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REVIEW OPEN ACCESS

Prevalence and determinants of obesity among school going adolescents: A systematic review

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Abstract

Adolescence is considered as critical period for the development of obesity. The frequency of childhood obesity has increased over the last 3 decades, and it has emerged as a public health concern in multiple places around the world. A number of factors interact in a complex way to cause obesity, which is still not fully understood. Therefore, the purpose of this review was to identify and assess the scientific literature on the prevalence of obesity, and behavioural, contextual and biological factors associated with obesity in adolescents. The search was carried out using PubMed, Web of Science, Embase and Scopus considering articles published from the establishment of the databanks until December, 2022. Data on the prevalence of overweight and obesity among children and adolescents, and articles on the determinants and factors affecting obesity were reviewed. The results obtained and the association observed among the factors studied will be helpful to support the planning, implementation and evaluation of preventive activities and interventions.

Keywords: adolescents; childhood; intervention; obesity; overweight

Introduction

World Health Organization (WHO) defines overweight and obesity as abnormal or excessive fat accumulation that may impair health. Once thought to be issues only in high-income countries, obesity and overweight are now more common in low- and middle-income countries, particularly in urban areas. The "New World Syndrome" is a group of non-communicable diseases that includes obesity and is causing a significant socio-economic and public health burden in developing nations.

Overweight and obesity have become a major public health problem in both developing and developed countries [1]. Worldwide the prevalence of obesity has tripled since 1975. In 2016, there were more than 1.9 billion adults who were overweight. Of these over 650 million were obese. In 2016, there were over 340 million overweight or obese kids and teenagers between the ages of 5 and 19. In 2019, Asia was home to nearly half of the world's young overweight or obese children. In 2020, an estimated 39 million children under the age of 5 years were overweight or obese [2].

Adolescence, as considered by WHO as from 10 to 19 years is treated as a transition period from childhood to adulthood. There are more than 1.2 billion adolescents in the worldwide. A global public health challenge is the adolescent age groups' susceptibility to lifestyle diseases and the growing prevalence of overweight and obesity among children and adolescents. The likelihood that obesity will persist into adulthood and, consequently, the entrainment of obesity-induced morbidities like pre-hypertension and hypertension, depends on the

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degree of obesity and the age at which it first appears. Several studies on malnutrition among adolescents and on overnutrition, in particular, have reported the concerning state of rising overweight/obesity among adolescents [3].

There is a dearth of research on the prevalence of adolescent obesity. While under-nutrition in children has been the major public health concern in India over the past several decades, little attention has been paid to childhood overweight and obesity until recently. Therefore, the aim of this systematic review is to summarize the evidence reported by various studies that have been conducted on the lifestyle of adolescents thus this will assist to understand the associations between various lifestyle related factors like diet and physical activity and cardio-metabolic risk factors in this age group. It is hoped that the findings of this systematic review will be useful in providing an indication of the interventions needed to improve the lifestyle related behavioral patterns and consequently the cardio-metabolic health of adolescents.

Methods

Search strategy

A computerized literature search was conducted using Medical Subject Headings (MeSH) terms such as "Obesity", "Overweight", "Adolescent", "Childhood", "Physical activity", "diet", "behavioural factors", "sleep" in PubMed, Web of Science, EMBASE and Scopus Database to identify potentially relevant articles of Childhood Obesity in English language and published from inception to September 2022.

Study selection

The selection criteria for the narrative review included original articles (prospective observational studies, case-control studies, and cohort studies) and review articles regarding the prevalence and determinants of obesity in adolescent age group. The publications that fulfilled the criteria for selection were thoroughly read and if found appropriate, other articles were also collected from their references and reviewed to incorporate the studies that the first search could have missed. Figure 1 reports the article selection flow chart.

