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Original Article

Nursing Section

Prevalence and Determinants of Childhood Obesity: A Cross-sectional Study from Vadodara, Gujarat, India

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ABSTRACT

Introduction: The world is heading towards an obese future and as a result, childhood obesity is rising at an alarming pace. According to the World Obesity Atlas (2024), it is projected that by 2035, 88% of children classified as overweight or obese will reside in low- and middle-income countries.

Aim: To identify the prevalence of childhood obesity among individuals aged 12 to 16 years, using the criteria established by the Centres for Disease Control and Prevention (CDC).

Material and Methods: A descriptive cross-sectional study was conducted among 606 school children selected through purposive sampling from three distinct schools in the Vadodara District, Gujarat, India, including one government, one semi-government, and one private school, over a period of one month (July 2024). The researcher employed a quantitative research approach. The study gathered written informed parental consent and participant assent from students to assess their Body Mass Index (BMI). Data were collected on Demographic Variables (DV) and BMI based on the CDC BMI tool metric version and analysed using Statistical Package for the Social Sciences (SPSS) version 23.0. To determine prevalence rates, associations of DVs with BMI, correlations of BMI with height, weight and Mid-Arm Circumference (MAC), Odds Ratio (OR), Analysis of Variance (ANOVA) and logistic regression were performed.

Result: Among the 606 study participants, the overall prevalence of obesity was 224 (36.96%). Out of these, 67 (11.06%) were underweight, 315 (51.98%) were normal weight, 134 (22.11%) were overweight, 58 (9.57%) were classified as obesity class I, 21 (3.47%) were classified as obesity class II and 11 (1.82%) were in the obesity class III category. Overall, males (22.77%) exhibited a higher prevalence of obesity compared to females (14.19%), with the majority representing urban residents. When analysed using logistic regression, the researcher found that age (13-15 years), private school enrollment, urban residence, vehicle transportation, higher socioeconomic status and daily consumption of sugar-sweetened beverages were significant predictors of obesity.

Conclusion: The study concluded that obesity was more prevalent among urban residents and a strong correlation was found between MAC, gender and school type, with an inverse relationship between physical activity and obesity.

Keywords: Arm circumference, Body mass index, Exercise, Growth chart

INTRODUCTION

According to the World Obesity Association, "overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health. A Body Mass Index (BMI) over 25 is considered overweight and over 30 is considered obese [1]." By 2035, more than 750 million children aged 5 to 19 years will be living with either overweight or obesity [2]. Childhood obesity can lead to subsequent adulthood issues such as cancer, diabetes, lung problems and other health risks, potentially resulting in premature mortality. It is predicted that 10% of the world's obese population will be from India alone, primarily due to nutritional behaviours, lifestyle practices and inconsistent physical activity, which can lead to disturbed mental and behavioural issues in youth [3].

It is estimated that by 2025, the combined prevalence of obesity and overweight will double compared to the 1990s, resulting in a triple burden of obesity. As indicated in a study by Ng M et al., by 2050, obesity prevalence will surpass that of overweight among late adolescent males and current strategies for managing childhood obesity are scarce [4]. According to the National Family Health Survey (NFHS) data from Gujarat, the prevalence of childhood obesity in the state (26.3%) is higher than the national average (24.1%), with Vadodara ranking second [5].

In recent years, several researchers have conducted studies assessing the prevalence of childhood obesity in Gujarat. Prajapati V and Amin MK reported that 13.03% of girls and 7.84% of boys were obese in Vadodara (2019) [6]. Eshwar TK et al., reported 14% in Rajkot (2022) [7], while Pathak S et al., reported 17.6% in Vadodara (2018) [8]. Previous studies measured prevalence based on small sample sizes and were not grounded in international standards (CDC). The present study follows globally accepted CDC criteria and recruits samples from both rural and urban settings, involving a relatively large number of participants.

