

A Systematic Review on Prevalence of Overweight and Obesity among School Children and Adolescents in Indian Population

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Abstract

Obesity has erupted as an epidemic around the world. It has set itself as a fast wave among other prevailing specific clusters of non-communicable diseases. The current study reviews and presents an updated meaningful review of the vast research work performed at schools located in different cities of India. A systematic search was conducted in PubMed, Scopus, Google Scholar and PEDro. Studies representing data on obesity and overweight among children in Indian cities were included in the review. A total of 21 articles with 71,466 participants were included in the review for analysis. Obesity developed in childhood and adolescence is greatly associated with heart disease, stroke and cancer (breast and ovarian in women and prostate in men) in the late stage of life. In India, despite being a country with a faster rate of population becoming overweight and obese in urban areas, in contrast, rural areas are still struggling with malnutrition.

Keywords: Adolescent, body mass index, children, obesity, overweight

INTRODUCTION

Obesity has erupted as an epidemic around the world. It has set itself as a fast wave among other prevailing specific clusters of non-communicable diseases. A few years back, 'overweight' and 'obesity' was a topic of concern restricted only to developed nations, but as time flew, populations of diverse age groups in different parts of the world could not resist getting engulfed by overweight and obesity. In developing countries, it was given the name of 'New World Syndrome' whose main carriers are individuals undergoing their early stage of life, in other words, the school-going children and adolescent population.^[1] 'India is no exception to it'. Rapid changes in dietary habits, increased consumption of junk food, reduced levels of outdoor physical activity, addiction towards mobile in association with social networking sites/e-applications and over-pampering from parents to children have shifted children from healthy individuals to overweight and obese.^[2]

Long-term energy imbalances, where daily energy intake exceeds daily energy expenditure, lead to obesity. Many variables, such as metabolic rate, appetite, food, and physical activity, affect energy balance.^[3] Although some children's genetic traits are influenced

by these factors, the rise in obesity prevalence over the past few decades cannot be explained by changes in the human gene pool. Instead, environmental changes that encourage excessive food intake and discourage physical activity are typically to blame.^[4] The diet and amount of inactive time children consume influence their chances of becoming obese.^[5] Parental obesity, low parental education, social deprivation, baby feeding patterns, early or more rapid puberty (both a risk factor and an impact of obesity), extremely high or extremely low birth weights, and gestational diabetes are additional risk factors.^[6] Just 36% of children and adolescents in the United States today reach the recommended levels of physical activity, a decline in levels of physical activity over time.^[7]

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Childhood nutritional exposures, which include the development of unhealthy eating habits and behaviours,^[8,9] a high intake of energy-dense foods and a higher rate of food consumption, are among the potential causes of childhood obesity.^[10] Inactivity and the amount of time spent watching TV are additional factors.^[11] Certain eating habits^[12,13] and sedentary behaviours^[14] developed in early childhood may persist throughout adulthood, according to longitudinal studies.^[15] Hence, early childhood interventions that alter nutritional consumption and/or physical exercise have the potential to enhance health outcomes.^[16]

The World Health Organization (WHO) and the International Obesity Task Force (IOTF) have established lower BMI (body mass index) cut-offs for Asian Indian adults for overweight and obesity, respectively, of 23 and 25 kg/m², but these are not applicable to children and adolescents. The numerous cut-points or classifications used to categorise obesity and overweight in children and adolescents have not always been agreed upon over the years. Because of this, it is challenging to compare and understand national or worldwide prevalence rates.^[17] Typically, age- and gender-specific BMI normograms are used to characterise overweight and obesity in children and adolescents.^[18]

In the new era, children are living a sedentary life and hesitate to withdrawal from their comfort zone. These factors aggravated the health hazard into an issue to be worked upon seriously to reduce the negative impacts on one's personality and ultimately towards society. Obesity developed in childhood and adolescence is greatly associated with heart disease, stroke and cancer (breast and ovarian in women and prostate in men) in the late stage of life.^[19] In addition, it is also associated with the risk of dyslipidaemia and gallbladder disease.^[20] In India, it is a great irony, that despite being a country with a faster rate of population becoming overweight and obese in urban areas, in contrast, rural areas are still struggling with malnutrition.^[21] Overweight and obese children, if not controlled in the early stage of life, turn into overweight adults or obese (Dietz, 2004). Hence, creating enormous personal, financial and social burdens on one's and state economy. The current study reviews and presents an updated meaningful review of the vast research work performed at schools located in different cities of India to determine the prevalence of overweight school children and adolescent populations, predict the incidence of overweight school children and adolescent population, look for ways to educate the population in the early stage of life and identify methods to educate parents or guardians in identifying and reducing the chances of overweight and obesity.

MATERIALS AND METHODS

Registration

We conducted a systematic review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations.^[22] The review was entered into the Prospective International Registry of

Systematic Reviews (PROSPERO – CRD42023414711). The present review did not require ethical board approval because the study does not involve human or animal participants.

Types of participants

Studies, where children were a part of a family group receiving the intervention, were also included if data could be retrieved individually for the children. We also included studies where children were less than 18 years old at the start of the research. To reflect a public health approach that acknowledges the presence of a range of weight among children in general, studies with interventions that included children who were already obese at baseline were included. We did not include studies of prenatal obesity prevention therapies or studies of children with life-threatening illnesses or significant co-morbidities.

Inclusion and exclusion criteria

This study focused on identifying the prevalence of overweight and obesity in school-going children and adolescents in India. The inclusion criteria set were articles published in context to investigate prevalence, magnitude, determinants or relationships concentrating with overweight and obesity only on school-going and adolescent population, that is, studies performed only at the school level were considered for the review. Articles published after 2007 were only taken into consideration with each article consisting of both boys and girls as participants were only considered. With respect to exclusion criteria, articles published before 2007 were not included. Studies performed in colleges, universities or any other educational establishments other than schools were not reviewed. Articles published other than in English were excluded. In addition, articles with any single gender as a participant were also excluded.