Prevalence of overweight and obesity

Several studies on malnutrition among adolescents and on overnutrition, in particular, have reported the concerning state of rising overweight/obesity among adolescents [3, 4]. The prevalence of overweight and obesity is noted to vary widely. In general, the prevalence of overweight plus obesity was higher in America, Oceania and Europe and lower in Africa and certain parts of Asia [5, 6]. Apart from the Czech Republic and Italy, where the prevalence was 13.7% and 17.9%, respectively, about 30% of American adolescents and 22%–25% of European adolescents were overweight or obese [7]. A 2019 study from South Indian Karnataka state revealed the prevalence of overweight and obesity at 10.8% and 6.2% respectively with a trend of higher prevalence among males than females [8]. Countries with a rapid development, as the United States, the prevalence of obesity in the paediatric population reaches 18.5%, affecting almost 14 million of children and adolescents [9]. In Italy, about 21% of children are overweight and 10% are obese, with obesity trends expected to increase further [10]. In various studies conducted in India it was found that prevalence of overweight among adolescents was ranging from 11-18% while that of obesity was between 3-7% [3, 4, 11].

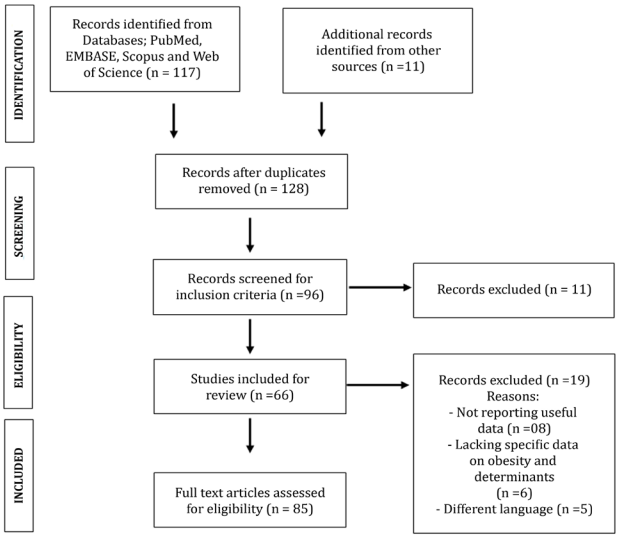

Figure 1: PRISMA flow chart of literature search.

Determinants of overweight and obesity

The factors commonly associated with the development of excess weight are related to the complex interaction between environment, lifestyle, diet, genetics, social, and economic condition (Figure 2). Several factors have contributed to the high prevalence of obesity in the developed countries, notably the very large and rapid increases in household income, with associated lifestyle changes that include reduced physical activity and increased consumption of obesogenic foods and drinks [12]. Various studies have observed strong positive association between the behavioural factors and prevalence of overweight and obesity in adolescents. The behavioural factors include insufficient physical activity, sedentary behaviour (SB), time spent in watching television, using computer games, skipping breakfast, insufficient sleeping hours, eating sweets,

fast-food, and drinking sugar-sweetened beverages [13–16].

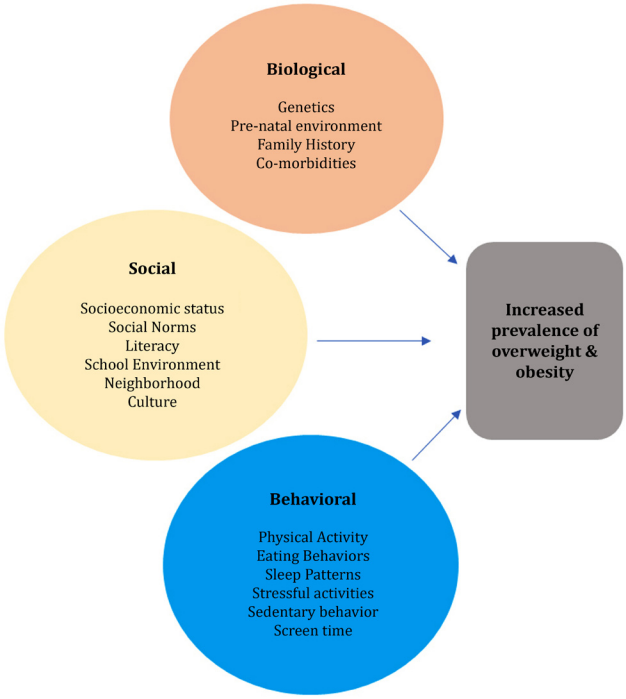

Figure 2: Determinants of overweight and obesity.