The present study provides novel baseline prevalence data from Vadodara District, where evidence on adolescent obesity is scarce and highlights the burden of malnutrition in a semi-urban Indian context. Methodologically, the study is distinctive, applying a survey design within resource-limited school settings and testing a low-cost, sustainable lifestyle intervention that can be implemented by school staff and nursing professionals. The outcomes of the present study may inform future policy and practice in India and other low- and middle-income countries.

The study objectives were to assess the prevalence of childhood obesity among students in selected schools in Vadodara District, to determine the association of Dietary Variables (DV) with BMI, to examine the correlation of BMI with the height and weight of study participants and to identify the sociodemographic determinants of childhood obesity among school children by applying binary logistic regression analysis on BMI-based prevalence data.

The present study is part of a larger randomised controlled trial and phase 1 study estimating the prevalence burden of childhood obesity in Vadodara.

MATERIAL AND METHODS

A descriptive cross-sectional study was conducted among 606 school children selected through purposive sampling from three distinct schools in the Vadodara District, Gujarat, India, including one government, one semi-government and one private school, over a period of one month (July 2024). The study was approved by the Institutional Ethical Committee (CHA/IEC/ADM/23/10/1385 dated 21/10/2023) and by the district education officer of Vadodara, followed by the principals of all three schools prior to the beginning of the study.

Inclusion and Exclusion criteria: Children studying in schools of Vadodara District who provided permission to participate in the study, aged between 12-16 years and whose parents provided written consent and assent to participate, were included. Children who were absent during the assessment period were excluded.

Sample size calculation: For computing the sample size for the current study, the researcher referred to the study conducted by Prajapati V and Amin MK [6]. The researcher used the formula (4PQ/D^2) for power analysis, where the prevalence reported was 27.62% (P=0.28), (q=1-P=(1-0.27)\times 0.723), (d=0.04). Based on these values, the calculated sample size was 492.75. Accounting for a 20% dropout rate, the estimated sample size was 592, against which 606 samples were ultimately recruited for the study. Formal permission from the CDC was obtained via email confirmation from the CDC-Information (INFO) Correspondence Team regarding the use of the Children's BMI Group Calculator.

Study Procedure

After reviewing the literature on childhood obesity, the researcher identified CDC BMI tools for assessing childhood obesity among school children. The study tool included demographic variables, height, weight, BMI status [9,10] and mid-upper arm circumference.

After obtaining all necessary permissions, the researcher recruited study samples. An average of 20 minutes was spent per student, during which demographic characteristics were assessed. Students were measured for height, weight and mid-arm circumference using calibrated electronic scales, stadiometers and tape measures in the same position and angle on a flat surface, following the guidelines in the Rastriya Bal Swasthya Karyakram participant's manual [11]. The data was tabulated and arranged in the CDC BMI tool metric version [10], with results classified as shown in [Table/Fig-1].

S. No.	Criteria	BMI category	n (%)
1	BMI<18.5 kg/m^2	Underweight	67 (11.06%)
2	BMI 18.5 to 24.9 kg/m^2	Normal	315 (51.98%)
3	BMI 25 to 29.9 kg/m^2	Overweight	134 (22.11%)
4	BMI 30 to 34.9 kg/m^2	Obesity class-I	58 (9.57%)
5	BMI 35 to 39.9 kg/m^2	Obesity class-II	21 (3.47%)
6	BMI above 40 kg/m^2	Obesity class-III	11 (1.82%)

[Table/Fig-1]: Prevalence of obesity among study participants [9].

The researcher referred to previously published studies [12-14] on similar topics and identified significant variables from those studies. After forming the research tool, it was validated by 14 experts, each possessing either a PhD in nursing or an MD/MS in Paediatrics. Additionally, the tool was validated by a language expert and a statistician.

STATISTICAL ANALYSIS

The researcher used Microsoft (MS) Office 365, MS Excel 365 and IBM SPSS V.25.0 to organise, analyse and visualise the research data. The CDC BMI tool, in Excel format, was utilised to record the sample data and create graphical presentations. The researcher computed means, standard deviations, Chi-square tests, t-tests and frequency and percentage distribution tables, along with BMI categorisation based on CDC criteria and prevalence calculations using the CDC BMI tool.

