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Research Article

Nutritional status and psychological distress of adolescent girls in Ernakulam, Kerala

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Highlights/Key Messages

- Dual burden of malnutrition: thinness and obesity seen in the same group
- High anaemia prevalence, possibly linked to low vitamin C and dietary iron intake
- Nearly one in five girls showed psychological distress
- No clear link between nutrition status and psychological distress
- Supports joint nutrition and mental health screening in schools

Background
Adolescence involves substantial physical, psychological, and social changes, making nutrition and mental health important public health concerns, particularly in socioculturally diverse regions such as Kerala.

Objective
This study aimed to assess the nutritional status of adolescent girls aged 12–18 years, determine the prevalence of depression, anxiety, stress (DAS), and identify correlates associated with DAS among them.

Methods
A cross-sectional study was conducted in two selected panchayats among 150 adolescent girls using school-based cluster sampling. Data was collected through face-to-face interviews using validated tools, along with assessment of socioeconomic and nutritional status. Socioeconomic status was determined using the Kuppuswamy scale. Nutritional status assessment included BMI-for-age z scores, Waist-to-Hip ratio (WHR), and Waist-to-Height ratio (WHtR). Haemoglobin levels were measured to assess anaemia. Dietary intake was evaluated using a 24-hour recall of one weekday, while psychological distress was assessed using the DASS-Y scale. Associations between selected variables and DASS-Y scores were statistically analysed.

Results
Thinness and overweight were each observed in 9.3% of participants, while 5.4% were obese. Elevated WHR and WHtR were observed among 24.6% and 22% of participants, respectively, indicating notable abdominal obesity. Mild to moderate anaemia was identified in 71.8% of those who were assessed (n=78). Dietary assessment revealed inadequate average energy intake across all age groups, mainly due to low carbohydrate and fat consumption, although protein intake was generally adequate. Several micronutrients, particularly calcium, iron, riboflavin, vitamin A, and thiamine, were below recommended levels, whereas vitamin B12 intake was adequate. Psychological distress, as measured by the DASS-21, was observed in 17.3% of participants. No significant associations were found between the demographic, anthropometric, or biochemical variables with the DASS-Y scores.

Conclusion
The findings highlight nutritional concerns among adolescent girls, including undernutrition, excess weight, anaemia, and dietary deficiencies, along with psychological distress, underscoring the need for integrated adolescent health strategies.

Keywords: **Adolescent girls, nutritional status, overweight, obesity, anaemia, depression, anxiety, stress, DASS.**

Introduction

Adolescence is a time when young people experience rapid physical growth, emotional shifts, and social transitions. These changes play an important role in shaping how they see themselves, think, understand, and manage their emotions. With so many changes happening within a short span of time, adolescence can be a critical and formative stage of life. At the same time, it provides an important period during which long-term mental health and overall development can be shaped in a beneficial way (WHO, 2025; Suppiej et al., 2025).

Being healthy during adolescence means much more than not having a physical ailment. It involves feeling emotionally balanced, mentally strong, and socially connected. These aspects of well-being gradually develop through the relationships adolescents form and the everyday environments that influence their growth and experiences. When adolescents are surrounded by encouraging relationships, have access to essential resources, and are given meaningful roles within their families, schools, and communities, they are more likely to develop in a healthy and balanced way (Ross et al, 2020).

In contrast, when such supports are absent—whether due to sedentary lifestyles, poor eating habits, exposure to violence, or financial strain—adolescents' well-being may be compromised, increasing their susceptibility to emotional challenges such as depression and anxiety, along with other physical health concerns (Patton et al., 2016). This deterioration in overall well-being can further adversely affect their nutritional status, making them more vulnerable to conditions such as anaemia and obesity. These personal struggles are not isolated experiences—they are mirrored in broader public health patterns seen worldwide.

Globally, overweight and obesity (BMI-for-age > 1 SD/+2 SD) affected about 20% of youth aged 5-19 in 2022, up from 8% in 1990 (WHO, 2025c). Underweight or thinness (BMI < -2SD) is less common globally (~5-10% in Low- and Middle-Income Countries (LMICs)) (Jaacks et al., 2015). Worldwide, anaemia remains a pressing issue for adolescents aged 10-19, affecting roughly 25-40% based on WHO thresholds for haemoglobin levels, with higher rates among girls in LMICs nearing 38% due to menstrual losses and dietary gaps (WHO, 2025a; WHO, 2025b). In India, NFHS-5 reports indicate that anaemia affects 59% of 15-19-year-old girls. However, Kerala shows lower anaemia (36%) among girls 15-19 years. NFHS-5 reports 25.6% thinness (<18.5 BMI) among adolescent girls aged 15-19 years nationally, versus 9.8% in Kerala (International Institute for Population Sciences (IIPS) & ICF, 2021).