Socioeconomic factors

A study concluded that having a mother with complete or incomplete higher education, having a rented house and without internet access, increase the chances of children and adolescents being overweight/obesity [17, 18]. Various studies observed the chances of overweight/obesity increased in the higher income groups [4, 19]. This finding is in contrast to the findings of developed countries like United States where lower income households tend to have higher rates of obesity. A possible explanation is that the low-income families are more exposed to junk food and other cheap calories including processed sugars [20]. As for the area of residence, several studies found that living in the urban area increases the chances of being overweight [8, 19].

Hereditary/ genetic factors

Family factors play an important role in the development of overweight and obesity in children and adolescents. In addition to the genetic effect, food preferences and availability, and habits within a family can easily influence what children and adolescents eat. High rates of overweight and obesity are observed in adolescents with family history of obesity [10, 11, 21]. Having a family history of dyslipidaemia, having a father with hypertension and having a father, mother and maternal grandmother with obesity increase the chances of children and adolescents being overweight/obese [22, 23]. Teenagers with the rs9939609 genotype were found to be more likely to be overweight or obese [23]. An association between miRNAs expression and biomarkers like miR-15b-5p, miR-486-5p and hsa-miR-122-5p was found with childhood obesity in many the studies [24, 25].

Lifestyle related or behavioural factors

Dietary habits and obesity

The fast-growing economy has led to clear changes in eating habits and patterns of food consumption among adolescents. These changes included eating for pleasure and not only for nourishment, increasing daily consumption of fat and decreasing energy expenditure, shifting from traditional healthy food, that consists of whole grains, vegetables, fruits with small amounts of meat and fat, to consuming unhealthy food which is ultra-processed, lack fibre and have high sodium, fat and refined carbohydrate content [26] .

More specifically, several studies found that Western dietary patterns, which contain unhealthy snacks, soft drinks and other sugar sweetened beverages, are related to greater obesity risk in adolescents, while healthier dietary patterns characterized by a high intake of vegetables, whole grains and legumes may decrease the overweight/ obesity risk [27]. Similarly, many studies found a positive association between unhealthy patterns, composed mainly of fast foods, processed meats, refined cereals, sweets, and sugary drinks with body adiposity markers [27–30]. Although the studies were carried out in different regions, with different cultures and eating habits, the unhealthy dietary patterns had a similar composition. In general, they were characterized by the following food groups: confectionery, refined grains, sweets, sweetened drinks, fat, and processed food. On the other hand, an inverse association was also found between dietary patterns advocated by dietary guides, mostly composed of fruits, vegetables, white meat, and whole grains, with body adiposity markers in adolescents [31]. Similar findings were observed by many other studies [28, 30–32]

The causes of obesity are complex and is driven largely by environmental factors that influence dietary choices. Education and income appear to be the most important of these. Due to increased access to unhealthy foods and shopping at retail chains, low levels of education and income are correlated with a higher risk of childhood obesity [33]. In contrast, adolescents with high socioeconomic background are more likely to be obese due to increased media use, sedentary lifestyles, and exposure to advertisements for foods with poor nutritional value and high energy density that are tempting, hyper-palatable, affordable, and ready to eat

[34, 35]. Similar to these findings, others studies have shown that exposure to unhealthy food advertising, results in significant increases in food consumption, particularly energy-dense, low-nutrient foods, and that increases are greatest among children with obesity [36]. Association between ultra processed food consumption and abdominal obesity, measuring waist circumference (WC), waist-to-height ratio (WHtR) or waist-to-hip ratio (WHR) was found to be significant in several studies [37].

