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High-Fat, Salt, and Sugar (HFSS) Food Consumption Patterns and Nutritional Status Among School and College Students in Urban Telangana, India: A Cross-Sectional Study

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List of Abbreviations

Abbreviation	Full Term
aOR	Adjusted Odds Ratio
BMI	Body Mass Index
CI	Confidence Interval
CTRI	Clinical Trials Registry–India
DFS	Dietary Food Score
FSSAI	Food Safety and Standards Authority of India
HFSS	High-Fat, Salt, and Sugar (foods)
ICMR	Indian Council of Medical Research
ICMR-NIN	ICMR–National Institute of Nutrition
IPAQ	International Physical Activity Questionnaire
IQR	Interquartile Range
KAP	Knowledge, Attitude, and Practice
NCD	Non-Communicable Disease
NFHS	National Family Health Survey
NIN	National Institute of Nutrition
NULRISC	Nutrition and Lifestyle Risk Surveillance System (for Schools and Colleges in India)
OBC	Other Backward Class
PCA	Principal Component Analysis
SC	Scheduled Caste
SD	Standard Deviation
SES	Socioeconomic Status

Abbreviation	Full Term
SSB	Sugar-Sweetened Beverage
ST	Scheduled Tribe
UPF	Ultra-Processed Food
WHO	World Health Organization

ABSTRACT

Background

Strong dietary behaviours are formed mostly during adolescence and young adulthood, making these periods critical, and the rising consumption of high-fat, salty, and sugary (HFSS) foods in urban India is a significant public health concern. India's National Family Health Surveys document an accelerating dual burden of malnutrition - rising overweight and obesity alongside persistent undernutrition -that is particularly pronounced in urban adolescent populations. Despite this, city-specific evidence on HFSS consumption patterns and their relationship to nutritional status among the 12–25-year age group remains limited in South India.

Objective

To analyse the consumption patterns of HFSS foods among adolescents and young adults in urban Telangana, India, and to classify the types of foods consumed.

Methods

A cross-sectional study was conducted among 845 participants (323 school students; 522 college students) aged 12–25 years across 16 institutions in three districts of urban Telangana as part of the ICMR-funded NULRISC project. HFSS intake was assessed using a nine-item seven-day food frequency questionnaire. Nutritional status was classified using WHO BMI-for-age z-scores (for ages below 19 years) and WHO Asian cut-offs (for ages 19 years and above); the resulting thinness/underweight and overweight/obesity categories combine two age-specific reference systems. Bivariate chi-square analyses and cluster-adjusted multinomial logistic regression (normal BMI as reference) identified independent predictors of BMI category.

Results

Thinness/underweight (pooled across the WHO BMI-for-age and WHO Asian adult BMI classification systems; hereafter "underweight") and overweight/obesity were observed in 20.7% and 23.7% of participants, respectively, demonstrating a double burden of malnutrition. In the unadjusted analysis, high HFSS consumption was associated with a higher prevalence of underweight compared with low HFSS consumption (24.55% vs. 16.54%; $p = 0.015$), with a similar association among school students ($p = 0.016$), but was not associated with overweight/obesity. However, HFSS consumption was not independently associated with either nutritional outcome in the cluster-adjusted multivariable analysis. Participants aged 19–25 years had significantly higher odds of both thinness (aOR 2.46; 95% CI: 1.71–3.53) and overweight/obesity (aOR 2.84; 95% CI: 1.77–4.54). A high Dietary Diversity Score was independently associated with thinness (aOR 2.04; 95% CI: 1.26–3.28), whereas moderate physical activity was associated with lower odds of thinness (aOR 0.69; 95% CI: 0.49–0.97).

Conclusion

The urban South Indian population, HFSS consumers were disproportionately underweight and also overweight, reflecting the dual burden of malnutrition characteristic of the nutrition transition. Age and dietary quality were stronger independent determinants of nutritional status than HFSS intake alone. Nutrition interventions and surveillance at individual and policy level must simultaneously address undernutrition and overweight across school and college settings; this makes the marked need for surveillance starting from this age group.

Trial registration: Clinical trial number: CTRI/2025/07/089988, Clinical Trials Registry–India (<http://ctri.nic.in/>), registered on 02.07.2025.

Keywords: HFSS foods; adolescent nutrition; nutritional status; nutrition transition; dual burden; NULRISC

1. BACKGROUND

Overweight and obesity have emerged as one of the most concerning public health challenges of the twenty-first century, and their epidemiology is shifting rapidly from high-income to low- and middle-income countries. According to the World Health Organization, in 2022 more than 390 million children and adolescents aged 5–19 years were living with overweight, including 160 million with obesity, while 2.5 billion adults were overweight, of whom 890 million were living with obesity more than double the proportion recorded in 1990(1). The prevalence of overweight (including obesity) among 5–19-year-olds rose from just 8% in 1990 to 20% in 2022, and adolescent obesity quadrupled over the same period (1). Critically, this rise increasingly coexists with persistent undernutrition, producing the "double burden of malnutrition" the simultaneous occurrence of undernutrition and overnutrition within the same populations, households, and even individuals—which is now recognized as a defining feature of the contemporary global nutrition reality (2)

This transition is strongly evident in South Asia. UNICEF's 2025 Child Nutrition Report, *Feeding Profit: How Food Environments Are Failing Children*, documented a historic turning point: for the first time, obesity has overtaken underweight as the most prevalent form of malnutrition among school-aged children and adolescents (5–19 years) globally. Drawing on data from over 190 countries, the report found that the prevalence of underweight in this age group fell from nearly 13% to 9.2% between 2000 and 2025, while obesity rose from 3% to 9.4%, such that "obesity surpassed underweight as the more prevalent form of malnutrition this year, affecting 1 in 10/188 million school-aged children and adolescents" (3). South Asia and sub-Saharan Africa remain the two regions where underweight still predominates, but the region is changing rapidly: UNICEF reports that "the number of children aged 5–19 living with overweight has increased fivefold to 70 million in South Asia since 2000... Obesity among children has more than doubled in the same period, while undernutrition and anemia remain stubbornly high" (3,4). India exemplifies this trajectory. Successive rounds of the National Family Health Survey (NFHS) show overweight/obesity among adolescent girls rising from 2.4% to 5.4% and among adolescent boys from 1.7% to 6.6% between NFHS-3 (2005–06) and NFHS-5 (2019–21), while adult women increased from 12.6% to 24.0% and adult men from 9.3% to 22.9% over the same interval (5). The most recent NFHS-6 (2023–24) reports that 30.7% of women and 27.3% of men aged 15–49 are now overweight or obese nationally, rising to 42.8% and 36.3% respectively in urban areas, even as childhood and adolescent undernutrition persists(6,7). Projections indicate that India will be home to over 27 million children and adolescents with obesity by 2030 among the highest absolute burdens worldwide, behind only China-accounting for approximately 11% of the global total (8)

Adolescence and young adulthood (approximately 12–25 years) constitute a critical window for the consolidation of dietary habits and the emergence of long-term cardiometabolic risk. Excess weight acquired during this period frequently tracks into adulthood, and a systematic review and meta-analysis by Umer and colleagues concluded that childhood and adolescent obesity is significantly and positively associated with elevated adult systolic and diastolic blood pressure and triglycerides, and negatively associated with adult HDL cholesterol, with associations persisting after adjustment for adult obesity status(9). This life-course vulnerability makes the eating behaviours established during the school and college years especially consequential for the future non-communicable disease burden.