Easy access to calorie-dense ultra-processed foods, frequent consumption of sugary beverages and snacks, prolonged screen time, reduced physical activity, and increasingly sedentary urban lifestyles all contribute to the increasing trend in overweight and obesity. In states like Kerala, rapid economic and lifestyle transitions have further accelerated these patterns (International Institute for Population Sciences (IIPS) & ICF, 2021).

Anaemia in adolescents is most often linked to iron deficiency. This can result from not consuming adequate iron-rich foods such as red meat, green leafy vegetables, or fortified staples, as well as from the increased iron demands during rapid growth and menstruation. In many low- and middle-income countries, recurrent infections like malaria and worm infestations, along with reduced iron absorption from phytate-rich, grain-based diets, further worsen the problem (WHO, 2025b). In India, limited meat intake, vegetarian dietary patterns, and sanitation challenges increase the risk, with consequences including impaired concentration, reduced academic performance, and weakened immunity.

Alongside these nutritional concerns, mental health problems are also emerging as a major public health issue in this age group. Globally, World Health Organization (WHO) estimates depression at 1.3% (ages 10-14) and 3.4% (ages 15-19), while 10-20% of adolescents experience mental or emotional disorders (WHO, 2025; Vision IAS, 2026). In India, school-based studies report mental health morbidities among adolescents ranging from 3.2% to 36.5%, with depression prevalence around 50-57% in some reviews, often higher in females (Haritay et al., 2025; Kamath et al, 2021). Kerala surveys report adolescent psychological distress/morbidity around 20-30%, with higher rates in girls (Jaisoorya et al, 2017; Balamurugan et al., 2024). Consistent with national patterns, multiple studies highlight a higher burden among girls, who tend to report more depressive symptoms and psychological distress than boys, often attributed to intense academic demands, family expectations, body-image issues, and stress associated with social-media use (Jaisoorya et al., 2017)

Kerala, widely recognized for its high literacy levels and relatively advanced health indicators, offers a unique setting to examine adolescent mental health, where longstanding family traditions intersect with rapid social and economic transformations (Pillai et al., 2022). As a result, there is growing interest in understanding how academic demands, increasing social media use, and changing family relationships affect the psychological well-being of adolescents in the state (Chirayath et al., 2024).

WHO emphasizes the importance of using validated, context-appropriate instruments to screen for and monitor depression and related mental health conditions, particularly in primary care and community settings (WHO, 2023). However, few relevant studies have used these among adolescent school girls in Kerala. This study aims to enhance the existing body of knowledge regarding the occurrence, intensity, and associated psychosocial factors of depression, anxiety, and stress as well as the nutritional status among adolescent girls in Ernakulam, Kerala, examining also the link between nutrition and psychological factors.

Materials and Methods

This cross-sectional study was conducted in two selected panchayats—Cheranalloor and Mulavukad—located near Kochi in western Kerala. These panchayats, among others, were identified through the Unnat Bharat Abhiyan (UBA) and the Teresian Rural Outreach Program (TROP) as having a higher prevalence of malnutrition and gender discrimination.

Both the panchayats share similar socioeconomic and cultural characteristics. Residents in both areas have comparable access to schools, healthcare facilities, markets, and other urban services, with livelihoods commonly linked to service-sector jobs, small businesses, and wage employment. Although Mulavukad is an island panchayat and Cheranalloor is situated on the mainland, sociocultural differences between the two are minimal due to their close proximity and shared urban influence.

Selection of Participants

According to the Indian Council of Medical Research (2020), adolescence includes individuals in the age group of 10-18 years of age. Given that the mean age at menarche in India is typically between 12.5 and 13 years (Ramraj et al., 2021; Sarika et al., 2013), the present study included adolescents between 12 and 18 years of age. The sample size was computed based on the population of the panchayats and prevalence of two nutritional problems -obesity and anaemia, considering the highest prevalence in the panchayats, using the equation.

$$n = [z2 * p * (1 - p) / e2] / [1 + (z2 * p * (1 - p) / (e2 * N))]$$

where: z = 1.96 for a confidence level (α) of 95%, p = proportion (expressed as a decimal), N = population size, e = margin of error.