Selection of studies

Studies published in or after 2007 were included. Studies that were recognised as included and omitted for earlier iterations of this evaluation and published after 2007 were carried over to this review. Articles were disqualified at the initial screening stage if the reviewer determined from the title and abstract that they did not meet the inclusion and exclusion criteria, or if the trial did not address goals to represent prevalence, improve food intake, physical activity, and/or prevent obesity, or if the trial involved only adults over the age of 18, pregnant women, young adults, or the critically ill. The authors searched literature from databases like PubMed, Google Scholar, PEDro and Scopus. All authors independently conducted the extraction of information and inferences. In this study, the search terminologies used for eligible searches were as follows: prevalence, overweight, obesity, BMI, India, children, adolescent, boys and girls. While searching articles, the date of publication, preference for any particular journal, was not made as a limitation. The authors used search terms and phrases to search articles based on the selection criteria set for the review. Snowball strategies were adapted to extract articles published between January 2007 to December 2022.

The extracted information has been presented in the form of Table 1, consisting of the author name, year and place of study, number of participants, outcome measures and results.

Data extraction and management

To collect data for this review, a data extraction form based on the Effective Public Health Practice Project Quality Assessment Tool for quantitative studies^[23] was created and pre-tested. Also, procedural aspects were sought, including ways to involve pertinent stakeholders in the planning and implementation of the findings; descriptions of formative research, pilot studies and ongoing evaluation; and the extent to which the programme may be modified and reached.

Data synthesis

According to factors including participant characteristics, prevalence characteristics, follow-up and individual data, each study was summarised and discussed. Studies' procedures for identifying prevalence groups, choosing individuals to evaluate outcomes in, using statistical analyses, and attrition rates were all evaluated. Summaries were conducted where it was both conceptually sound and practical to do so. It is increasingly helpful to include possible review users at crucial phases of the review process for systematic reviews to be applicable to policy and practise.^[24] This participation can guarantee that the review will address the crucial issues that policymakers and practitioners deem significant, take into account all relevant outcomes, and deliver its conclusions and recommendations in an understandable manner.^[25] Since many of the authors of this review presently hold these positions and are actively involved in advising on policy and disseminating review evidence to users, we did not explicitly involve any new policymakers and review users in the development of this version of the review.

Risk of bias assessment

The Grading of Recommendations Assessment, Development, and Evaluation Working Group (GRADE) was used.^[26] It assesses the term quality to refer to both the individual study itself and the overall strength of the body of evidence (referred to as the quality of evidence). Two authors have independently assessed the risk of bias as it is essentially interchangeable with the concept of internal validity, which assesses how effectively a study's design and implementation have minimised bias or ensured that the results are accurate for the circumstances being studied. "Quality assessment" is a common alternative, but its meaning can vary depending on the specific guidelines being followed. For example, one definition of quality includes the extent to which a study's design and implementation protect against systematic bias, nonsystematic bias and inferential error.

Sensitivity analysis

Two primary reviewers conducted a repeated analysis of the main results using either a modified dataset or a different statistical method. The purpose was to assess whether these changes had any impact on the overall outcome estimate. When modifying the dataset, the decision to include or exclude specific studies was often based on assumptions regarding

their quality or size, and it was typically left to the discretion of the author. Sub-group analyses were employed to extract this lost information and are akin to sensitivity analyses. In sub-group analyses, the entire dataset is re-analysed, but it is divided based on a specific factor of interest to the authors, rather than adding or removing individual studies.

Methodological quality assessment

The methodological quality of included studies was assessed using critical appraisal tool for cross-sectional studies (AXIS).^[27] The AXIS tool is designed to assess the credibility and reliability of published research findings based on the presented methods and results, rather than focusing on the interpretation or discussion of the study. The tool's components are developed through a combination of evidence, epidemiological processes and the input of researchers and participants in the Delphi method. The AXIS tool is considered an evidence-based initiative and aims to be a dynamic and adaptable tool that can evolve and improve as needed. It is intended to be continuously assessed and its validity measured over time. The tool's primary focus is on evaluating the aims, methods and analysis reported in a study to determine the credibility and reliability of the findings.

RESULTS

One thousand four hundred seventy-eight potential studies were found in the initial search (1475 from chosen databases and 3 from manual searches). One thousand three hundred seventy-seven records were excluded after we reviewed 1478 titles and abstracts since they did not fit our inclusion criteria. In total, 228 duplicate records were eliminated. Sixty-nine of these were judged to have full text. Of these, 29 papers were eliminated due to the inappropriate publication type, 11 due to the incorrect study design, 2 due to the incorrect outcome, 3 due to the incorrect methodology and 3 due to the incorrect demographic. Finally, 21 studies were found to be eligible and included in the review [Figure 1].

Overall, 21 studies conducted between 2007 and 2022 and involving 71,466 participants were included for review (summary of articles is discussed in Table 1). The age of participants ranged from 5 to 18 years. All selected studies employed a cross-sectional study design and were school-based, except one involving a door-to-door survey. The majority of the studies were conducted in South India,^[8] followed by Western India,^[4] North India,^[4] North-eastern India^[3] and Eastern India.^[2]

Criteria for screening obesity

The most used reference standard for the classification of childhood overweight and obesity in India was WHO BMI classification^[28-30] (8 studies) followed by IOTF – Cole TJ *et al* 2007^[31,32] (7 studies), Centres for Disease Control and Prevention's (CDC) age- and sex-specific growth chart^[33,34] (2 studies) and Indian Academy of Pediatrics (IAP) age- and gender-specific BMI guidelines^[29] (2 studies). One study used classification via waist circumference values of the