RESULTS

When assessing BMI for age using the CDC tool, study results presented in [Table/Fig-2] revealed that 2% of boys were underweight (below the 5th percentile), 44% of boys and 52% of girls had a normal BMI (5th-85th percentiles) and 55% of boys and 47% of girls were overweight or obese (≥85th percentile). Additionally, 32% of boys and 20% of girls were classified as obese (≥95th percentile).

	Boys	Girls	Total
Parameters	%	%	%
Number of children assessed	57.5%	42.5%	100%
Underweight (<5th percentile)	2%	0%	1%
Normal BMI (5th - 85th percentile)	44%	52%	47%
Overweight or obese (≥ 85th percentile)	55%	47%	52%
Obese (≥ 95th percentile)*	32%	20%	27%

[Table/Fig-2]: Prevalence of childhood obesity as per CDC BMI tool (Metric version) 10.
*% of obese children calculated from Overweight or obese group (percentages rounded off)

When categorising study samples according to CDC criteria [10], it was found that the majority of the samples fell within the normal category. To provide a more specific understanding of the study outcomes, the results were simplified into BMI categories, as shown in [Table/Fig-1]. The overall prevalence of childhood obesity was 36.96%, with a mean BMI Z score of 24.25±5.58 for the study. The research was conducted at three schools and the setting-based prevalence distribution is presented in [Table/Fig-3]. According to [Table/Fig-3], which represents the school-wide prevalence of obesity categories, it was observed that the majority (34.55%) were underweight children. Overweight (23.69%) and obesity class I (10.90%) were more prevalent among private school children. No students were found in obesity class III in either government or private schools.

BMI	Government	Government-aided	Private
Category	n (%)	n (%)	n (%)
Underweight	19 (34.55)	14 (18.92)	34 (7.13)
Normal	26 (47.27)	43 (58.11)	246 (51.57)
Overweight	9 (16.36)	12 (16.22)	113 (23.69)
Obesity class I	1 (1.82)	5 (6.76)	52 (10.90)
Obesity class II	0	0	21 (4.40)
Obesity class III	0	0	11 (2.31)
Obesity	0	0	0

[Table/Fig-3]: School-wise prevalence.

The demographic characteristics of study samples are depicted in [Table/Fig-4a-c], with each table/figure representing a stack of 7 demographic variables out of 21 assessed during the study. [Table/Fig-4] displays the percentage share of all demographic variables along with their component-wise percentages. Among children who reported a positive family history of disease, 35 (5.78%) were affected, with the majority (73.33%) of diagnosed family members experiencing cardiac arrest, followed by hypertension and other disorders.

The study was conducted using 21 demographic variables, of which 11 were found to be significantly associated with BMI at a 0.05 level of significance [Table/Fig-5].