A two-stage cluster sampling method was adopted for this study. In the first stage, schools were considered as clusters. From the selected panchayats, two aided schools in Mulavukad and five schools in Cheranalloor were chosen randomly after ensuring they met certain criteria. These included the willingness of the school authorities to participate, no prior conduct of similar sequential nutrition and health assessments, similarity in students' socioeconomic background, adherence to comparable health regulations, and the need to avoid close geographical location to limit interaction between students of different schools. Parents were provided with a clear written explanation about the purpose and benefits of the study. Written informed consent was obtained from those who agreed to allow their children to participate. The inclusion and exclusion criteria are detailed below.

Inclusion Criteria:

- Girls aged 12–18 years who provided assent and whose parents/guardians provided informed consent to participate in the study.
- Residents of the selected panchayats.

Exclusion Criteria

- Adolescents with known communication difficulties that would interfere with understanding or responding to the study questionnaire.
- Adolescents with chronic medical conditions that could significantly affect anthropometric or psychological assessment.
- Those who were absent on the day of data collection.
- Those who did not provide assent or whose parents/guardians did not provide informed consent.

In Mulavukad, a total of 640 adolescents were studying in two aided schools. Based on the sample size calculation, 38 participants were required from this area. In Cheranalloor, where 1,642 adolescents were enrolled across four aided schools and one private school, the estimated sample size was 97. The overall sampling methodology is presented in Figure 1.

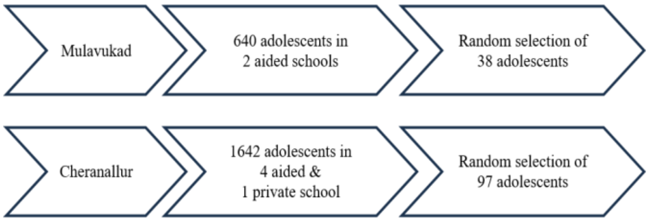

Figure 1. Sampling Methodology adopted for the study

Sample size estimation indicated a requirement of 135 participants; however, to account for non-response and enhance representativeness, 150 adolescents were included.

Data Collection

Data was collected through face-to-face interviews by trained personnel using a questionnaire. Pertinent information with respect to the following details was collected through the questionnaire using validated tools:

- **Sociodemographic details**- The participants were requested to provide their demographic information, which included their age and grade. Socioeconomic status was assessed using the Kuppuswamy Socio-economic Status Scale (Mohanty et al., 2024).
- **Nutritional assessment**- This comprised anthropometric, biochemical, and dietary evaluations. Anthropometric assessment included computation of BMI-for-age z-scores, which were classified into standard deviation units using the WHO Growth References (WHO, 2007). Abdominal obesity was evaluated using WHR and WHtR. WHR was calculated as the ratio of waist circumference to hip circumference, and WHtR as waist circumference (cm) divided by height (cm), according to the guidelines of WHO (WHO, 2011) and the National Institute for Health and Care Excellence (NICE, 2025), respectively. The biochemical assessment focused on haemoglobin estimation to determine the prevalence of anaemia among participants. Haemoglobin was measured using the standardized HemoCue® capillary blood collection method, in which a finger-prick sample is obtained with a lancet and blood is directly wicked into a microcuvette for analysis. Haemoglobin measurement using HemoCue® was conducted in a subsample of 78 adolescents from whom parental consent had been obtained. Subsampling was undertaken due to logistical and resource constraints associated with biochemical assessments, including cost, time, the need for trained personnel, and occasional participants' unwillingness to undergo blood sampling. The participants were classified into categories of normal, mild, or moderate anaemia based on haemoglobin (Hb)

levels using WHO cutoffs for adolescents (WHO, 2024). Dietary assessment was carried out using a 24-hour dietary recall to capture information on all foods and beverages consumed by the adolescents on the preceding day. From the compiled list of raw foods consumed by the participants, nutrient intakes were calculated using the standardized software NSR Nutrical, based on data from the Indian Food Composition Tables (Longvah et al., 2017). Mean dietary and nutrient intakes were calculated and compared against the issued by Indian Council of Medical Research- National Instituition of Nutrition (ICMR-NIN, 2024), with dietary pattern guidelines specific to age, gender, physiological status, and activity levels. Nutrient intake gaps were evaluated as percentage differences relative to the RDA.