Table 1: Presentation of articles in line with objectives and main findings regarding the prevalence of obesity and overweight among children and adolescents in India

Author	Objective	Study design	Outcome measures	Result	Conclusion
Harish BR <i>et al.</i> , 2015	To determine the prevalence of obesity in high school children and assess the validity of waist circumference (WC) in detecting obesity	A cross-sectional study	Height Weight BMI Waist circumference	8.85% of girls and 6.03% of boys had WC above the prescribed values and were considered obese. The overall prevalence of obesity was 7.59%	WC can be considered as a simple and alternative measure to BMI for obesity assessment
Das MK <i>et al.</i> , 2017	To record the prevalence of overweight and obesity among urban school children	A cross-sectional study	Height: Standing barefoot with head in Frankfurt plane position. Weight BMI	The prevalence of overweight and obesity increased with age in both genders (15% and 4.9%, respectively, using the IAP criteria) whereas the prevalence of under-weight decreased from 33.1% at 5–6 years of age to 25.9% at 9–10 years	A notable percentage of children are overweight and obese in the Delhi-NCR region. The proportion of children with overweight and obesity increased with a decrease in the under-weight proportion
Aggarwal T <i>et al.</i> , 2008	To study the prevalence of obesity among adolescents catering to the affluent segment of population	A cross-sectional study	Height Weight Pre-validated questionnaire: Socio-economic status Dietary habits Exercise pattern	A significantly greater number of boys (15%) as compared to girls (10.2%) were overweight. Most of the adolescents, (57.2% boys and 52.8% girls) spent 1–4 hours/day watching TV. Incidence was higher in adolescents who ate frequent meals outside the home	In high-income population, the overweight and obesity trends tend to increase from childhood to adulthood
Mahendra B <i>et al.</i> , 2017	To know the prevalence of overweight and obesity and factors contributing to overweight and obesity among school children	A cross-sectional study	Height Weight BMI Questionnaire: general information on factors contributing to overweight and obesity	The prevalence of overweight and obesity was more (14.00%) in private schools than in government schools (7.20%). 22.73% of overweight and obese children had working mothers. 29.92% of children presented a family history of overweight and obesity. Incidence was high in girls 12.60% and boys 8.60%.	Overweight and obesity was high among girls and school children with working mothers
Pathak S <i>et al.</i> , 2018	To compare the prevalence of obesity among urban and rural school going adolescent and study various factors predisposing to obesity	A cross-sectional study	Height Weight BMI Questionnaire: Socio-economic factors Physical activity Eating habits	65.22% of urban males and 62.26% of females were obese and overweight whereas prevalence in rural males and females was 15.78% and 3.92%, respectively. ($P < 0.0001$)	The frequency of obesity and overweight was high among adolescents with higher annual family income. Increased restaurant visits, school canteen food and lesser frequency of physical training sessions conducted in schools were factors predisposing to increased risk of obesity
Goyal JP <i>et al.</i> , 2011	To determine risk factors for overweight and obesity among affluent adolescents	A cross-sectional study	BMI Pre-designed and pre-tested questionnaire: Dietary history Physical activity.	The prevalence of obesity and overweight was higher in boys compared to girls, but the difference was very small and statistically non-significant. Unhealthy dietary habits and sedentary lifestyles were associated with an increased risk for obesity and overweight.	Findings concluded that low levels of physical activity, television watching or playing computer games, consuming junk food and carbonated drink are associated with higher prevalence of overweight and obesity

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Table 1: Contd...

Author	Objective	Study design	Outcome measures	Result	Conclusion
Tiwari HC <i>et al.</i> , 2014	To assess the prevalence of overweight and obesity among school-going adolescents	A cross-sectional study	Anthropometric Measures: Weight height Pre-designed and pre-tested questionnaire: Socio-demographic profile Physical activities Frequency and duration of participation in household activities Time spent watching television/playing on a computer Diet preferences	Children consuming carbonated drink daily and more than three times per week were having 19.7 times (OR: 19.7; 95% CI=10.93–35.53) and 6.9 times (OR: 6.95; 95% CI=4.41–10.94) more risk of overweight and obesity Prevalence of overweight was maximum in late adolescence (8.3%). Female students (7.4%) were overweight as compared to male students (5.9%). Urban students presented with a high incidence than rural students. Among urban students, prevalence of overweight and obesity was found to be 13.0% and 2.1% among female students and 8.2% and 1.4% among male students. Among rural students, 3.1% males were overweight and no obese male was found. Overweight and obesity was found higher in students belonging to socioeconomic class I (11.7% and 2.2%) followed by socioeconomic class II (7.4% and 1.1%)	A high magnitude of overweight/obesity was observed among school-going adolescents. Regular participation in household activities and outdoor games and healthy eating habits should be incorporated curb this problem
Cherian AT <i>et al.</i> , 2012	To examine the prevalence of obesity and overweight among urban school children with varying socio-economic status	A cross-sectional study	Height Weight Parental Occupation	The prevalence of obesity was 3.0% for boys and 5.3% for girls. Prevalence of obesity and overweight among upper income group, middle income group and lower income group boys was 5% and 16%, 3% and 12%, and 1% and 2%, respectively ($P<0.005$)	Findings revealed a lower incidence of overweight and obesity in the lower socioeconomic groups as compared to developed countries
Bishwalata R <i>et al.</i> , 2010	To determine the prevalence of overweight and obesity among school children	A cross-sectional study	Height Weight Waist circumference Hip circumference Fat percentage Fat mass Fat-free mass BMI Waist-hip ratio Questionnaire: Dietary habits Physical activity Parental built Knowledge of obesity	Obesity was found to be more prevalent among boys whereas overweight was predominantly seen among girls. BMI significantly correlated with waist and hip circumference, waist-hip ratio, fat percentage and fat mass	The prevalence was low owing to a traditional low-fat diet and ample physical activity
Dabade SK <i>et al.</i> , 2018	To find the prevalence and risk factors for overweight and obesity	A cross-sectional study	measurements: Height Weight BMI Pre-designed and pre-tested questionnaire: Sociodemographic characters	The prevalence of overweight and obesity was 12.97% in boys and 9.14% in girls. 14.04% of school students from private school were overweight whereas only 6.88% of students from government school were found overweight.	The findings of the present study showed that boys have more prevalence of overweight and obesity compared to girls. Family history of obesity, working status of mother, and insufficient sleep have a direct relationship with childhood obesity

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Table 1: Contd...