These behaviours are being reshaped by India's ongoing nutrition transition and rapid urbanisation. Rising incomes, changing occupational and labour-market structures, and the penetration of transnational food retail have driven a shift away from traditional diets toward energy-dense patterns high in saturated fat, refined sugar, and ultra-processed foods, coupled with declining physical activity (10,11). This dietary shift has a measurable economic footprint: as cited in the Economic Survey of India 2024–25, retail sales of ultra-processed foods in India surged from approximately USD 900 million in 2006 to USD 37.9 billion in 2019 (12). Urban populations are particularly exposed, enjoying greater physical proximity to inexpensive, heavily marketed, ready-to-eat foods and consuming more food away from home (13).

Within this landscape, high-fat, salt, and sugar (HFSS) foods have become ubiquitous. The Food Safety and Standards Authority of India (FSSAI), in its draft front-of-pack nutrition labelling framework under the Food Safety and Standards (Labelling and Display) Regulations, 2020, characterises HFSS foods as processed products containing high levels of saturated fat, total or added sugar, or sodium specifically, products in which energy from total sugar exceeds 10% of total energy, energy from saturated fat exceeds 10% of total energy, or sodium exceeds 1 mg per kcal (14). India's national dietary guidance reinforces these concerns: Guideline 15 of the ICMR–National Institute of Nutrition's *Dietary Guidelines for Indians (2024)* classifies diets deriving more than 15% of energy from visible fats/oils, containing more than 5 g of salt (sodium >2 g) per day, or more than 25 g of added sugar per day (>5% of energy at 2,000 kcal) as "high" (15). HFSS and sugar-sweetened-beverage consumption is consistently associated with obesity, insulin resistance, hypertension, and dyslipidaemia in young people; a meta-analysis of nearly 94,000 participants found that high sugar-sweetened-beverage consumers were 1.36 times more likely to be hypertensive than low consumers (16).

Despite mounting national concern, robust city-level data on HFSS consumption across the combined 12–25 age bracket spanning both school and college environments remain limited, particularly in South India. School and college settings differ structurally in food access, personal autonomy, peer influence, and parental oversight, yet the two are rarely examined together within a single study population. A cross-sectional study of 409 college students in urban Hyderabad found that 46.4% consumed junk food on more than three days per week, with consumption significantly higher among females and only 5.8% abstaining altogether (17), while school-based studies elsewhere in South India report high fast-food intake and rising overweight, with frequent fast-food consumption independently predicting excess body weight (18). Despite this growing body of evidence, an integrated, item-level characterization of HFSS consumption spanning the transition from the relatively supervised school environment to the more autonomous college environment within a single urban setting remains lacking. Existing Indian studies have typically examined school children and young adults as separate populations, precluding direct comparison of consumption patterns across these two structurally distinct food environments. Addressing this gap is essential for designing setting-specific interventions and for establishing surveillance systems capable of tracking nutritional risk across the adolescent-to-young-adult continuum. (19)

The present study was therefore undertaken as part of the formative research phase of the ICMR-funded project "Developing a Model Nutrition and Lifestyle Risk Surveillance System for Schools and Colleges in India (NULRISC)." The specific objectives were: (i) to characterise item-level HFSS food consumption patterns among school and college students in urban Telangana; (ii) to examine the association between composite HFSS intake and nutritional status as defined by body mass index; and (iii) to ascertain the sociodemographic, dietary, and lifestyle factors independently associated with undernutrition and overweight/obesity in this population.

2. METHODOLOGY

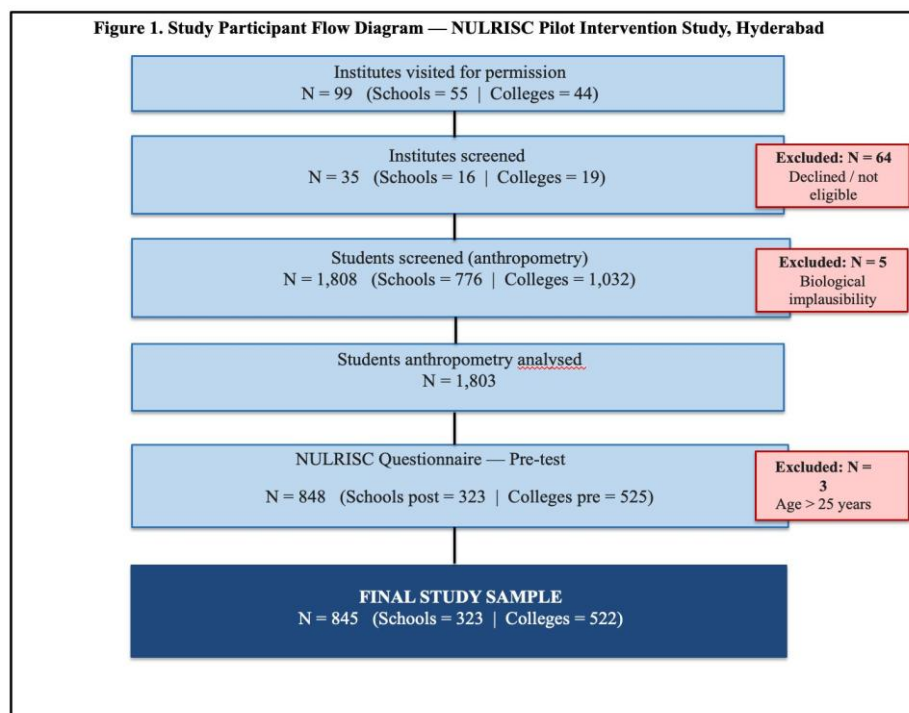
2.1 STUDY DESIGN & SETTING:

A cross-sectional study was conducted as part of the formative research phase of the ICMR-funded project, "Developing a Model Nutrition and Lifestyle Risk Surveillance System for Schools and Colleges in India (NULRISC)" (Project ID: IIRP-2023-0000178), which aims to develop an mHealth-based surveillance platform for monitoring nutrition and lifestyle risk factors among school and college students in India. The study was carried out among students aged 12–25 years across eight high schools (grades 8–12) and eight degree colleges in three districts of urban Telangana: Hyderabad, Medchal-Malkajgiri, and Rangareddy encompassing both government and private institutions. This dual-institution design enabled comparison of HFSS food consumption patterns and their association with nutritional status across two institutionally distinct groups: adolescents in school settings and young adults in undergraduate college settings.