- **Depression anxiety stress score (DASS)**- Psychological distress was measured using the Depression, Anxiety, and Stress Scale. The DASS is a set of psychometrically sound scales that is widely used to assess negative emotional states in adults. The DASS-Y is a 21-item youth version of the Depression Anxiety Stress Scales to assess depression, anxiety, and stress in children and adolescents aged 8–19 (Lovibond and Lovibond, 1995). DASS-Y scores were categorized into two broad categories- normal and psychological distress groups for statistical analysis. Participants falling in the mild, moderate, severe, and extremely severe categories were combined into a single psychological distress group to enable clearer comparison with the normal category who reported no psychological distress.

For the purpose of data analysis, the sample was divided into age categories as follows: 12 years, 13–15 years, and 16–18 years. This is based on adolescent developmental stages referenced in Indian health research frameworks, including the Nutrient Requirements and Recommended Dietary Allowances for Indians (ICMR-NIN, 2024), which classify adolescence into early, middle, and late phases characterized by distinct physiological, psychological, and behavioural transitions.

Statistical Analyses

Statistical analyses were conducted using SPSS Version 20.0 for Windows (IBM Corporation, Armonk, NY, USA). Pearson's Chi-square test or Fisher's Exact Test was used to examine associations between sociodemographic, anthropometric parameters and DASS-Y interpretation groups. Effect sizes were calculated using Cramér's V for Chi-square tests. Corresponding 95% confidence intervals (CI) were reported where applicable. A p-value < 0.05 was considered statistically significant.

The study obtained ethical clearance from the Institutional Research Ethics Committee (STCAU/115/25). Informed consent was obtained from the participants along with parental/guardian assent.

Results

The participants consisted of 150 adolescent girls (12-18 yrs). The sociodemographic details of the participants are represented in Table 1.

Table 1. Sociodemographic details of participants

Sl. No.	Criteria	Adolescents (n=150) n (%)
1. Age group(yrs.)		
i.	12	34 (22.6)
ii.	13-15	81 (54)
iii.	16-18	35 (23.4)
2. Grade/class		
I	6th-7th	50 (33.3)
ii.	8th- 10th	72 (48)
iii.	11th - 12th	28 (18.7)
3. Socio-economic status*		
i.	Lower	0
ii.	Upper lower	49 (32.7)
iii.	Lower middle	77 (51.3)
iv.	Upper middle	23 (15.3)
v.	Upper	1 (0.7)

*Calculated using Modified Kuppuswamy socio-economic status scales, 2024

As age and class increase, the number of girls decreases. The majority were from a middle-class background. The detailed anthropometric and biochemical profile of the participants is presented in Table 2.

Table 2. Anthropometric and Biochemical assessment of participants

Criteria	n (%)
Anthropometric assessment (n=150)	
BMI for age[3]	
Thinness (< -2SD)	14 (9.3)
Normal (-2SD - +1 SD)	114 (76)
Overweight (> +1 SD)	14 (9.3)
Obesity (> +2 SD)	8 (5.4)
Waist Hip Ratio (WHR)[1]	
Normal (< 0.85)	113 (75.3)
Substantially increased (≥ 0.85)	37 (24.6)
Waist Height Ratio (WHtR)[2]	
Healthy central adiposity (0.4 to 0.49)	117 (78)
Increased central adiposity (0.5 to 0.59)	18 (12)
High central obesity (0.6 or more)	15 (10)
Anaemia assessment (n=78)	
Anaemia severity based on Haemoglobin (Hb)[4]	
Normal (≥12 g/dL)	22 (28.2)
Mild (11.9- 10 g/dL)	45 (57.7)
Moderate (9.9- 7 g/dL)	11 (14.1)

[1]Bulletin of WHO, 2011 [2]NICE guidelines, 2025 [3]WHO growth charts (WHO, 2007) [4]WHO, 2024

Most participants had a normal BMI and fat distribution, although a notable proportion exhibited elevated central adiposity, as assessed by WHR and WHtR. Biochemical assessment revealed a high prevalence of anaemia, with the majority exhibiting mild to moderate forms.