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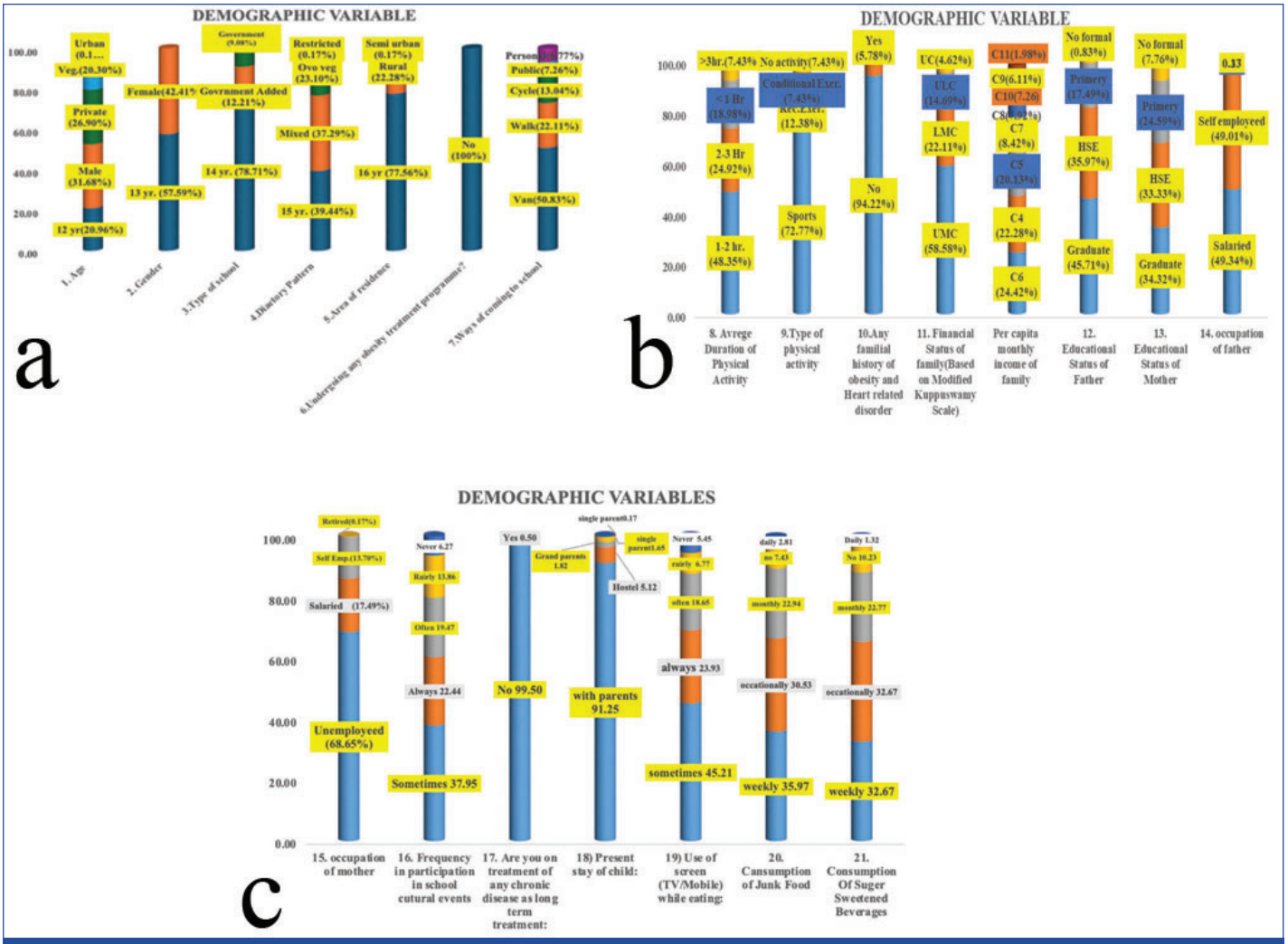

[Table/Fig-4]: (a-c): Stacked graph displaying distribution of demographic variables.
*UMC: Upper middle class, LMC: Lower middle class, ULC: Upper lower class, UC: Upper class; *As per Kuppuswamy scale monthly income in INR C4 (36527-45588), C5 (45589-54650), C6 (54651-59251), C7 (59252-63853), C9 (68455-73053), C10 (73,054-109,579), C11 (109,580-146,103)

S. No.	Demographic variables	df	Pearson's Chi-square	p-value
1	Age of Child	20	70.986	<0.0001
2	Gender	5	11.487	0.042
3	Type of school of child	10	56.463	<0.0001
4	Diatory pattern	15	36.228	0.001
5	Area of Residence	10	51.575	<0.0001
6	Undergoing any obesity treatment programme	0	--	--
7	Ways of coming to school	20	48.357	0.0004
8	Average duration of physical activity per day	15	32.729	0.005
9	Types of physical activity	15	22.418	0.095
10	Any familial history of obesity and heart related disorder	5	4.412	0.491
11	Financial status of family	15	50.87	<0.0001
12	Educational status of father	15	31.134	0.008
13	Educational status of mother	15	50.544	0.0001
14	Occupation of father	20	24.327	0.228
15	Occupation of mother	15	10.251	0.803
16	Frequency of participation in school cultural and sports in last 1year	20	17.461	0.622
17	Are you on treatment of any chronic disease	10	7.017	0.723
18	Present stay of child	20	14.52	0.803
19	Use of screen while eating	15	7.017	0.957
20	Consumption of junk food	20	35.811	0.016
21	Consumption of sugar sweetened beverages	20	13.575	0.851

[Table/Fig-5]: Association of BMI with demographic variables.