Author	Objective	Study design	Outcome measures	Result	Conclusion
Tapnikar LA <i>et al.</i> , 2017	To study the prevalence and find risk factors contributing to obesity and overweight among high school children	A cross-sectional study	Parents working status Family history of overweight and obesity Height Weight BMI Questionnaire: Economic status Education and occupation of parents	Family history of obesity, working status of the mother, and less duration of sleeping are directly associated with childhood obesity 12% of the total students in the overweight and obese category preferred fast food and 13.33% turned out to be binge eaters. Prevalence of obesity is high in children who do not have food in between meals (10.67%)	Findings emphasised on inculcating healthy eating habits and ample sleep to control the incidence of overweight and obesity
Kotian MS <i>et al.</i> , 2010	To estimate the prevalence and determinants of overweight and obesity among school children	A cross-sectional study	Physical activity Diet preferences Height Weight	Risk of overweight was two times higher among the adolescents of high socio-economic status, 21 times higher among those participating <2 h/week in any type of physical activity, 7.3 times higher among those who reported watching television and playing games on the computer for >4 h/day, and 5.6 times higher among those who ate chocolates daily in addition to a normal diet	The results revealed that regular physical activity was an important factor in reducing the prevalence of overweight and obesity
Nagaraj S <i>et al.</i> , 2015	To estimate the prevalence and describe determinants of overweight and obesity among school-going adolescents	A cross-sectional study	Anthropometric measurements: Height Weight Pretested structured questionnaire	The results showed a female preponderance for overweight (18.7%) and obesity (6.1%) as compared to males. Those residing in urban areas had a higher prevalence of overweight (16.6%) and obesity (7.0%)	The findings emphasised adopting measures for the prevention and control of obesity in school health programmes and training schoolteachers in the detection of obesity among adolescents
Premanath M <i>et al.</i> , 2008	To document the prevalence of obesity, overweight and underweight in a sample of schoolchildren	A cross-sectional study	Anthropometric measurements: Height Weight Pretested questionnaire	Children from private schools were significantly overweight as compared to those from government schools, (9.1% vs 5.9%) Prevalence of underweight was higher in children from government schools (24%) as compared to (15.9%) of those from private schools	Findings revealed that obesity and overweight were prevalent in childhood and early adolescence
Shanmugam K <i>et al.</i> , 2016	To study the prevalence of overweight and obesity among rural school children	A cross-sectional study	Height Weight BMI	The prevalence of obesity was greater in boys when compared to girls (6.43% vs. 2.96%). However, the prevalence of overweight was similar in both	A high proportion of rural school children with weight more than normal, indicates the need for public awareness and preventive measures on childhood obesity
Prasad RV <i>et al.</i> , 2015	To measure the prevalence of overweight and obesity among adolescents	A cross-sectional study	Height Weight BMI	Overweight and obesity were observed maximum in urban private school (20%), while the minimum prevalence was seen in the rural government school (5.2%) The prevalence of overweight/obesity increased with advancing age	The prevalence of overweight and obesity was predominant among students at private schools in the urban region
Gautum S <i>et al.</i> , 2018	To determine the prevalence and assess the factors associated with obesity among school children	A cross-sectional study	Anthropometric measurements: Height Weight BMI	The prevalence of overweight and obese were 11.0% and 7.1% among males and 10.6% and 5.4% among females, respectively.	The findings emphasised the importance of effective implementation of school health activities to reduce and curb the burden of childhood obesity

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Table 1: Contd...

Author	Objective	Study design	Outcome measures	Result	Conclusion
			Semi-structured questionnaire: Demographic characteristics Dietary habits	The prevalence of elevated BMI varied significantly among students in different types of schools (6.9%, 10.9% and 31.2% in government, aided and unaided/private schools, respectively; $P < 0.001$)	
Bose K <i>et al.</i> , 2007	To determine the prevalence of overweight and obesity among schoolgirls	A cross-sectional study	Height Weight BMI	Results revealed an increase in mean weight from 20.4 kg at age 6 years to 30.6 kg at age 9 years. Mean BMI increased consistently from age 6 years to age 9 years (15.2, 16.2, 16.7 and 17.6 kg m ² at ages 6, 7, 8 and 9, respectively). A significant increase was observed ($P = 0.0119$) in the rate of overweight with increasing age	The prevalence of overweight among affluent Bengalee children was higher than those reported from other Asian countries
Patnaik S <i>et al.</i> , 2011	To study the prevalence of overweight and obesity among school children of an affluent school and assess risk factors related to obesity	A cross-sectional study	Height Weight BMI Physical activity Dietary habits	Maximum prevalence, i.e., 36.54% was found in 5–10 years age group and 22.3% in the adolescence period (10–15 years). A higher incidence was observed among children with a family history of obesity (39.79%), not playing outdoor games (40.8%), not doing regular exercise (33.9%), watching TV for more than 2 hours daily (32.5%), consuming junk food regularly (42.86%)	Emphasis should be laid on timely screening for overweight and obesity in schools followed by counselling sessions for parents and adolescents
Longkumer T <i>et al.</i> , 2012	To find growth status and the prevalence of underweight and overweight among tribal children	A cross-sectional study	Height Weight BMI	Overall incidence of overweight was higher in girls (2.48%) than in boys (2.08%)	Findings revealed that both underweight and overweight coexisted among children, although the prevalence of overweight was not high
Singh MS <i>et al.</i> , 2012	To determine the nutritional status (underweight and overweight) among Meitei children and adolescents	A cross-sectional study	Height Weight	A high prevalence of underweight (30.21%) and overweight (3.12%) was found among children and adolescent boys, respectively. The prevalence of both underweight (33.86%) and overweight (5.18%) was found to be higher among children than adolescents in girls. The in the prevalence of underweight and overweight were significant	As per the findings, poverty, low dietary intake, socioeconomic condition, nutrition transition, changing lifestyles, peer pressure and inappropriate eating habits contributed to both underweight and obesity among children