Table 3. Intake of nutrients (on one day) among participants

Nutrient	Adolescent age group (n=150) 12 yrs			13-15 yrs			16-18 yrs		
	RDA	Mean ± SD	% RDA	RDA	Mean ± SD	% RDA	RDA	Mean ± SD	% RDA
Energy[1] (kcal)	2060	1597.6±512	77.5	2400	1329.8±451.7	55.4	2500	1297.7±489.8	51.9
Protein (gm)	33	39.1±14.8	118.5	43	40.7±15.8	94.6	46	42.8±14.6	93
Carbohydrate[2] (gm)	257.5	232.5±20.9	90.2	300	202.5±74.3	67.5	312.5	200.7±85.0	64.2
Fat (gm)	57.2	51.8±33.5	90.6	66.6	37.0±19.8	55.5	69.4	34.6±18.7	49.8
Calcium (mg)	850	232.8±142.7	27.3	1000	173.5±119.3	17.3	1050	219.9±184.1	20.9
Iron (mg)	28	6.9±3	24.6	30	5.5±3.7	18.3	32	6.5±3.8	20.3
Vitamin A (µg)	790	274.1±313.7	34.6	890	198.9±173.3	22.3	860	405.5±819.5	47.1
Thiamine (mg)	1.4	0.67±0.39	47.8	1.6	0.57±0.30	35.6	1.7	0.5±0.3	29.4
Riboflavin (mg)	1.9	0.64±0.26	33.6	2.2	0.57±0.28	25.9	2.3	0.6±0.3	26
Niacin (mg)	14	9.7±5.4	69.2	16	10.5±5.9	65.6	17	10.8±5.3	63.5
Vitamin C (mg)	50	23.5±18.0	47	65	19.2±14.7	29.5	70	25.4±30.1	36.2
Total folate (µg)	225	170.3±108.6	75.6	245	143.6±118.6	58.6	270	193.9±183.8	71.8
Total dietary fibre[3] (gm)	25	23.8±9.3	95.2	25	17.1±11.6	68.4	25	19.7±12.1	78.8
Magnesium (mg)	250	214.5±89.7	85.8	340	146.5±93.5	43.0	380	184.5±113.1	48.5
Copper (mg)	1.7	1.3±0.55	76.4	1.7	1.0±0.5	58.8	1.7	1.1±0.5	64.7
Vitamin B6 (mg)	1.9	1.1± 0.4	57.8	2.2	1±0.5	45.4	2.3	1±0.5	45.4
Vitamin B12 (µg)	2.2	2.6±3.1	118.1	2.2	1.9±3.2	86.3	2.2	3.2±2.4	168.2

[1] Revised Dietary Guidelines 2024 mentions Estimated Energy Requirement (EER) rather than Recommended Dietary Allowance (RDA)
[2] As per RDA guidelines, carbohydrate intake should contribute 50% of total energy intake
[3] Adequate intake

On analysing the dietary intake of adolescents (Table 3), the mean energy intake was below the recommended dietary allowance across all age groups, with a declining trend in older adolescents. A considerable proportion of participants also reported regularly skipping breakfast, which may have contributed to the overall lower energy intake.

Protein intake was adequate or above the RDA among younger adolescents but declined with age. While carbohydrate intake approached adequacy among younger adolescents, it was suboptimal among older adolescents. Fat intake was also notably lower among older adolescents, which may partly explain the overall deficit in total energy intake.

The intake of several micronutrients was consistently inadequate across all age groups, particularly calcium, iron, vitamin A, B vitamins, and vitamin C. However, relatively better intakes of dietary fibre and folate were observed among younger adolescents. In contrast, vitamin B12 intake exceeded the RDA, possibly reflecting regular consumption of animal-source foods and/or fortified products.

The distribution of adolescents based on DASS-Y scores is represented in Table 4.