Adolescent obesity risk can be increased by nine major factors, with the most significant being age 15 (OR: 3.76), followed by daily junk food consumption (OR: 3.67) and attending a private school (OR: 3.19). Conversely, three factors—living in a rural area, having a lower socioeconomic status and being physically active—can help prevent obesity (all ORs around 0.31-0.33) [Table/Fig-6].

To evaluate the correlation between variables, the researcher employed Pearson's correlation and the results are presented in [Table/Fig-7].

On computation of Pearson's correlation, it was revealed that there was a weak positive correlation between height and BMI, a strong positive correlation between weight and BMI and a moderate positive correlation between MAC and BMI.

DISCUSSION

The overall prevalence of childhood overweight and obesity was found to be 36.96%, with a mean BMI Z-score of 24.25±5.58. This is similar to the prevalence reported in a study conducted in the U.S. by Dehghan M et al., [15], which indicated a collective prevalence of obesity and overweight at 36% (25% overweight + 11% obese), highlighting the severe burden of excess weight among children. These findings align with those of Iyer U et al., in a study conducted in Vadodara City (2011), where they assessed

S. No.	Variables	Observation	Interpretation
1	Age (in years) (p<0.0001)	Reference Category: 12 years (OR =1.0) 1.1: Age 13: OR =1.85 (95% CI: 1.1-3.12)	• Adolescents aged 13 years are 1.85 times more likely to be obese compared to 12-year-olds • The risk increases by 85% with one year increase from age 12 to 13
		1.2: Age 14: OR=2.86 (95% CI: 1.69-4.84)	14-year-olds have 2.86 times higher odds of obesity Risk increases by 186% compared to the reference group
		1.3: Age 15: OR=3.76 (95% CI: 2.17-6.54) (S)	• Strongest age effect: 15-year-olds are 3.76 times more likely to be obese • Risk increases by 276% compared to 12-year-olds
		1.4: Age 16: OR=0	• Insufficient data - only 1 case
2	Gender (p=0.0425)	Reference category: Male (OR=1.0) 2.1 Female: OR=0.77 (95% CI: 0.55-1.08)	• Females have 23% lower odds of obesity compared to males • However, the confidence interval crosses 1.0, indicating this difference is not statistically significant
3	Type of school (p<0.0001)	Reference category: Government School (OR=1.0) 3.1: Government Aided: OR=1.24 (95% CI: 0.51-3.0) (NS)	• 24% higher odds but not statistically significant
		3.2: • Private School: OR=3.19 (95% CI: 1.57-6.49) (S)	• Students in private schools have 3.19 times higher odds of obesity • This represents a 219% increase in obesity risk
4	Dietary pattern (p=0.0016)	Reference category: Vegetarian (OR=1.0) 4.1: Mixed Diet: OR=0.94 (95% CI: 0.65-1.37) (NS)	• Slightly lower odds (6% decrease) but not significant.
		4.2: Ovo-vegetarian: OR=1.03 (95% CI: 0.67-1.58) (NS)	• Almost indistinguishable odds to vegetarian diet but not significant.
		4.3: Restricted diet: OR=undefined (only 1 case)	• No odd's ratio calculated.
5	Area of residence (p<0.0001)	Reference category: Urban (OR=1.0) 5.1: Rural: OR=0.33 (95% CI: 0.21-0.52) (S)	• Rural residents have 67% lower odds of obesity • This is a strong protective effect
6	Ways of coming to school (p=0.0004)	Reference category: Walking (OR=1.0) 6.1: By Cycle: OR=1.85 (95% CI: 1.01-3.39) (S)	• Counterintuitively, cycling is associated with 85% higher odds of obesity • This may reflect reverse causation or confounding factors