2.2 Sample Size and Sampling

This cross-sectional study represents the baseline assessment of an ongoing cluster randomised controlled trial (cRCT) within the larger NULRISC surveillance system development project. The present analysis includes only baseline data collected before randomisation of participating institutions. A total of 845 participants (323 school students and 522 college students) were recruited from eight high schools and eight degree colleges purposively selected to ensure representation by district and institution type (government and private) across three urban districts of Telangana (Hyderabad, Medchal-Malkajgiri, and Rangareddy). Within each institution, participants were selected using systematic random sampling from class rosters.

Participants were eligible for inclusion if they were aged 12–25 years, currently enrolled in one of the selected institutions, and free from any diagnosed chronic illness. Written informed consent was obtained from all participants; for those under 18 years of age, written assent accompanied by parental or guardian consent was required prior to enrolment. Students absent on the scheduled day of data collection who could not be revisited within the data collection window were excluded.



2.3 DATA COLLECTION:

Data were collected using a structured self-administered questionnaire in English language developed as part of the NULRISC surveillance system to assess nutritional and lifestyle risk factors, obesogenic behaviours, and environmental determinants of nutritional status among students. The questionnaire comprised modules covering sociodemographic characteristics, dietary intake, nutritional knowledge and food label behaviour, physical activity, sleep and screen time, and mental health and behavioural risk factors. The questionnaire was developed drawing on validated tools and National Institute of Nutrition (NIN) dietary guidelines, reviewed by content experts, and pre-tested in a pilot sample prior to final administration. The questionnaire was administered in printed form and completed by students in their respective classrooms under the supervision of trained field investigators.

Anthropometric measurements: height and weight were collected by trained field investigators using standardised procedures and calibrated SECA (Digital Weighing scale: Seca 876 and Stadiometer: Seca 213) anthropometric

equipment. Data were subsequently entered into Microsoft Excel for verification, cleaning, and preparation for statistical analysis.

2.4 Variables Measured

2.4.1 Sociodemographic Variables

Sociodemographic information collected included sex, age group (12–18 years; 19–25 years), institute type (school/college), district of residence, religion, caste (Scheduled Caste, Scheduled Tribe, Backward/OBC, Other), and socioeconomic status. Wealth was assessed using a principal component analysis (PCA)-based wealth index derived from household asset data and categorised into tertiles: low, medium, and high.

2.4.2 Dietary Assessment

HFSS Consumption: The frequency of consumption of nine HFSS (high fat, salt, and sugar) food categories was assessed using a food frequency questionnaire capturing intake over the preceding week. The nine categories were: sugar-sweetened beverages (SSBs), bakery foods, packaged namkeen, instant foods, biscuits and cookies, street food/chaat, fast food corner meals, outside breakfast, and desserts and sweets(20). Frequency of consumption was recorded on a four-point scale: 0 days/week, 1–2 days/week, 3–4 days/week, and 5–7 days/week and each frequency category scored 0/1/2/3 (0 days=0, 1–2 days=1, 3–4 days=2, 5–7 days=3). A composite HFSS score was derived by summing frequency scores across all nine items. The median composite score was used to dichotomise participants into low (below median) and high (at or above median) HFSS consumers.

A composite Dietary Food Score (DFS) was computed for participants, using a scoring approach analogous to the HFSS composite score, as a surveillance-derived indicator of the frequency and range of food groups consumed. The DFS was derived by summing frequency scores across the relevant food groups assessed in the questionnaire, and the median composite score was used to dichotomise participants into low (below median) and high (at or above median) DFS categories. This surveillance-derived score has not been independently validated as a measure of dietary diversity, quality, or energy adequacy in this population(15).

2.4.3 Nutritional Status

Anthropometric measurements of height and weight were obtained by trained field investigators using standardised procedures. Height was measured to the nearest 0.1 cm using a portable stadiometer, and weight to the nearest 0.1 kg using a calibrated digital weighing scale, with participants wearing light clothing and no footwear. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). For participants aged below 19 years, BMI-for-age z-scores were computed and classified using age- and sex-specific WHO references, while participants aged 19 years and above were categorised using WHO Asian cut-offs: underweight ($<18.5 \text{ kg}/m^2$), normal ($18.5\text{--}22.9 \text{ kg}/m^2$), and overweight/obese ($\geq 23.0 \text{ kg}/m^2$). Because these two systems use different pediatric and adult definitions, the resulting categories are hereafter reported as the pooled labels "thinness/underweight" and "overweight/obesity"(21)

2.4.4 Knowledge and Food Label Behaviour

Nutritional knowledge was assessed through four items from the KAP section of the questionnaire: (1) ability to correctly define obesity, (2) knowledge of the health consequences of consuming high-fat foods, (3) habitual behaviour of checking food packaging information when purchasing food, and (4) regular checking of the nutrient composition table on food labels.

2.4.5 Lifestyle Variables

Physical activity was assessed using the short form of the International Physical Activity Questionnaire (IPAQ), which captures moderate and vigorous activity and walking over the preceding seven days. IPAQ categories were assigned as low, moderate, and high based on standard IPAQ scoring guidelines (22). Sedentary behaviour was assessed through two items: average daily sitting time (categorised as <3, 3–5, 6–8, >8 hours, or not sure) and average daily non-academic screen time (categorised as <2, 2–4, 5–7, >7 hours, or not sure). Sleep duration was assessed by self-report and categorised as <6, 6–7, 7–8, or >8 hours per night.

2.5 Statistical Analysis

Data was entered into Microsoft Excel, cleaned, and exported for analysis using Stata (version 17.0; Stata Corp, College Station, TX, USA). Continuous variables were summarized as means and standard deviations or medians and interquartile ranges, as appropriate, while categorical variables were presented as frequencies and percentages.

BMI was categorized as underweight, normal, and overweight/obese. For participants aged below 19 years, BMI-for-age z-scores were computed using WHO growth references (23), and for those aged 19 years and above, WHO Asian BMI cut-offs were applied (21). HFSS consumption and DFS were derived as composite scores by summing frequency scores across relevant questionnaire items and were dichotomized into low and high categories using the sample median as the cut-off.

Bivariate associations between explanatory variables and BMI category were assessed using the chi-square test. Variables with a p-value < 0.20 in bivariate analysis, along with biologically plausible covariates, were entered into a multinomial logistic regression model with normal BMI as the reference category. The model was adjusted for clustering at the institution level to account for the cluster randomized study design. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported. Statistical significance was set at $p < 0.05$.