Various studies have concluded that skipping breakfast is associated with an increased risk or prevalence of overweight/obesity [38, 39]. Although the reason for this association is not clear, some authors suggest that breakfast skipping is affected by collinearity with confounding factors such as sleep duration and quality, circadian rhythms with more eating in the evening, length of night fasting, and lower physical activity levels [40]. Similarly, some studies investigated the association between frequency of snacking and cardio-metabolic health including abdominal obesity, body mass index (BMI) (z-score) and body weight, but none found significant associations [41].

Physical activity and obesity

Several studies investigated the association between physical activity (PA) and cardio-metabolic health. Some of them did not find any significant associations between PA and BMI, abdominal obesity or WC [41]. However, significant associations were found between PA and weight status, BMI, the percentage of body fat (BF) and WC in the other studies [42, 43]. Adolescent with daily total PA levels of less than 1.5 hours per day had a significantly higher risk of being obese than those with higher daily total PA levels (OR 3.0; 95% CI: 1.1-8.1; p 0.05), according to the study [44]. Many studies reported that, there was statistically significant reduction in BMI in kg/m^2, fat mass and per cent body fat, as a result of exercise (aerobic, strength training or both) [43, 45].

Active commuting and obesity

Recent research has shown that active commuting to school (ACS), which involves walking, riding a bike, or using a scooter to get to and from school, is one way to increase youth PA levels and lower the prevalence of obesity [46–48]. Several articles [49, 50] found a consistent association between ACS and body composition and while few others [51, 52] showed no differences in body composition between active or passive commuters to school. Similar results showed that adolescents who rode their bikes or walked to school more than 3.5 days per week were 33% less likely to be obese than those who never rode their bikes or walked to school. Another recent study supported the idea that in order to prevent obesity in adolescents, it is crucial to take into account not only changing the mode of transportation but also the obesogenic environment and unhealthy food/drink purchases and consumption [53]

Sedentary behaviour patterns and obesity

Decrease in physical activity and increased sedentary behaviour (SB) among children and adolescence is a serious health problem. It has been reported that 50.1% of students spend at least 3 hours in a typical or usual day in sitting activities [54]. A study evaluated the association between screen-based sedentary practices and BMI (z-score) and weight status. A significant, three times greater probability of risk of being obese was determined among adolescents with SB levels ≥ 3.5 h/day than with SB levels of < 3.5 h/day (OR 2.8; 95% CI: 1.0–7.5; $p < 0.05$), after adjustment for confounders (i.e., age, pubertal tanner status, ethnicity, household income, total PA levels, total energy and fat density intakes [44].

Screen time: Recent studies have explored that SB among 10–12 year-old children was nearly 8 h per day and they spent more than 2 hr per day in front of computer or TV screens [55]. There is evidence to suggest that greater time spent in SB, especially recreational screen time like watching TV, playing video games or using computer is associated with lower fitness, poorer cardiometabolic health, shorter sleep duration, and unfavourable measures of adiposity [52].

Most of the findings concerned television screentime. Van Ekris et al [56] reported a strong association between television screentime and incidence of overweight/obesity over time. A study reported that unfavourable adiposity measures were associated with computer screentime and obesity but no evidence for an association between video/videogame screentime and adiposity was found [57]. In a study strong evidence was obtained between screentime and increased dietary intake. It was found that television screentime increases intake of very palatable energy-dense foods and drinks. It also showed that even near 20 min increased screen time might increase obesity risk [58]. Various studies found television food advertising to be associated with dietary intake [36, 59].