75th percentile for urban Indian children^[35] whereas another study employed age-specific cutoff values for risk of overweight and obesity corresponding to adult equivalent BMI of 23 and 28 kg/m² at the age of 18 years for Indian boys and girls.^[36]

Study findings

Studies reporting the prevalence of obesity and overweight among children and adolescents in India are included in Table 2. The overall prevalence of overweight and obesity ranged from 2.28% to 21.9% and 2.4% to 17.6%, respectively. The prevalence of overweight was higher than obesity in most of the studies included for discussion in the review. A higher predominance of obesity was reported among boys compared to girls. However, the findings of one study suggested a lower

incidence of obesity among rural boys as compared to rural girls, urban girls and urban boys.^[37]

Studies reported a higher prevalence of overweight and obesity (14.00%) among children from private schools than in government schools (7.20%).^[38] Also, urban students presented with a higher rate of incidence of overweight and obesity compared to rural students.^[13,39]

Risk factors for overweight and obesity

Socio-economic status

A study to examine the prevalence of obesity and overweight among urban school children with varying socio-economic status indicated a higher prevalence of obesity and overweight among boys from upper income group followed by middle

Table 2: Overweight and obesity trends among children and adolescents in India

Author (Year)	Sample Size	Age Group (Years)	Study Location	Criteria for Screening Obesity	Prevalence of Obesity (%)			Prevalence of Overweight (%)		
					Overall	Girls	Boys	Overall	Girls	Boys
Harish BR <i>et al.</i> , 2015	4663	11–16	Government and Private high schools in Mandya City, Bangalore	Waist Circumference (WC) values of the 75 th percentile for urban Indian children (Kurian <i>et al</i>)	7.59	8.85	6.03	-	-	-
Das MK <i>et al.</i> , 2017	5643	≥5–<10	Private schools in urban Faridabad, Haryana	International Obesity Task Force (IOTF) references for body mass index (BMI)	2.4	2.1	2.6	6.4	6.7	6.2
Aggarwal T <i>et al.</i> , 2008	1000	14–18	Public schools of Ludhiana, Punjab	World Health Organization (WHO) International cutoff points for BMI	3.4	-	-	12.7	10.2	15
Mahendra B <i>et al.</i> , 2017	1000	12–>16	Government and private schools in Udaipur, Rajasthan	WHO BMI criteria for the Asian population	2.40	-	-	8.20	-	-
Pathak S <i>et al.</i> , 2018	188	10–17	Rural and urban private schools of Vadodara, Gujarat	BMI for age-weight status categories with corresponding percentiles as follows: (underweight <5 th percentile, normal weight 5 th to 85 th percentile, overweight 85 th to 95 th percentile and obese >95 th percentile)	17.6	15.4	20.2	20.2	-	-
Goyal JP <i>et al.</i> , 2011	1209	12–15	Private schools in Surat, Gujarat	Indian Academy of Pediatrics (IAP) growth monitoring guidelines for Children	13.9	13.35	15.1	6.55	6.4	6.7
Tiwari HC <i>et al.</i> , 2014	900	14–17	Schools in Allahabad district, Uttar Pradesh	WHO BMI criteria for age classification	1.1	1.4	0.8	6.6	7.4	5.9
Cherian AT <i>et al.</i> , 2011	1634	6–15	Urban school children in Kochi, Kerala	Centre for Disease Control and Prevention (CDC) standard chart	7.5	5.3	3	21.9	12.1	10.2
Bishwalata R <i>et al.</i> , 2010	3236	12–19	Government and private schools in Manipur	International obesity task force (IOTF) references for BMI	0.7	0.4	1	4.4	4.7	4.1
Dabade SK <i>et al.</i> , 2018	360	12–>16	Government and private schools in Satara, Maharashtra	Age-specific cutoff values for risk of overweight and obesity corresponding to adult equivalent BMI of 23 and 28 kg/m ² at the age of 18 years for Indian boys and girls were used	2.5	-	-	9.16	-	-
Tapnikar LA <i>et al.</i> , 2017	150	12–17	Private schools in Nagpur, Maharashtra	WHO BMI classification 2007	2	-	-	12	-	-
Kotian MS <i>et al.</i> , 2010	1000	12–15	School children in Mangalore, Karnataka	The International Obesity Task Force (IOTF) references for BMI	4.8	4.3	5.2	9.9	10.5	9.3
Nagaraj S <i>et al.</i> , 2015	467	10–18	Middle school, high school and preuniversity colleges students of Mysuru, Karnataka	International obesity task force (IOTF) guidelines 2012	5.9	6.1	-	13.7	18.7	-
Premanath M <i>et al.</i> , 2008	43152	5–16	Government and private schools in Mysore, Karnataka	Children with body mass index (BMI) >95 th percentile were considered as obese, those between 85 th and 95 th percentile as overweight, and those with BMI below the 5 th percentile were considered as underweight	3.4	3	3.7	8.5	8.2	8.8
Shanmugam K <i>et al.</i> , 2016	890	5–15	Rural school children in Coimbatore, Tamil Nadu	WHO Criteria for childhood (5–19 years) Overweight:	4.72	2.96	6.43	8.32	8.20	8.43

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Table 2: Contd...