Item-level HFSS consumption patterns and their association with BMI were examined separately for school and college students using descriptive statistics and chi-square tests.

2.6 Ethical Approval

The Institutional Ethics Committee of ICMR–National Institute of Nutrition, Hyderabad approved the protocol (Reference No: NIN/IEC/2026/3/RR/007). The proposal was registered with the Clinical Trials Registry-India (CTRI/2025/07/089988 registered on 02.07.2025). Written informed consent was obtained from all adult participants. For participants under 18 years of age, written assent from the participant and consent from a parent or guardian were obtained prior to enrolment. Participation was voluntary, and participants were free to withdraw at any time without consequence. Confidentiality of all participant data was maintained throughout the study.

3. Results

3.1 Study Population

A total of 845 participants were enrolled, comprising 374 males (44.3%) and 471 females (55.7%). The majority were aged 12–18 years (63.4%), and college students constituted 61.8% of the sample (Table 1). Participants were distributed across three districts: Medchal-Malkajgiri (43.7%), Hyderabad (38.7%), and Rangareddy (17.6%). Hinduism was the predominant religion (77.3%), and among those who reported caste, Backward/OBC was the largest group (36.4%). Wealth quintiles were approximately evenly distributed, with low (34.1%), medium (34.1%), and high (31.9%) SES percentiles.

Table 1. Sociodemographic, dietary, knowledge, and lifestyle characteristics of study participants by BMI category (N = 845).

Variable	N	%	Underweight n (%)	Normal n (%)	Overweight/Obese n (%)	*p*
Overall Sample	845	100	175 (20.7)	470 (55.6)	200 (23.7)	
Sex						
Male	374	44.3	92 (24.6)	206 (55.1)	76 (20.3)	
Female	471	55.7	83 (17.6)	264 (56.1)	124 (26.3)	0.017
Age group						
12–18 years	536	63.4	87 (16.2)	337 (62.9)	112 (20.9)	
19–25 years	309	36.6	88 (28.5)	133 (43.0)	88 (28.5)	<0.001
Institute type						
School	323	38.2	39 (12.1)	205 (63.5)	79 (24.5)	
College	522	61.8	136 (26.1)	265 (50.8)	121 (23.2)	<0.001
District (n = 845)						
Hyderabad	327	38.7	84 (25.7)	167 (51.1)	76 (23.2)	
Medchal-Malkajgiri	369	43.7	54 (14.6)	225 (61.0)	90 (24.4)	
Rangareddy	149	17.6	37 (24.8)	78 (52.3)	34 (22.8)	0.004
Religion (n = 792)						
Hindu	612	77.3	118 (19.3)	345 (56.4)	149 (24.3)	
Muslim	107	13.5	28 (26.2)	54 (50.5)	25 (23.4)	
Christian	57	7.2	12 (21.1)	30 (52.6)	15 (26.3)	
Other	16	2.0	3 (18.8)	9 (56.3)	4 (25.0)	0.815
Caste (n = 687)						
Scheduled Caste	164	23.9	38 (23.2)	90 (54.9)	36 (22.0)	
Scheduled Tribe	43	6.3	9 (20.9)	25 (58.1)	9 (20.9)	
Backward/OBC	250	36.4	49 (19.6)	142 (56.8)	59 (23.6)	
Other Caste	230	33.5	51 (22.2)	123 (53.5)	56 (24.4)	0.969
Wealth/SES (n = 731)						
Low	249	34.1	65 (26.1)	129 (51.8)	55 (22.1)	
Medium	249	34.1	48 (19.3)	143 (57.4)	58 (23.3)	
High	233	31.9	32 (13.7)	135 (57.9)	66 (28.3)	0.014
Knowledge of obesity (n = 831)						
Incorrect/Don't know	495	59.6	111 (22.4)	270 (54.5)	114 (23.0)	
Correct	336	40.4	61 (18.2)	193 (57.4)	82 (24.4)	0.329

Knowledge of high-fat risk(<i>n</i> = 833)						
No	156	18.7	43 (27.6)	83 (53.2)	30 (19.2)	
Yes	677	81.3	127 (18.8)	381 (56.3)	169 (25.0)	0.034
Checks food label (<i>n</i> = 831)						
No	547	65.8	123 (22.5)	300 (54.8)	124 (22.7)	
Yes	284	34.2	48 (16.9)	161 (56.7)	75 (26.4)	0.133
Checks nutrient table (<i>n</i> = 831)						
No	559	67.3	125 (22.4)	302 (54.0)	132 (23.6)	
Yes	272	32.7	46 (16.9)	159 (58.5)	67 (24.6)	0.186
Dietary food score (DFS)						
Low	414	48.99	86 (20.77)	221 (53.4)	107 (25.85)	
High	431	51.01	89 (20.65)	249 (57.8)	93 (21.58)	0.308
Physical activity (IPAQ)						
Low	253	29.94	69 (27.27)	132(52.17)	52 (20.55)	
Moderate	437	51.72	81 (18.54)	255(58.35)	101 (23.11)	
High	155	18.34	25 (16.13)	83 (53.55)	47 (30.32)	0.011
Sitting time (<i>n</i> = 826)						
<3 hours	191	23.1	36 (18.9)	114 (59.7)	41 (21.5)	
3–5 hours	296	35.8	58 (19.6)	160 (54.1)	78 (26.4)	
6–8 hours	172	20.8	45 (26.2)	84 (48.8)	43 (25.0)	
>8 hours	105	12.7	17 (16.2)	63 (60.0)	25 (23.8)	
Not sure	62	7.5	12 (19.4)	39 (62.9)	11 (17.7)	0.308
Sleep duration (<i>n</i> = 812)						
<6 hours	155	19.1	35 (22.6)	83 (53.5)	37 (23.9)	
6–7 hours	306	37.7	61 (19.9)	168 (54.9)	77 (25.2)	
7–8 hours	265	32.6	49 (18.5)	155 (58.5)	61 (23.0)	
>8 hours	86	10.6	21 (24.4)	46 (53.5)	19 (22.1)	0.861
Screen time (<i>n</i> = 830)						
<2 hours	236	28.4	34 (14.4)	145 (61.4)	57 (24.2)	
2–4 hours	326	39.3	74 (22.7)	176 (54.0)	76 (23.3)	
5–7 hours	139	16.7	29 (20.9)	74 (53.2)	36 (25.9)	
>7 hours	68	8.2	17 (25.0)	35 (51.5)	16 (23.5)	
Not sure	61	7.3	14 (23.0)	33 (54.1)	14 (23.0)	0.412

