures were self-reported and may be subject to reporting bias, and biochemical or micronutrient assessment was beyond the scope of the study, so sub-clinical deficiencies could not be characterised.

Conclusion

Undernutrition is highly prevalent among school-going adolescents in Ambala district, with a large proportion positioned close to the clinical threshold of thinness. Biological sex emerged as the principal determinant of nutritional status, whereas residence, socioeconomic class and household-level factors were not predictive, pointing to a regional convergence of adolescent lifestyles. Public health responses should prioritise gender-sensitive nutrition support and institutionalised, twice-yearly school-based anthropometric screening using BMI-for-age Z-scores to identify and support adolescents at risk before clinical thinness develops.

Declarations

Ethics approval and consent: The study was conducted as an MD thesis in the Department of Paediatrics, MMIMSR, Mullana. Informed consent/assent was obtained from participants and, as applicable, their parents/guardians, and confidentiality was maintained. [Author query: insert Institutional Ethics Committee approval number and date.]

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Author contributions: HPR conceived and conducted the study, collected and analysed the data, and drafted the manuscript. BM supervised the study and critically revised the manuscript. HK contributed to study design and manuscript review. All authors approved the final version.

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