Author (Year)	Sample Size	Age Group (Years)	Study Location	Criteria for Screening Obesity	Prevalence of Obesity (%)			Prevalence of Overweight (%)		
					Overall	Girls	Boys	Overall	Girls	Boys
Prasad RV <i>et al.</i> , 2015	2465	10–18	Schools and polytechnic colleges in Pondicherry	>+2SD (equivalent to BMI 25 kg/m ² at 19 years) Obesity: >+3SD (equivalent to BMI 30 kg/m ²) Indian Academy of Pediatrics (IAP) age- and gender-specific BMI guidelines	4.3	-	-	9.7	-	-
Gautum S <i>et al.</i> , 2018	1185	12–16	Government and private secondary school in Udupi, Karnataka	WHO 2007 Multicentre Growth Reference Study (MGRS) charts: based on distribution by gender and age	6.2	7.1	5.4	10.8	11	10.6
Bose K <i>et al.</i> , 2007	431	6–9	Schoolgirls in Kolkata	Overweight and obesity were classified following the internationally recommended cut-off points (Cole <i>et al.</i> 2000)	5.10	-	-	17.63	-	-
Patnaik S <i>et al.</i> , 2011	468	5–15	School in Bhubaneswar	Age- and gender-specific cut-points as per Center for Disease Control (CDC) growth charts (85 th percentile of BMI for age and sex is used as a reference point for overweight and the 95 th percentile for obesity in children)	14.53	-	-	14.1	-	-
Longkumer T <i>et al.</i> , 2012	571	8–15	Children from Mokochung town, Nagaland	Body mass index (BMI) classification by Cole <i>et al.</i>	-	-	-	2.28	2.48	2.08
Singh MS <i>et al.</i> , 2012	854	8–18	Urban Meitei children and adolescents in Manipur	International Obesity Task Force (IOTF) references for BMI	-	-	5.18	-	-	3.12

income group and lower income group boys (5% and 16%, 3% and 12%, and 1% and 2%, respectively) ($P < 0.005$).^[40] Findings from another study concluded that the risk of being overweight was two times higher among adolescents of high socio-economic status.^[41]

A study comparing the prevalence of overweight and obesity among different socio-economic classes reported a higher risk among students belonging to socioeconomic class I (11.7% and 2.2%) than socioeconomic class II (7.4% and 1.1%). In a study comparing obesity trends among urban and rural adolescents, a positive correlation was found between type of residence and BMI categories, which was statistically significant ($P < 0.001$).^[37]

Age

Findings from a study to determine the prevalence of overweight and obesity among schoolgirls reported an increase in mean BMI consistently from age 6 to 9 years (15.2, 16.2, 16.7 and 17.6 kg m² at ages 6, 7, 8 and 9, respectively). Also, a significant increase was observed ($P = 0.0119$) in the rate of overweight with increasing age.^[42] The prevalence of overweight and obesity increased with advancing age in both boys and girls.^[43] As per the recommendation of a study on 900 adolescents aged 14–17 years, the prevalence of overweight was predominant in late adolescence (8.3%). Similar findings were seen in another study indicating maximum prevalence, that is, 22.3% in the adolescence

period (10–15 years) (Kumar RK *et al.*, 2010). BMI significantly correlated with waist and hip circumference, waist-hip ratio, fat percentage and fat mass (Bishwalata R. *et al.*, 2010).

Lack of physical activity

A higher incidence of overweight and obesity was found among adolescents (57.2% boys and 52.8% girls) who spent 1–4 hours/day watching TV.^[44] A study among opulent adolescents suggested that eating while watching TV was associated with the likelihood of overweight and obesity 1.81 times (OR: 1.81; 95% CI = 1.19–2.79), whereas watching television and playing computer games for 1–3 hours and >3 hours increased risk of overweight and obesity 1.84 (OR: 1.84; 95% CI = 1.19–2.84) and 5.4 times (OR: 5.4; 95% CI = 2.77–10.54), respectively. Using a transport medium to school by bus or auto was also linked to 2.81 times (OR: 2.81; 95% CI = 1.41–5.61) increase in the risk of overweight and obesity.^[17] Incidence of obesity and overweight was found 21 times higher among adolescents participating <2 hours/week in physical activity and 7.3 times more among those watching television and playing games on the computer for ≥4 hours/day.^[41]

Dietary habits

Children consuming carbonated drink daily and >3 times/week had 19.7 times (OR: 19.7; 95% CI = 10.93–35.53) and 6.9 times (OR: 6.95; 95% CI = 4.41–10.94) more risk

of overweight and obesity.^[17] Among adolescents catering to the affluent section of society, the likelihood of obesity and overweight was found to be significantly higher among those adolescents who ate frequently outside the home.^[44] Children consuming chocolate daily in addition to a normal diet were at a higher risk (5.6 times more) of obesity compared to others.^[41]

A study conducted on 1209 private school students suggested that taking snacks daily and >3 times/week had 4.19 times (OR: 4.19; 95% CI = 2.34–7.51) and 1.97 times (OR: 1.97; 95% CI = 1.24–3.11) more risk of overweight and obesity. Eating outside food >2 times/week increased the probability of being overweight and obese 7.97 times (OR: 7.97; 95% CI = 5.23–12.15). Also, the risk increased to twice among children consuming junk food more than once a day (OR: 2; 95% CI = 1.30–3.08).^[45] Among participants belonging to the overweight and obese category, 12% of the total were found to prefer fast food and results were found to be highly significant at $X^2 = 45.23$ with $P < 0.000$, whereas 13.33% were reported as binge eaters ($X^2 = 68.63$ with $P < 0.000$; highly significant).^[46]