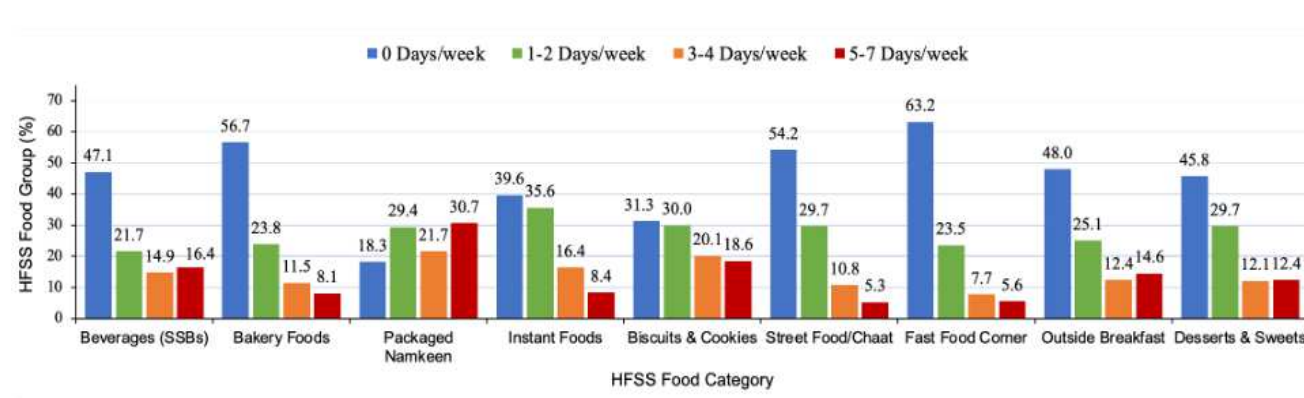
Overall, 20.7% of participants were classified as thinness/underweight, 55.6% had a normal BMI, and 23.7% were overweight or obese. BMI distribution differed significantly by sex ($p = 0.017$), with underweight more prevalent among males (24.6%) than females (17.6%), while overweight/obesity was more common among females (26.3% vs. 20.3%). Age group was strongly associated with BMI ($p < 0.001$) underweight was nearly twice as prevalent among 19–25-year-olds compared to 12–18-year-olds (28.5% vs. 16.2%), and overweight/obesity was similarly higher in the older group (28.5% vs. 20.9%). Institute type showed a significant association ($p < 0.001$), with underweight substantially more prevalent among college students (26.1%) than school students (12.1%). The district of residence was also associated with BMI distribution ($p = 0.004$), with Hyderabad showing the highest underweight prevalence (25.7%) and Medchal-Malkajgiri the lowest (14.6%).

Socioeconomic status was significantly associated with BMI ($p = 0.014$) underweight declined progressively with increasing wealth (low: 26.1%; medium: 19.3%; high: 13.7%), while overweight/obesity showed the opposite trend (low: 22.1%; high: 28.3%), consistent with a socioeconomic gradient in nutritional status. Religion and caste showed no significant association with BMI ($p = 0.815$ and $p = 0.969$, respectively). Among knowledge variables, awareness of high-fat food risks was the only significant predictor ($p = 0.034$), with those unaware showing higher underweight prevalence (27.6% vs. 18.8%). Physical activity assessed by IPAQ was significantly associated with the outcome variable, with most participants in the moderate activity group (51.72%), followed by low (29.94%) and high (18.34%) activity levels. The proportion of obesity increased across activity levels (20.55% in low, 23.11% in moderate, 30.32% in high), while underweight was highest in the low activity group (27.27%) and lowest in the high activity group (16.13%). Checking food labels and the nutrient composition table, knowledge of obesity, dietary food score, and all sedentary behaviour variables like sitting time, screen time, and sleep duration showed no significant association with BMI category (all $p > 0.05$).

3.2 HFSS Consumption Patterns

Among school students (figure 1), packaged namkeen was the most frequently consumed HFSS item, with 30.7% reporting consumption on 5–7 days per week, the highest near-daily consumption rate of any category in this group. Biscuits and cookies were consumed on 3 or more days per week by 38.7% of school students, and outside breakfast by 27.0%. In contrast, fast food corner visits were largely infrequent: 63.2% reported zero consumption per week, and only 5.6% consumed it daily. Similarly, bakery foods (56.7% reporting zero days) and street food/chaat (54.2% zero days) were consumed by the majority of school students. Despite 47.1% of school students reporting no SSB consumption, 16.4% consumed SSBs on five or more days per week.

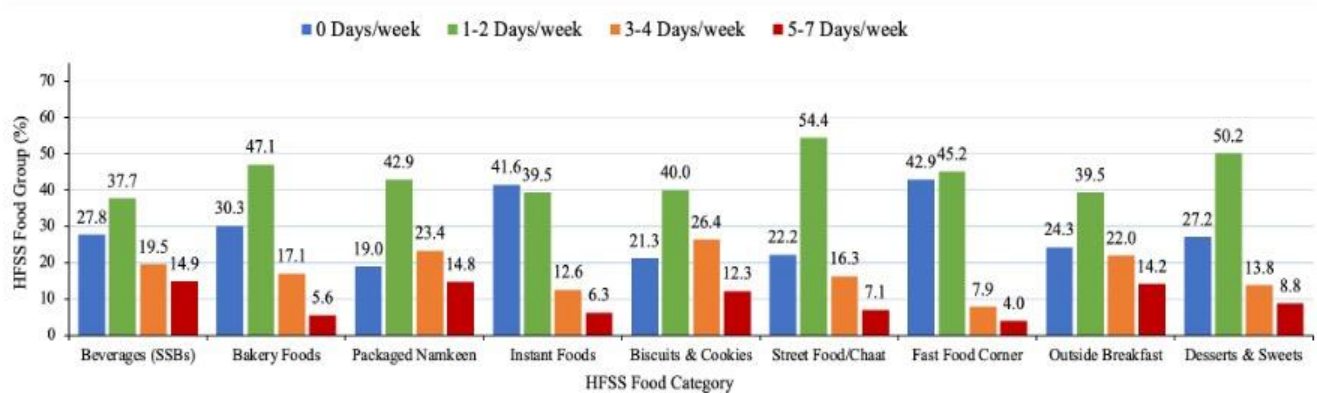
Figure 1: HFSS Food Consumption- School Students- Total n = 323 | Number (%) by days of HFSS food consumption per week



Among college students (Figure 2), the overall pattern shifted toward higher and more consistent consumption across most categories. Street food/chaat was predominantly consumed 1–2 days per week (54.4%), while bakery

foods showed the same pattern (47.1%). SSB consumption was notably more prevalent than in school students; only 27.8% reported zero weekly consumption compared to 47.1% among school students, and 34.9% consumed SSBs three or more days per week. Outside breakfast was consumed 3 or more days per week by 36.2% of college students. Fast food corner use, while still infrequent in a plurality (42.9% reporting zero days), showed greater regular use compared to school students (11.9% consuming 3+ days/week vs. 13.3% in school students). Packaged namkeen remained a commonly consumed item, with 38.1% of college students consuming it three or more days per week.