Sleep patterns and Obesity

Recent research shows that sleep may be a new modifiable factor contributing to weight gain at a

young age [60]. Some short-term experiments in adults show that sleep deprivation affects several hormonal responses and energy balance in body, which result in increasing level of the orexigenic factor ghrelin, decreasing level of the anorexigenic hormone leptin, and increasing of hunger and appetite, and eventually lead to overweight or obesity [61]. (Figure 3) There is evidence that chronically sleep-deprived adolescents would have a change in nutritional behaviour, that is, making them more likely to choose sweets with a higher glycaemic index and glycaemic load. In addition, sleep-deprived people consume more food than usual to maintain the physiological need for additional wakefulness. All of these factors mentioned above would finally affect children's dietary pattern or energy intake, result in increased BMI or weight gain. Fatigue and tiredness due to sleep deprivation are additional factors that could lead to increased sedentary time, reduced physical activity, and decreased energy expenditure. The excessive use of electronic devices in children and adolescents leads to poor sleep habits and disturbances in normal sleep, including decreased sleep quality and inhibition of melatonin secretion [62].

In a study it was observed that living in areas with greater artificial light was associated with delayed bedtime and wake up time, shorter sleep duration, and increased daytime sleepiness. The decline of the total amount of sleep plays a critical role in the increase of obesity, due to a series of mechanisms, and the misalignment of sleep time of the evening is associated with metabolic risk factors [63].

In a review it was found that increasing sleep duration reduced BMI z-scores and caloric intake, and led to better breakfast choices, which are important factors for preventing obesity in children and adolescents aged 1-18 years [64]. In a study it was found that, independent of self-reported sleep duration, children with delayed sleep timing (late to bed and late to wake) related to a higher risk of being affected by overweight and obesity relative to early to bed/wake counterparts [65]. Across the various articles, bedtime appears to be more influential than wake time, with much stronger evidence for the association of later bedtimes and increased weight status among school children, than that of later wake times. One proposed mechanism suggests children with later bedtimes use the time that they should be sleeping engaged in sedentary leisure activities (watching TV, computer games, etc.) and had poorer eating habits measured by number of cumulated eating risk factors (e.g., snacking and sweetened beverage consumption) [65].

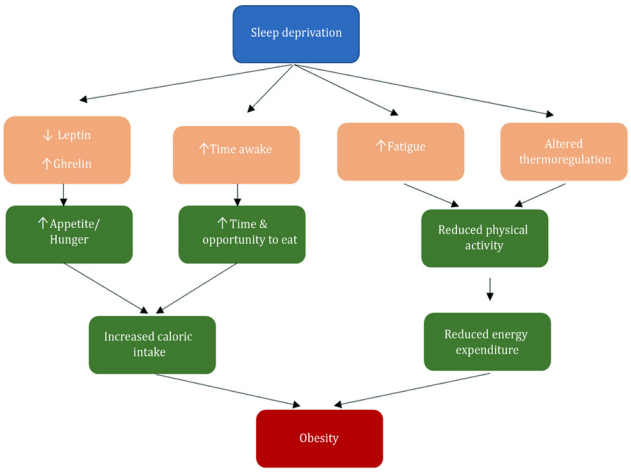

Figure 3: Relation between sleep deprivation and obesity.

School food/environment and obesity

The food environment is the interface where people interact with the food system to acquire and consume foods, which covers the physical, economical, policy and socio-cultural conditions [66]. It is believed that the food environment is associated with dietary intake. School contextual factors, such as policies regulating food and beverage sales in schools and school meal programs, have been associated with a healthy dietary intake and lower obesity rates across the world [67]. On the other hand, an unhealthy food retail environment in the school or immediate vicinity may have a negative influence on students' dietary intake and overall health. Other factors related to lower BMI are participation in school breakfast programs, the availability of fruits and vegetables during school breaks, the supply food prepared at the school, and the presence of school gardens [68]. In contrast, the availability of unhealthy food at school, such as soft drinks in school cafeterias and the presence of vending machines [69], was found to be associated with a higher average BMI. The consumption of ultra-processed foods, such as candies, soft drinks, and salty snacks, which are often available at school cafeterias, negatively impact students' weight status [70].