Family history of obesity

Findings from a study to document the prevalence of overweight and obesity among school children of an affluent school suggested a higher incidence among children with a family history of obesity (39.79%).^[37] In another study on schoolchildren, 29.92% presented a family history of overweight and obesity.^[38]

Results from a study conducted in government and private schools of Maharashtra stated that the prevalence of overweight or obesity was 29.97% among those having a family history of overweight and obesity compared to only 7.63% without a history of overweight and obesity and this difference was found highly statistically significant with $P < 0.0001$.^[47]

Other factors

A study from government and private schools in Udaipur revealed a predominance of overweight and obesity (22.73%)

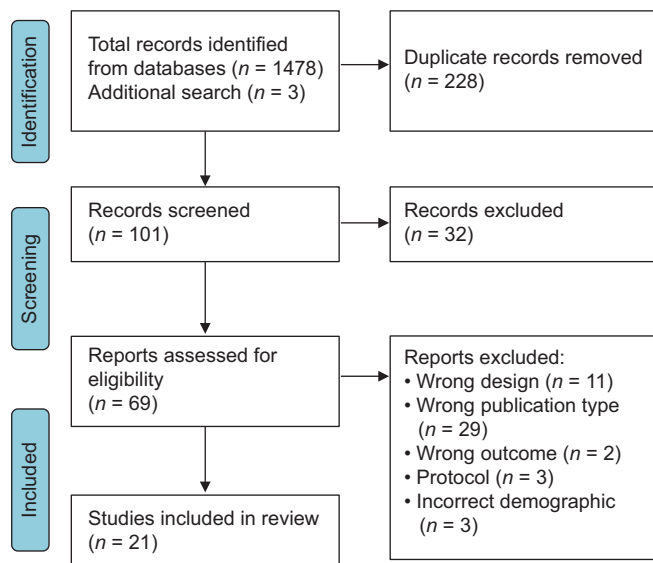


Figure 1: Flow chart for selecting studies for review

among children with working mothers. Overweight and obesity were more prevalent among those sleeping <8 hours/day.^[38] Similar findings were reported from another study, indicating a predominance of overweight and obesity (32.29%) in study participants with <7 hours of sleep, and this difference was found highly statistically significant with $P < 0.0001$.^[46] The prevalence of region-wise obesity is shown in Figure 2.

DISCUSSION

At present time, the potential health hazard already emerged and increasing at a faster rate in India is increasing the incidence of overweight and obesity in children and adolescent population.^[48,49] The studies present interesting facts that are discussed below after thorough evaluation in the current systematic review. This upgraded review broadens the range of information offered by the research process and offers helpful information on published studies themselves, making it more beneficial for decision-makers in public health.

This review’s conclusions may be better understood by considering a few additional elements of the studies’ techniques, which were used in this study. The studies have generally been underpowered and/or poorly planned, given the intricacy of the research questions and the desired results. Second, rather than addressing some of the environmental factors (physical and social) that have an impact on the sustainability of the intervention (cultural norms, organisational system changes, long-term commitment), the majority of the approach’s content has been short-term in impact and downstream or midstream (i.e., impact on behaviour change, school meal services).^[50] The results of the research did not specify whether subsequent changes in health outcomes could be caused by environmental changes.

Databases were searched to gather studies in relation to prevalence of both, overweight and obesity. This was attributed

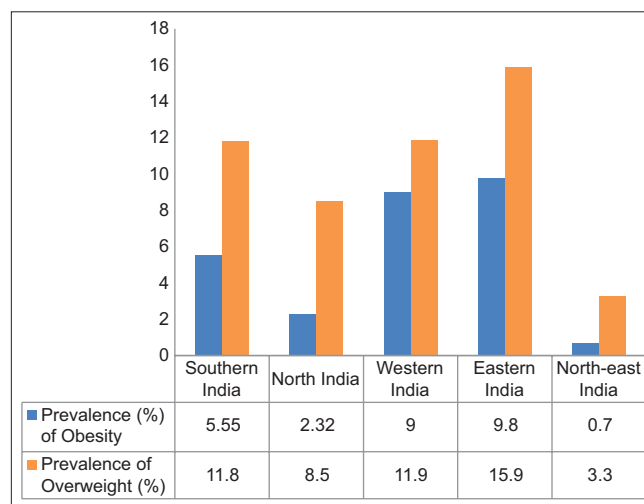


Figure 2: Graph indicating the prevalence of obesity and overweight in various regions of India

to generalising proper categorisation of the work done and forming specific characteristic guidelines in favour of either condition found more than the other and reducing its incidence in the future. As it takes several years to show observable differences, which can be statistically proved, confirmative status is appreciable when at least two components are compared with each other. All studies included in the current review checked the prevalence of overweight and obesity in both genders: boys and girls.^[37,38,40,44,51,52]

Treatment strategies

The authors examined both male and female subjects together in a study having explainable benefits like, ratio been compared for estimating prevalence that is based on the ratio, futuristic treatment strategies to be formulated which would be applicable to both genders. However, if the ratio is found to be higher for boys, strategies focusing on boys shall be executed and vice versa. If both genders have the same or nearly the same ratio, the level of physical activity, dietary changes and weight reduction programmes applicable for both genders can be designed and commissioned. Studies on both genders in a single time help researchers save time which, otherwise, have to be spent on performing the same outcome measures for other gender studies in the same settings doubling the efforts and hence increasing the time spent and expenditure of funds.^[37,39,41] While reviewing the articles, the authors noticed that all studies used in the current review were performed between the age group of 5-19 years of boys and girls^[8-28]. Thus, review evaluation of articles done with a particular age groups helps authors to yield a broader view and subsequently an unbiased result wherein similar age groups were studied in a single study benefitting in saving time, expenses and labour. After staircase analysis, treatment strategies applicable to different age groups are focused so that samples of all age groups can benefit and later research can be conducted on the same population to check the efficacy and sustainability of treatment strategies applied.