		6.2: Personal transportation: OR=2.26 (95% CI: 1.08-4.72) (S)	• Private vehicles use increases obesity odds by 126%
		6.3: Public transportation: OR=1.94 (95% CI: 0.70-3.14)(NS)	• Wide confidence interval suggests high uncertainty.
		6.4: School van: OR=2.39 (95% CI: 1.51-3.77) (S)	• Shown strongest transportation effect: 139% increased odds.
7	Average duration of physical activity per day (p=0.0051)	Reference category: < 1 hour (OR=1.0) 7.1: 1-2 hours: OR=0.69 (95% CI: 0.44-1.07) (NS)	• 31% lower odds but confidence interval crosses 1.0
		7.2: 2-3 hours: OR=0.82 (95% CI: 0.50-1.34) (NS)	• 18% lower odds but not significant
		More than 3 hours: OR=0.31 (95% CI: 0.14-0.71)(S)	• Strong protective effect: 69% lower odds of obesity • Children with >3 hours daily physical activity are about one-third as likely to be obese
8	Type of physical activity (p=0.0958)	Reference category: No physical activity (OR=1.0) 8.1: Conditional exercise: OR=0.91 (95% CI: 0.39-2.11) (NS)	• Minimal difference from no activity
		8.2: Recreational exercise: OR=0.98 (95% CI: 0.46-2.08) (NS)	• Nearly matching to no activity
9	Financial status (Modified kuppuswamy scale) (p<0.0001)	Reference category: Lower middle class (OR=1.0) 9.1: Upper Class: OR=1.11 (95% CI: 0.49-2.53)(NS)	• Similar odds to lower middle class
		9.2: Upper lower class: OR=0.32 (95% CI: 0.17-0.62) (S)	• 68% lower odds of obesity • Strong protective effect of lower socioeconomic status
		9.3: Upper middle class: OR=0.99 (95% CI: 0.66-1.18) (NS)	• Almost undistinguishable to reference category
10	Father's educational status (p=0.0084)	Reference category: No formal education (OR=1.0) 10.1: Primary Education: OR=0.65 (95% CI: 0.10-0.47)(S)	Those with just a primary education face 35% lower chances of the outcome when compared to individuals with no formal schooling at all.
		10.2: Education up to high school: OR=0.92 (95% CI: 0.15-5.63) (NS)	While the odds are slightly reduced by 8% for those with formal education compared to those without, the confidence interval is quite wide, stretching from 0.15 to 5.63. This suggests that there isn't a statistically significant relationship.
		10.3: Graduation and above: OR=0.94 (95% CI: 0.16-5.74) (S)	People who have graduated or pursued higher education have a 6% lower chance of experiencing the outcome compared to those without any formal education.

[Table/Fig-6]: Odd's ratio.

prevalence using multiple tools like the International Obesity Task Force (IOTF), CDC standards and those given by Cole et al., (2005), finding childhood obesity prevalence rates of 20.3% (IOTF), 21.6% (CDC) and 23.4% (Cole et al.,). This current study reported a prevalence of 20% among girls (obese ≥95th percentile), with a mean BMI score of 24.25 compared to Iyer U et al.,'s results (CDC) of 23.44 [16].

Boys are more likely than girls to fall into the categories of both underweight and obesity, highlighting a clear differentiation by gender. These trends were measured using the CDC BMI percentiles as a benchmark instrument and the results appear to be in great harmony. A study conducted by Mustafa AEM et al., [17] reported similar prevalence rates of 33.1% for males and 35.8% for females.

In terms of age, the mean age of the participants was 13.47±1.04 years, consistent with a study by Mangrola NY et al., [18], indicating the need for a precise age framework in school health surveys.