Figure 2: HFSS Food Consumption – College Students - Total n = 522 | Number (%) by days of HFSS food consumption per week



Across both groups, instant foods had relatively low near-daily consumption, only 8.4% of school students and 6.3% of college students reported eating instant foods on 5–7 days per week while remaining the food category with the highest zero-consumption rate among college students (41.6%). Desserts and sweets followed a largely occasional pattern in both groups, with the 1–2 days per week category being predominant (29.7% school; 50.2% college), though daily consumption was non-trivial among school students (12.4% consuming 5–7 days/week).

Overall, the data in both Figure 1 & 2 indicate that college students consume a broader range of HFSS foods with greater regularity than school students, particularly SSBs, outside breakfast, biscuits, and street food. School students, while consuming HFSS foods less frequently overall, showed disproportionately high near-daily packaged namkeen and biscuit consumption, categories that are low-cost, portable, and widely available in school environments.

3.3 Composite HFSS Consumption Association with BMI Status

Across the full sample, high composite HFSS consumption was significantly associated with BMI status ($p = 0.015$). High HFSS consumers had a notably higher prevalence of underweight (24.55% vs. 16.54%), while overweight/obesity was marginally lower (22.05% vs. 25.43%), indicating that HFSS intake in this population is more strongly associated with undernutrition than overweight (Table 2).

Table 2. Association Between Composite HFSS Consumption and BMI Category.

Group	HFSS Level	N	%	Underweight %	Normal %	Overweight/ Obese %	p-value
School Students	Low	185	57.28	7.57	67.03	25.41	0.016
	High	138	42.72	18.12	58.70	23.19	

College Students	Low	220	42.15	24.09	50.45	25.45	0.492
	High	302	57.85	27.48	50.99	21.52	
Overall	Low	405	47.93	16.54	58.02	25.43	0.015
	High	440	52.07	24.55	53.41	22.05	

3.3.1 School Students

Among school students, high HFSS consumption was significantly associated with the BMI category at the composite level ($p = 0.016$; Table 2). Students in the high HFSS group had a more than twofold higher prevalence of underweight (18.12% vs. 7.57%) compared to low consumers, while overweight/obesity prevalence was marginally comparable (23.19% vs. 25.41%). At the item level, only fast food corner consumption ($p = 0.008$) and desserts and sweets ($p = 0.018$) reached statistical significance; all other HFSS subcategories showed no significant association with BMI in this group.

3.3.2 College Students

In college students, the composite HFSS-BMI association was not statistically significant ($p = 0.492$). Among individual HFSS subcategories, only outside breakfast consumption showed a significant association with BMI ($p = 0.029$), with higher consumers exhibiting substantially greater underweight prevalence (31.8% vs. 21.1%). No other item-level association reached significance.

3.3.3 Item-level Association

Among school students, only fast food corner consumption ($p = 0.008$) and desserts and sweets ($p = 0.018$) reached statistical significance at the item level; all other HFSS subcategories showed no significant association with BMI. Among college students, only outside breakfast consumption was significantly associated with BMI ($p = 0.029$), with higher consumers recording substantially greater underweight prevalence (31.8% vs. 21.1%). No other item-level association reached significance in either group (Tables S1 and S2).

3.4 Multivariable Predictors of BMI Status

In the cluster-adjusted multinomial logistic regression model (reference = normal BMI; Table 3), age was the most consistent and statistically significant independent predictor of both nutritional outcomes. Participants aged 19–25 years had substantially greater odds of both overweight/obesity (aOR 2.84; 95% CI: 1.77–4.54; $p < 0.001$) and thinness (aOR 2.46; 95% CI: 1.71–3.53; $p < 0.001$) compared to those aged 12–18 years. Female sex was associated with lower odds of thinness compared to males (aOR 0.59; 95% CI: 0.34–1.02), though this association was of borderline significance ($p = 0.058$) and was not significant for overweight/obesity (aOR 1.24; 95% CI: 0.87–1.77).

Table 3. Multivariable Predictors of BMI Status (*Cluster-adjusted multinomial logistic regression; reference category = Normal BMI*)

Variable / Category	Thinness OR	95% CI	Overweight OR	95% CI
HFSS Exposure				
Low	1.00	[Ref]	1.00	[Ref]
High	1.24	[0.77, 1.99]	1.05	[0.57, 1.95]

Sex				
Male	1.00	[Ref]	1.00	[Ref]
Female	0.59	[0.34, 1.02]	1.24	[0.87, 1.77]
Age Group				
12–18 years	1.00	[Ref]	1.00	[Ref]
19–25 years	2.46***	[1.71,3.53]	2.84***	[1.77, 4.54]
Education				
School	1.00	[Ref]	1.00	[Ref]
College	1.89	[0.97, 3.69]	0.78	[0.41, 1.51]
District				
Hyderabad	1.00	[Ref]	1.00	[Ref]
Medchal-Malkajgiri	1.17	[0.59, 2.31]	0.99	[0.52, 1.90]
Ranga Reddy	1.02	[0.54, 1.95]	1.10	[0.59, 2.05]
Religion				
Hindu	1.00	[Ref]	1.00	[Ref]
Muslim	1.18	[0.50, 2.78]	0.45	[0.17, 1.21]
Christian	0.94	[0.49, 1.83]	1.35	[0.52, 3.49]
Others	1.14	[0.25, 5.18]	1.79	[0.43, 7.33]
Caste				
Scheduled Caste	1.00	[Ref]	1.00	[Ref]
Scheduled Tribe	0.25	[0.06, 1.09]	0.51	[0.14, 1.89]
Backward / OBC	0.69	[0.44, 1.08]	0.76	[0.41, 1.43]
Other Caste	1.03	[0.58, 1.84]	1.42	[0.83, 2.44]
Wealth SES				
Low	1.00	[Ref]	1.00	[Ref]
Medium	0.91	[0.55, 1.52]	0.79	[0.51, 1.22]
High	0.65	[0.36, 1.15]	0.93	[0.56, 1.52]
Knowledge of Obesity Definition				