Outcome measures

The commonly used outcome measures in the studies taken for the review were height, body weight, BMI questionnaire. Limited studies used triceps and skin fold thickness,^[52] and hip^[46] and waist circumference^[38,39,46] as their outcome measure. Nearly 93% of studies demonstrated prevalence of overweight greater than obesity.^[17,37,40,53,54] To mention 'overweight' is an early stage of obesity. Regarding this, the author has both positive and negative impressions. Positive impressions to be glad that the majority of children and adolescents are not in the obese category representing early treatment strategies if applied while augmenting weight reduction and increasing physical fitness. This will reduce the risk of development of mental and physical pressure, which is highly exaggerated when the children are already with obesity.

Obesity and gender

Another interesting finding of the current review is that in almost all articles prevalence of overweight and obesity has been found profoundly higher in boys than girls.^[37,41,43,44,54,55] This could be justified with over pampering towards boys

than girls, expressing affection towards boys with gifts like mobile phones, e tablets, laptops, computers and play stations, which makes boys glued to be indoors for the majority of the time, which is a significant feature of sedentary life and over a period of time reduces indulgence towards physical activity and sports. While girls are benefitted due to household engagements, lack of personal vehicles insisting them to take more steps and use public transport making them constantly burn more calories on a daily basis. In addition, girls have become more conscious regarding their looks and physical attitude act in the early stage by dieting, brisk walking or static bicycling.^[56]

Obesity and socioeconomic background

We detect disparities in the prevalence of overweight and obesity by socioeconomic background based on epidemiological and population-level statistics globally. Social variables have a significant role in both being overweight and underweight. On the contrary, some studies seem to have attempted to perform their intervention with well-educated demographic groups and families, limiting both the generalizability of the findings and possibly escalating the inequities faced. Our ability to assess their respective contributions as an effective therapeutic option is limited by the lack of well-designed analyses of upstream determinants like food availability, financial alternatives for better food and activity options, safer play places, school-community connections, etc.

It is plausible to suppose that the obesogenic environment in many nations, where the physiological goals of being sedentary and well-fed are overwhelmingly supported by an increasingly complex socio-political environment, will lessen the efficacy of measures aimed at individuals.^[57,58] Our poor grasp of the link between people's behaviours and the environment presents another conceptual difficulty. There is a dearth of evidence for interventions that try to alter the environment so that people can more readily eat a balanced diet and engage in physical activity. The disparity between the condition's prevalence and importance and the knowledge base used to guide preventive action continues to be astounding.

Future tasks are to incorporate a large sample while assessing prevalence and predicting incidence, use of advanced and scientific outcome measures, studying urban and rural samples together in a single study for generation of explorative data to be used for formulation and implementation of therapeutic strategies to reduce the incidence of overweight and obesity.

Temporal trends of obesity among children in India

Numerous studies have reported the prevalence of obesity in children and adolescents across different regions of India, ranging from 12% to 29%.^[49,55] In urban South India, specifically, research indicates that 4.5% of children were classified as overweight and 1.4% as obese.^[59] According to the IOTF classification, the combined prevalence of overweight and obesity was 19.6%, while it increased to 27% when compared to the WHO standards.^[49] During adolescence (10–17 years), these percentages raised to 22.3% (IOTF) and

29.8% (WHO). Consequently, the overall prevalence of overweight and obesity based on WHO criteria is higher than that determined using the IOTF criteria.^[52,59]

Implications for practice

This review draws attention to a perplexing circumstance. We only have a few pieces of research from which to draw conclusions at a time when obesity prevalence and prevention have been suggested as a public health priority. The review can suggest a focus on short-term behaviour change, which is unlikely to be sustainable or effective in influencing children's weight status and is therefore not a good strategy in the absence of complementary interventions that would have an impact on the sustainability of the initiatives and a conducive and supportive environment. While addressing behaviour change, practitioners need to take into account the problems affecting sustainability and environmental change.

A sustained strategy to create supportive environments and behaviour change in physical activity, sedentariness, and healthier food choices is likely to have a greater positive impact. We advise that stakeholders (families, school environments and others) be involved in the decision-making process regarding the potential strategies to be implemented.

Future recommendations

To attain the objective of a healthy weight for all children, current efforts at obesity prevention need to continue to enhance the evidence base to identify the most practical and health-promoting approaches. The following design elements should receive special attention while conducting new studies: using qualitative inquiry techniques to generate ideas for treatments; addressing the socioeconomic causes of overweight and obesity; reporting the stages of intervention development and design; adequate numbers and power; participant follow-up and accuracy of outcome measurements (BMI reporting). Instead of merely reporting height and weight, think about providing additional adiposity measurements, including waist circumference.

Limitations

Articles published before 2007 were not considered for the present study. Studies performed only at the school level were a part of the current review. Research carried out at college, university or any other establishments were excluded. Studies consisting of any single gender only were not considered for review.

CONCLUSION

The prevalence of overweight is higher than obesity, with predominance in boys than girls. Early detection and education towards commonly prevailing health issues at school can help for early detection and timely therapeutic interventions towards reducing the chance and short- and long-term effects of overweight and obesity. Thus, these vital steps will help in reducing the economic, health and psychological burden on one's economy. Parents should be counselled for alertness in relation to overweight and obesity as a crucial health hazard

to be worked upon either in association with healthcare professionals or efficient self-knowledge.

Authors' contribution

Conceptualization: NS, AS, AC; Methodology: NS, AS, MS; Data curation: NS, KB, RRS, AS; Formal analysis: AS, AC; Writing - original draft: NS, AS, AC; Supervision: AC, MS; Writing - review & editing: AS, NS, AC.

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Conflicts of interest

There are no conflicts of interest.

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