Interventions & prevention of obesity

A meta-analysis study found that 80% of obese adolescents remained obese in adulthood and 70% remained obese after 30 years of age [71]. Thus, identifying dietary patterns that are associated with obesity in adolescence contributes to the prevention and control of this outcome and, consequently, to a lower risk of developing chronic noncommunicable diseases, such as hypertension. There is a need for strategies to combat unhealthy diets (sugary beverage consumption, food addiction) and circadian mismatch (social jetlag, meal timing, sleep time) (Table 1).

Table 1: Interventions recommended for the factors affecting obesity.

Factor affecting obesity	*Recommended Intervention*
Physical activity	Children and adolescents aged 5-17 years should do at least an average of 60 minutes per day of moderate-to-vigorous intensity, mostly aerobic, physical activity, across the week [84].
Diet	Reduce the intake of salt by 30% of total energy intake, total fat by 30%, saturated fats less than 10%, trans-fats less than 1% and free sugars to less than 10% of total energy intake [73].
Screen time	Children and adolescents should limit screen-time to < 2 h per day [77].
Sleep	The American Academy of Sleep Medicine has recommended that children aged 6–12 years should regularly sleep 9–12 hours per 24 hours and teenagers aged 13–18 years should sleep 8–10 hours per 24 hours [85].

Dietary interventions

According to the WHO, the consumption of fruits and vegetables on a regular basis in adolescence is related to favourable health outcomes, and it is considered as a protective factor for the risk of chronic noncommunicable diseases, including obesity [72]. WHO Member States have agreed to reduce the global population's intake of salt by 30%, total fat should not exceed 30% of total energy intake, intake of saturated fats should be less than 10%, trans-fats less than 1% and limiting intake of free sugars to less than 10% of total energy intake, and thus halt the rise in diabetes and obesity in adults and adolescents as well as in childhood overweight by 2025 [73].

Interventions to increase physical activity

Moderate- and low-intensity exercise combined with adequate protein and low-fat diet can significantly improve lipid metabolism and decrease fasting insulin level. It also can increase the sensitivity of tissue cells to insulin, decrease the serum levels of insulin-like growth factor binding protein 3 (IGFBP-3), increase the activity of insulin-like growth factor 1 (IGF-1), relieve the degree of fatty liver, and improve the liver function in adolescents with obesity [74]. In addition, regardless of the amount of sedentary time, higher levels of moderate to vigorous physical activity (MVPA) have been linked to better cardio-metabolic health in adolescents. Additionally, research-backed studies have shown that PA has beneficial effects on adiposity along with non-traditional cardiovascular risk factors (inflammatory markers and irregular heart rate levels) in adolescents with normal body weight, plasma lipid and lipoprotein levels and blood pressure (BP) [75].

Active video games (AVGs), which have grown in popularity among kids recently, are newer games that encourage kids to be more physically active and live less sedentarily. AVGs allow kids to engage in more physical activity during physical education classes at school or at home and increase the amount of energy they expend playing video games [42, 76]. AVGs can be incorporated into homes and classrooms. American Academy of Paediatrics recommends limiting screen-time among children and adolescents to less than 2 h per day with no screens for kids under 2, and less than an hour a day for kids 2–5 [77].

Parental involvement

A review has stated that parental encouragement and support can increase PA in children [78], as well as reduce SB. According to this review, parenting style affects a child's behaviour. Positive association between children's PA levels and the PA levels of their parents was found and that a reduction in parental (sedentary) screen time can lead to decreased screen time in children [78]. The availability of PA equipment seemed to have a positive effect on children's PA levels, whereas busy work schedules and parent fatigue demonstrated negative effects.