Correct response*	1.00	[Ref]	1.00	[Ref]
Incorrect / Don't know	0.76	[0.48, 1.19]	1.45	[0.89, 2.35]
Knowledge of High-fat Food Risks				
No	1.00	[Ref]	1.00	[Ref]
Yes	0.81	[0.48, 1.36]	1.43	[0.84, 2.44]
Checks Food Packaging Information				
No	1.00	[Ref]	1.00	[Ref]
Yes	0.63	[0.37, 1.08]	0.98	[0.56, 1.74]
Checks Nutrient Composition Table				
No	1.00	[Ref]	1.00	[Ref]
Yes	0.99	[0.53, 1.86]	0.93	[0.51, 1.70]
Composite DFS (Dietary Food consumption)				
Low	1.00	[Ref]	1.00	[Ref]
High	2.04**	[1.26, 3.28]	0.93	[0.59, 1.49]
IPAQ Categories				
Low	1.00	[Ref]	1.00	[Ref]
Moderate	0.69*	[0.49, 0.97]	1.23	[0.57, 2.64]
High	0.96	[0.44, 2.10]	2.16	[0.89, 5.24]
Sitting Time				
<3 hours	1.00	[Ref]	1.00	[Ref]
3–5 hours	1.10	[0.51, 2.34]	1.53	[0.78, 3.00]
6–8 hours	1.54	[0.67, 3.54]	1.69	[0.88, 3.22]
>8 hours	0.56	[0.22, 1.42]	0.79	[0.26, 2.37]
Not sure	1.29	[0.55, 3.05]	1.09	[0.41, 2.94]
Sleep Hours				

<6 hours	1.00	[Ref]	1.00	[Ref]
6–7 hours	0.91	[0.37, 2.22]	1.16	[0.61, 2.20]
7–8 hours	0.90	[0.37, 2.21]	0.96	[0.54, 1.69]
>8 hours	1.70	[0.57, 5.11]	1.51	[0.56, 4.10]
Screen Time				
<2 hours	1.00	[Ref]	1.00	[Ref]
2–4 hours	1.64	[0.60, 4.46]	1.43	[0.67, 3.04]
5–7 hours	1.52	[0.67, 3.44]	1.51	[0.57, 3.99]
>7 hours	0.98	[0.25, 3.80]	1.23	[0.49, 3.10]
Not sure	1.02	[0.36, 2.89]	1.51	[0.47, 4.84]
<i>aOR, adjusted odds ratio; CI, confidence interval. Reference category = Normal BMI. Model is cluster-adjusted for school/college sampling design. Wide confidence intervals in certain strata reflect sparse cell counts; direction of association is consistent but point estimates should be interpreted with caution. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.</i>				

Among dietary variables, a high dietary food score was independently associated with significantly greater odds of thinness (aOR 2.04; 95% CI: 1.26–3.28; $p < 0.01$), but showed no significant association with overweight/obesity (aOR 0.93; 95% CI: 0.59–1.49). In contrast, composite HFSS consumption was not independently associated with either thinness (aOR 1.24; 95% CI: 0.77–1.99) or overweight/obesity (aOR 1.05; 95% CI: 0.57–1.95) after adjustment for all covariates.

Moderate physical activity was independently associated with lower odds of thinness/underweight compared to low physical activity (aOR 0.69; 95% CI: 0.49–0.97; $p < 0.05$), while high physical activity showed no significant association with either outcome. Sociodemographic variables including institute type, district, religion, caste, and wealth/SES were not significantly associated with either BMI outcome in the adjusted model. Similarly, nutritional knowledge, food label behaviour, sitting time, sleep duration, and screen time showed no statistically significant independent associations with thinness or overweight/obesity (all $p > 0.05$), although several variables showed directional patterns consistent with biological plausibility.

Notably, composite HFSS consumption was not independently associated with either thinness (aOR 1.24; 95% CI: 0.77–1.99) or overweight/obesity (aOR 1.05; 95% CI: 0.57–1.95) after adjustment for all covariates.

4. DISCUSSION

This study evaluated HFSS food consumption and nutritional status among 845 school and college students from three urban districts of Telangana, providing institution-stratified evidence across adolescence and young adulthood. The findings demonstrate the coexistence of a double burden of malnutrition, with 20.7% of participants classified as underweight and 23.7% as overweight or obese, consistent with the nutritional transition documented in successive National Family Health Surveys (7,24). An unexpected observation was the higher prevalence of underweight among participants with greater HFSS food consumption in the unadjusted analysis. However, this association was no longer statistically significant after adjustment for demographic, dietary, and

lifestyle factors, suggesting that HFSS consumption alone may not independently explain nutritional status in this population.

4.1 The Dual Burden in Urban Telangana - Context from National Surveys

The coexistence of underweight and overweight/obesity observed in this study reflects the ongoing double burden of malnutrition reported nationally across successive NFHS surveys. NFHS-5 (2019–21) reported the same coexistence among urban Indian adolescents and adults, with urban areas carrying a greater burden of obesity (25). NFHS-6 (2023–24) reinforces this trend, with the prevalence of overweight/obesity increasing from 24.0% to 30.7% among women aged 15–49 years and from 22.9% to 27.3% among men, while the prevalence among urban women reached 42.8% (3). Despite these increases, undernutrition persists, underscoring the ongoing double burden of malnutrition in India. NFHS-6 still finds a meaningful share of the 15-49 population underweight, concentrated in lower-SES groups (3). The prevalence estimates observed in the present study closely show national trends while providing context-specific evidence for urban Telangana. Such local surveillance data are important for designing targeted interventions that address regional variations in nutritional risk.

The key finding is the high prevalence of underweight among college students (26.1%) and participants aged 19–25 years (28.5%). National data generally show overweight rates increasing with urbanisation and age, the persistence of high rates of underweight among young adults here suggests something specific is happening during the school-to-college transition. Potential explanations include changes in dietary autonomy, meal-skipping behaviours, irregular eating patterns, and greater dependence on inexpensive foods; however, these mechanisms were not directly measured in the present study and therefore require further investigation (26,27).

4.2 HFSS Consumption: School Versus College Environments

HFSS food consumption patterns differed between school and college students, reflecting differences in food environments and dietary autonomy. School students reported more frequent consumption of packaged namkeen and biscuits, whereas college students reported greater consumption of sugar-sweetened beverages and breakfast purchased outside the home. This pattern is broadly consistent with the wider nutrition-transition literature, in which greater financial independence and increased access to commercial food outlets among urban young adults have been associated with higher consumption of sugar-sweetened beverages and fast foods(2). These findings suggest that school and college settings may require distinct, context-specific nutrition interventions targeting their respective food environments.