Table 4. DASS-Y scores among adolescent girls (N=150)

Severity ratings	n (%)
Depression	
Normal (0-6)	119 (79.3)
Mild (7-8)	10 (6.7)
Moderate (9-13)	12 (8)
Severe (14-16)	5 (3.3)
Extremely Severe (17+)	4 (2.7)
Anxiety	
Normal (0-5)	114 (76)
Mild (6-7)	11 (7.3)
Moderate (8-12)	18 (12)
Severe (13-15)	6 (4)
Extremely Severe (16+)	1 (0.7)
Stress	
Normal (0-11)	119 (79.3)
Mild (12-13)	15 (10)
Moderate (14-16)	14 (9.3)
Severe (17-18)	1 (0.7)
Extremely Severe (19+)	1 (0.7)
Total DASS score	
Normal (0-23)	124 (82.7)
Mild (24-29)	8 (5.3)
Moderate (30-39)	14 (9.3)
Severe (40-46)	3 (2)
Extremely Severe (47+)	1 (0.7)

Table 4 shows that the majority of adolescents were within the normal range for depression, anxiety, and stress, indicating overall low levels of psychological distress. Mild to moderate symptoms were observed in a smaller proportion, particularly for anxiety and stress, while severe and extremely severe cases were relatively uncommon across all domains.

The association of psychological distress with demographic, anthropometric, and biochemical variables is presented in Table 5.

Psychological distress was relatively higher among 13-15 year olds and those in higher grade levels and was more prevalent among participants from lower socioeconomic groups. With respect to nutritional status, a greater proportion of distress was observed among adolescents with overweight/obesity and central adiposity, as well as among those with anaemia compared to their counterparts. Despite these observed trends, statistical analysis revealed no significant associations between psychological distress and age, grade, socioeconomic status, anthropometric indicators, or anaemia status, with all variables showing weak effect sizes.

Table 5. Association of Demographic, Anthropometric, and Biochemical variables with Psychological Distress (DASS-Y) among Adolescents

Variables	DASS-Y interpretation Normal n (%)	Psychological distress* n (%)	Chi-Square value	Effect Size (Cramer's V)	P value
Age (yrs.)					
12	31(91.2)	3 (8.8)			
13-15	64 (79)	17 (21)	2.474	0.128	0.290NS
16-18	29 (82.9)	6 (17.1)			
Grade					
6th -7th	45 (90.0)	5 (10)			
8th - 10th	56 (77.8)	16 (22.2)	3.086	0.144	0.214NS
11th-12th	22 (81.5)	5 (18.5)			
Socio-economic status					
Upper lower	36 (73.5)	13 (26.5)			
Lower middle	66 (85.7)	11 (14.3)	4.564	0.175	0.102NS
Upper middle	21 (91.3)	2 (8.7)			
BMI for Age					
Thinness	58 (86.6)	9 (13.4)			
Normal	37 (82.2)	8 (17.8)	1.787	0.109	0.409NS
Overweight/obese	29 (76.3)	9 (23.7)			
Waist-Hip Ratio (WHR)					
Normal	69 (84.1)	13 (15.9)	0.276	0.043	0.599NS
Substantially increased	55 (80.9)	13 (19.1)			
Waist-Height Ratio (WHtR)					
Healthy central obesity	98 (83.8)	19 (16.2)			
Increased central obesity	15 (83.3)	3 (16.7)	1.015	0.082	0.602NS
High central obesity	11 (73.3)	4 (26.7)			
Anaemia (n=78) #					
Normal	19 (86.4)	3 (13.6)	-	0.070	0.746NS
Anaemic	45 (80.4)	11 (19.6)			

#Chi-Square not valid. NS not significant

Discussion

The participants of the study comprised adolescent girls in the age group of 12 -18 years. The mean age of the subjects was 14 years. This demographic profile aligns with patterns observed in other Indian investigations of adolescent health, where school-recruited cohorts typically span comparable age ranges. These age ranges are particularly significant because they coincide with crucial phases of physical growth, as well as social, emotional, and cognitive development (National Academies of Sciences, Engineering, and Medicine, 2019).

The findings reveal a clear dual burden of malnutrition among the adolescent girls, with both undernutrition and overweight or obesity coexisting in the cohort. Approximately, 76% of participants had a normal BMI, 9.3% each were classified as thin and overweight, respectively, and 5.4% as obese. In other words, while approximately three-fourths of the study participants had optimal weight status, nearly one-fourth (24%) were at either end of the nutritional spectrum.

This pattern is similar to broader trends reported across India and neighbouring regions, where adolescent girls experience malnutrition, making their nutritional needs especially challenging to address. A similar large study from North India documented the prevalence of underweight to be 47% among schoolgirls, along with nearly 9% prevalence of overweight or obesity (Ahmad et al., 2018). National survey data also support this inference, indicating that issues like stunting and excess weight coexist among Indian adolescents, often shaped by factors such as socioeconomic status and urban–rural differences (Parida et al., 2025). These findings emphasize the need for effective public health approaches that address both undernutrition and overnutrition simultaneously, envisaging realistic improvements in adolescent nutritional status.