School based interventions

A comprehensive intervention is urgently required to address the high rates of childhood obesity around the world. Interventions must target parents, kids/adolescents, and education and health professionals who can have a positive impact on early education. Since students spend most of their time in school, the data on childhood and youth obesity indicate that this is the most crucial time for intervention, and it is during school age that they establish health and lifestyle behaviours that may be difficult to change in the future. It may be particularly crucial to create interventions that take chronotype into account when it comes to diet, sleep patterns, or screen time [79].

Evidence shows that increasing the number of physical education lessons is a key strategy to promote PA in school children. Furthermore, several reviews provide evidence for the integration of (more) PA into the curriculum. Another successful tactic for promoting PA in the educational setting is the use of activity breaks, which incorporate brief periods of PA into daily routine. Numerous reviews suggest that altering the school environment can have an impact on students' PA. In particular, the provision of playground and game equipment has proven successful. Promotion of active transport; community and peer involvement are other

interventions which can promote physical activity in school [80].

The food environment in the school and its immediate vicinity involves all the spaces, infrastructure, and conditions within and around the school where food can be obtained, purchased, or consumed [81]. This environment has been particularly investigated as a determinant of food behaviour and changes in BMI of children and adolescents. Therefore, improvement in the school food environment is proposed as a promising strategy to prevent the growing burden of childhood obesity. Offering fruits and vegetables as snacks, promoting breakfast programs, and school feeding have been identified as preventive steps against weight gain [68]. Therefore, enhancing students' access to healthy food at school via government programs, banning sweetened beverage sales, establishing adequate food and snack portion sizes, and adopting nutritional criteria is perhaps an important strategy to improve dietary intake and nutritional status of students.

Policies for tackling obesity

The policies adopted across the world for tackling obesity are education and information dissemination to create awareness about the negative effects of obesity through labelling of products, advertisements, etc; and employing market instruments like taxes and subsidies**.** In order to discourage the use of unhealthy items while accounting for their societal marginal costs, "fat taxes," which are now being tested in Europe, are implemented [82]. To combat obesity, Kerala has also looked upon imposing a "fat tax" on fast food. There isn't much proof that these funds are actually being put to good use. In this case, "fat tax" would result in a wealth transfer from the poor to the government. A prerequisite is consumer awareness. A fat tax cannot address the broader issue of lifestyle disorders on its own. Expert nutritionists must work together to create guidelines for a healthy lifestyle, and policymakers must control the marketing and advertising of junk food, the labelling of food products, and the promotion of the production and consumption of healthy foods through tax breaks and subsidies for farmers and consumers [83].

Future aspects

Concerns about the effects of early abnormalities during childhood and adolescence are raised by the global epidemic of obesity and obesity-related comorbidities. To correctly classify metabolic abnormalities and reduce the likelihood of additional dysmetabolic changes in later life, accurate evaluation of body composition parameters is needed at a young age. In obese children and adolescents, appropriate metabolic screenings and related comorbidities should begin as soon as possible, ideally in schools. However, the best therapeutic approaches to date for reducing childhood obesity, CVD, and diabetes risk in adults are improving dietary intake and raising physical activity performance.

The studies included in the review were from different geographical areas and were heterogeneous in terms of conceptualization, measurement, lifestyle and behavioural patterns.

However, improving the quality of further studies could lead to more consistency among results and increase the overall strength of any identified associations.

Conclusion

This review provided a comprehensive view of several behavioural factors and lifestyle preferences that play a very important role in promoting excess weight gain among children and adolescents. A positive consistent association was found between physical inactivity, sedentary behaviour and various dietary habits with obesity during adolescence. For the remaining factors like screen time, sleep deprivation and other sociodemographic factors like family history and parent education, the evidence was either conflicting or limited. The multifactorial contributors to obesity and possible interactions between them will aid in the development of effective strategies and interventions to manage and prevent obesity during adolescence.

Conflicts of interest

The authors declare no conflict of interest.

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