Obesity rates by gender were also similar to findings by Mangrola NY et al., [18]. The type of school emerged as a significant variable in nutritional levels. For instance, students in government schools tend to exhibit normal or elevated BMI levels. This school-based finding illustrates socioeconomic classification, supported by a study conducted by Singh R and Srivastava S in Lucknow [19]. Furthermore, mid-arm circumference showed a strong positive correlation with BMI and weight in both males and females, with all correlations being highly significant (p<0.0001). The correlation with height, however, was moderate, suggesting that mid-arm circumference is more closely related to body mass than to height.

Observation 1	Observation 2	Pearson's r static value	Results
Body mass index	Height	0.257	As p<0.01 it indicates statistically significance hence there is weak positive correlation between BMI and height
	Weight	0.889	As p<0.01 it indicates statistically significance hence there is a strong positive corelation between BMI and weight.
	Mid-arm circumference	0.772	As p<0.01 it indicates statistically significance hence there is a moderate positive linear correlation between BMI and Mid Arm Circumference.

[Table/Fig-7]: Correlation (Pearson's) of BMI with height, weight and MAC.

Notably, private school students exhibited significantly higher BMI levels, while government school students had lower BMI scores, with no significant difference in BMI between government and government-aided schools. These findings are corroborated by a meta-analysis conducted by Singh S et al., which reviewed two decades of prevalence. They found that male children are at greater risk of obesity and those studying at private schools are more at risk of developing obesity than those in government schools [20]. In another study by Varghese AD et al., in Kerala, it was reported that students at private schools had a higher prevalence (17.8%) of childhood obesity compared to government (8%) and government-aided (15.3%) schools [21].

Logistic regression revealed that the risk of obesity among adolescents is influenced by factors such as age, socioeconomic status, school environment, transportation mode and residence. These findings are supported by the Comprehensive National Nutrition Survey (CNNS) [22], which reported that approximately 32% of adolescents aged 10-19 years in Gujarat are classified as thin based on BMI-for-age Z-scores below –2 SD, primarily in government schools. Conversely, the highest percentage (58.10%) of normal children was found in government-aided schools [22].

The National Family Health Survey (NFHS-5) [5] indicates that 36% of adolescent girls (15-19 years) in Gujarat have a BMI below 18.5, reflecting underweight status. Data from the Integrated Child Development Services (ICDS) monitoring system further support this trend, with reports indicating that 51% of adolescent girls are underweight in several rural blocks [23].

The present study contributes to the understanding of obesity prevalence in the Vadodara District and supports the findings of other researchers, indicating a consistent increase in obesity rates, especially among urban children compared to their rural counterparts. Despite numerous alarming reports, there is a gradual rise in childhood obesity prevalence among urban dwellers, which may be attributed to:

- The influence of Western cultural trends
- Parental negligence
- Misconceptions about health, thinking one is healthy when overweight
- A lack of scientific approaches in lifestyle choices
- Imbalanced dietary intake of carbohydrates and fats
- Irregular exercise habits in students' daily lives

It was also observed that the majority (34.54%) of underweight students belong to government schools, while the difference in the normal BMI category between government and private school students is only 3.98%. Conversely, a significant proportion of obese students are in private schools and urban areas.

Limitation(s)

The present study was restricted to one region and may not be generalisable to a wider population. Additionally, BMI categories specific to the Asian population were not utilised.

CONCLUSION(S)

The study concluded that the prevalence of childhood obesity reported is close to the estimated prevalence indicated by the World Obesity Atlas for the next decade. Results showed that most study participants were categorised as overweight or obese, with boys exhibiting a higher BMI than girls. Among the measured variables, most were significantly associated with BMI, while factors such as type of physical activity, familial history of disease, occupation, participation in activities, treatment of chronic diseases, residence, use of screens while eating and beverage consumption were found to be nonsignificant. When analysed for correlation it was found that BMI has weak positive co relation with height, moderately positive correlation with MAC and strong positive correlation with weight. Further studies should include more settings and a larger number of samples. A longitudinal follow-up study of the assessed children could be performed to estimate the long-term effects of obesity on their health. The results of the present study can be utilised for further administrative planning and policy-making.

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