In this group, one in four girls (24.6%) had a high waist-to-hip ratio, and 22% showed excess central fat based on their waist-to-height ratio. Increased central obesity increases the risk of insulin resistance, cardiovascular disease, and metabolic complications (Eslami et al., 2023). Similar findings have been reported among Indian adolescents, where central obesity is becoming more common—even among those with a normal BMI, indicating an emphatic need for focused preventive measures (Gowda & Yamuna, 2018). Haemoglobin assessment in a subsample of 78 participants revealed suboptimal levels, with only 28.2% indicating normal haemoglobin, 57.7% having mild anaemia, and 14.1% suffering from moderate anaemia. These findings suggest persistent concerns about iron deficiency among adolescent girls. These findings align with high anaemia burdens among adolescent girls in India, where a meta-analysis of adolescent girls (10–19 years) reported a pooled prevalence of 65.7% (95% CI: 59.3%–71.9%), predominantly mild cases (Daniel et al., 2023). Similar patterns persist in middle-income countries such as Nepal, with a prevalence of 17.5% among schoolgirls, often mild and linked to dietary gaps (Ghimire et al., 2024).

In contrast, high-income settings report far lower rates; US female adolescents aged 12–19 years had 17.4% prevalence during 2021–2023 (Williams et al., 2024), while a multi-city European study among adolescents noted 4.4% overall anaemia prevalence (1.1% - 10.1% by city) (Ferrari et al, 2011). These lower rates in high-income countries stem from widespread food fortification, better dietary diversity, and routine healthcare screening (WHO, 2025b), whereas middle-income settings like Nepal face ongoing challenges from inconsistent supplementation, limited nutrition education, and socioeconomic barriers that sustain milder forms of anaemia (Chalise et al., 2018).

Considering participants' macronutrient intakes, it appears that protein intake was not a major concern for most adolescents. Despite this, their overall energy intake did not meet the recommended levels. This shortfall may be due to lower carbohydrate and fat consumption, especially among older adolescents. The inadequate energy intake across age groups could be influenced by irregular meal timings, particularly breakfast skipping, which was reported among approximately one-third of the adolescents. Inadequate intake during this important stage of life can influence overall energy balance, how effectively nutrients are used by the body, and ultimately impact growth and development.

Nevertheless, energy intakes may appear to be lower than expected, given macronutrient intakes we documented. This arises because the percentage adequacy of energy and individual macronutrients were calculated independently using their respective reference values, and therefore are not directly additive or expected to sum to 100%.

As per the ICMR-NIN Revised Dietary Guidelines 2024, energy requirements are expressed as Estimated Energy Requirement (EER)/Estimated Average Requirement (EAR), rather than as RDA. These values represent the intake level required to meet the energy needs of the population on average, whereas RDA values—provided for macronutrients—are higher intake levels sufficient to meet the needs of nearly all (97–98%) individuals.

The micronutrient intakes follow a pattern often observed in adolescents from other parts of India, suggesting inadequate dietary intake of calcium, iron, and important vitamins. These gaps, especially among older adolescents, may be linked to rising trends in fast-food consumption, which replace nutrient-dense foods like fruits, vegetables, and dairy (Arya & Dubey, 2024). The persistence of these can interfere with optimal growth, affect concentration and academic performance, and impact overall health in the long term (Singh et al., 2023).

A study among 150 adolescent girls residing in hostels at Guntur, Andhra Pradesh, reported markedly inadequate dietary intake, with energy, protein, and carbohydrate consumption meeting only 51%, 68%, and 34% of the RDA, respectively, highlighting significant nutritional deficits (Seva et al., 2021). A similar pattern was observed in a cross-sectional study by Kaur et al. (2025), which included 453 adolescents aged 10–16 years from public schools at Chandigarh, North India. The researchers reported that many students had inadequate intake of energy (1782 kcal), fibre (7 gm), other vitamins and minerals and their dietary intake of fruits and vegetables was low. Undernutrition was found to be common in the study population. These findings concur with the present findings regarding nutritional concerns among adolescents.