4.3 HFSS Consumers: Underweight Rather Than Overweight

One of the most notable observations in the unadjusted analysis was the association between higher HFSS food consumption and a greater prevalence of underweight. Participants with higher HFSS consumption demonstrated a significantly greater prevalence of underweight than those with lower HFSS consumption (24.55% vs. 16.54%; $p = 0.015$), whereas the prevalence of overweight/obesity differed only marginally between the two groups. The pattern was sharper among school students specifically - high consumers nearly doubled the underweight rate of low consumers (18.12% vs. 7.57%), overweight/obesity essentially unchanged (23.19% vs. 25.41%). One of the most notable observations in the unadjusted analysis was the association between higher HFSS food consumption and a greater prevalence of underweight. Participants with higher HFSS consumption demonstrated a significantly greater prevalence of underweight than those with lower HFSS consumption (24.55% vs. 16.54%; $p = 0.015$), whereas the prevalence of overweight/obesity differed only marginally between the two groups. The pattern was sharper among school students specifically-high consumers nearly doubled the underweight rate of low consumers (18.12% vs. 7.57%), while overweight/obesity remained essentially unchanged (23.19% vs. 25.41%). The unexpected association between higher HFSS consumption and underweight may reflect unmeasured dietary

and socioeconomic factors rather than a direct effect of HFSS intake. Further studies incorporating dietary intake, meal patterns, and food security are required to clarify this relationship(26,28), (29).

The results, when interpreted in view of the socioeconomic gradient, showed that underweight was highest in the lowest wealth tertile (26.1%) and lowest in the highest (13.7%), with overweight moving in the opposite direction, a pattern that lines up with NFHS data showing the double burden concentrated in lower-SES urban households mid-transition (3). Once we adjusted for other factors, HFSS consumption was no longer significantly associated with either outcome. This suggests the raw bivariate link was largely attributable to age, SES, and diet quality rather than an independent HFSS effect; the cross-sectional design does not permit conclusions about a causal pathway either way.

Importantly, the association between HFSS consumption and BMI was not retained in the multivariable analysis after adjustment for demographic, socioeconomic, dietary, and lifestyle factors. This suggests that the crude association was likely influenced by confounding variables, particularly age and overall dietary quality, rather than representing an independent effect of HFSS consumption.

These findings highlight the importance of interpreting unadjusted associations cautiously, as demographic and dietary factors may substantially influence the observed relationship between HFSS consumption and nutritional status.

4.4 Age as the Dominant Nutritional Risk Factor

Age was the strongest independent predictor of both underweight and overweight/obesity in the adjusted analysis. Participants aged 19–25 years had more than twice the odds of both nutritional outcomes compared with younger participants, highlighting the nutritional vulnerability of young adults during the transition from adolescence to adulthood of both thinness (aOR 2.46) and overweight/obesity (aOR 2.84) - a genuine dual vulnerability in older adolescents and young adults. This tracks with what's known about the nutrition transition in South Asian cities more broadly, where the dietary and lifestyle shifts of early adulthood create conditions for both energy deficit and energy excess at the same time (22,27) Practically, this means college-going young adults need to be treated as their own priority group for surveillance - not folded into "adolescents" generally - because the interventions that work for school-age students won't necessarily transfer.

4.5 Dietary Quality, Physical Activity, and Other Predictors

The link between a high DFS and greater thinness odds (aOR 2.04) appears counterintuitive, but it may reflect the limitations of frequency-based dietary diversity scoring of how frequency-based diversity scoring works: a student can eat small amounts of many food groups, score high on diversity, and still fall short on total energy (30,31). The inverse association between moderate physical activity and thinness (aOR 0.69) is consistent with existing evidence linking regular activity to better appetite regulation and energy balance in adolescents. We found no significant link between sedentary behaviour (screen time, sitting time, sleep) and BMI, which several comparable Indian cross-sectional studies have also reported - possibly a real null result, possibly a limitation of self-reported ordinal categories for these behaviours (2,32,33)

4.6 Strengths and Limitations

The present study has several strengths. It included participants from both school and college settings across three urban districts of Telangana, enabling comparison between two educational environments that are rarely examined simultaneously. Standardized anthropometric measurements and cluster-adjusted regression further strengthened the validity of the findings. The school and college comparison, in particular, is useful for pointing interventions at the right environment.

The present study has several limitations. First, its cross-sectional design precludes causal inference. Second, the nine-item HFSS food frequency questionnaire assessed consumption frequency but did not capture portion size or total dietary intake, limiting the assessment of actual HFSS exposure. Lifestyle variables were self-reported and are therefore subject to recall bias. In addition, the Dietary Food Score (DFS) is a surveillance-derived composite frequency score and was not independently validated as a measure of dietary diversity or energy adequacy, which may have influenced its observed association with thinness. Finally, residual confounding cannot be excluded because dietary energy intake, portion sizes, food insecurity, and household food expenditure were not assessed. Accordingly, the observed associations should be interpreted with caution. Furthermore, no adjustment for multiple comparisons was applied to the bivariate analyses. Consequently, statistically significant findings from these analyses should be considered exploratory and interpreted with appropriate caution.

5. CONCLUSION

This study demonstrates the coexistence of underweight and overweight/obesity among school and college students in urban Telangana, reflecting the persistent double burden of malnutrition reported nationally. Although higher HFSS food consumption was associated with underweight in the unadjusted analysis, this association was no longer statistically significant after adjustment for demographic, dietary, and lifestyle factors. These findings suggest that factors beyond HFSS consumption alone contribute to nutritional status in this population. Participants aged 19–25 years exhibited the greatest risk of both underweight and overweight/obesity, highlighting young adulthood as a critical period for nutrition surveillance and intervention.

These findings highlight the need to strengthen nutrition surveillance across both school and college settings while implementing comprehensive interventions that promote healthy dietary behaviours, improve food environments, and simultaneously address undernutrition and overweight. Policies aimed at reducing HFSS food availability should be integrated with broader strategies that enhance overall diet quality and nutritional adequacy. Further prospective longitudinal studies incorporating detailed dietary assessment, portion sizes, total energy intake, socioeconomic indicators, and food security measures are warranted to clarify the causal pathways linking HFSS food consumption with nutritional status among adolescents and young adults and to inform evidence-based nutrition policies and interventions.

Declarations

Ethics approval and consent to participate: The study was approved by the Ethics Committee of the ICMR–National Institute of Nutrition (Protocol No. NIN/IEC/2026/3/RR/007, 20th March 2026) and was conducted in accordance with the principles of the Declaration of Helsinki. As the participating cohort consisted of minors, written informed consent was obtained from their parents or legal guardians. Furthermore, written assent was obtained directly from the minors, and all participants voluntarily took part in the study.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare no competing interests.

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Authors' contributions: S.R.C. and S.T. conceptualized the study, interpreted the findings, and contributed to the preparation of the manuscript. S.R.C. critically reviewed the manuscript and approved the final version for submission. P.S. contributed to data analysis and interpretation of the findings. All authors participated in revising the manuscript, approved the final version, and agreed to be accountable for all aspects of the work. HV and NB critically reviewed the manuscript and analysis.

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