With respect to psychological health, the majority of adolescent girls in the present study depicted normal levels of depression, anxiety, and stress based on the DASS-Y scale. However, relatively higher levels of psychological distress were observed among students in grades 8–10 and those aged 13–15 years.

This is fairly common during this phase of development, as mid-adolescence is a phase marked by rapid physical growth, emotional shifts, changing social relationships, and rising academic expectations. During this period adolescents are vulnerable to stress. Other studies (Balamurugan et al., 2024; Devi & Kumar, 2025) have also reported that although many young people adjust well, some experience mild to moderate emotional challenges during this stage. These observations highlight the importance of providing timely guidance and support to safeguard both the nutritional and psychological well-being of adolescents.

No statistically significant associations were found between demographic, anthropometric, or biochemical variables and psychological distress, as assessed using the DASS-21. The weak effect sizes observed across variables indicate that the relationships between these factors and psychological distress were minimal. However, this finding may also be influenced by the relatively small sample size used for the analysis, which could have limited the ability to detect significant statistical associations.

Limitations

A key limitation of this study is that haemoglobin levels were measured only in a subsample of participants rather than the entire group. Although efforts were made to ensure that this subgroup was representative, the findings related to anaemia may not fully reflect the status of all adolescents included in the study.

We measured dietary intake based only on recall and only from one weekday in lieu of the practical challenges that existed in the conduct of a three-day food record or a weighment survey. Given the high prevalence of abdominal obesity and the fact that low energy intakes were widely reported, we believe that many participants underestimated their intake.

Another limitation was the relatively small overall sample size, especially for the micronutrient assessment, which may have reduced the study's statistical power and limited the ability to detect meaningful associations between variables. Additionally, confidence levels could not be estimated because the analysis was primarily based on cross-tabulations. While cross-tabulation is useful for understanding patterns and distributions between variables, it does not allow for the calculation of statistical significance or confidence intervals. This limits the ability to draw stronger inferential conclusions from the findings.

Conclusions

The findings of this study highlight the coexistence of undernutrition, micronutrient deficiency, and excess weight among adolescent girls in the study area. While some girls were found to be thin, others were overweight or obese, including a proportion with higher levels of abdominal fat. Together, these findings reflect the dual burden of malnutrition that adolescents are increasingly facing.

In terms of psychological well-being, most participants reported normal levels of depression, anxiety, and stress. However, nearly one in five girls showed signs of mild to moderate psychological distress, particularly during mid-adolescence (13–15 years), a phase often marked by rapid physical and emotional changes. However, no statistically significant link was found between nutritional status and psychological well-being.

These findings emphasize that adolescent health programs need to look at physical and mental well-being together rather than in isolation. Paying attention to both aspects can lead to more meaningful and lasting outcomes. They also point to the value of early screening and recognizing potential concerns at the right stage of development. Offering timely support, practical guidance, and a nurturing environment during these formative years can go a long way in preventing future health issues and fostering confidence and resilience among adolescent girls in this region.

Author Contributions

RHP, FN, and SPS contributed to conceptualization and methodology of the study. Data curation and formal analysis were carried out by FN, SPS, OKD, and MCJ. FN and RHP contributed to writing the original draft of the manuscript. SPS contributed to supervision and provided critical review and editing of the manuscript. All authors reviewed and approved the final version of the manuscript and consented to its submission for publication.

Declaration of Generative AI and AI-Assisted Technologies in Scientific Writing

During the preparation of this manuscript, generative AI tools (ChatGPT and Perplexity) were used to support the interpretation of statistical outputs, refine the language, and improve the clarity and presentation of the results. All final interpretations and conclusions remain the responsibility of the authors.

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Data Availability Statement

The datasets generated and analysed during the current study are not publicly available due to ethical considerations and the inclusion of identifiable information from adolescent participants. Informed consent and parental assent were obtained with the assurance that individual-level data would remain confidential.

De-identified data supporting the findings of this study can be made available from the corresponding author upon reasonable request for academic and research purposes, subject to approval by the Institutional Research Ethics Committee and in compliance with applicable data protection guidelines. Requests for access to the dataset should clearly state the purpose of the research and the intended use of the data.

Institutional Review Board

The study obtained ethical clearance from the Institutional Research Ethics Committee (STCAU/115/25). Informed consent was obtained from the participants, and parental/ guardian assent was obtained in case of adolescents.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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