

The prevalence and prevention strategies of pediatric obesity: a narrative review

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Pediatric obesity has rapidly increased globally over the past few decades, including in Korea. We aimed to discuss trends in the prevalence of pediatric obesity and effective prevention strategies. Its prevalence has markedly increased in most high-income nations. According to recent reports, this increase has slowed in developed countries, but the levels remain alarmingly high. In Korea, the rate of pediatric obesity has surged notably since the 1990s; however, since the 2000s, this increase has become more gradual. According to recently published 2017 growth charts, the prevalence of pediatric obesity in Korea varies slightly depending on the data source. The National School Health Examination data showed that pediatric obesity gradually increase from 11.5% in 2014 to 15.1% in 2019, and after the coronavirus disease 2019 pandemic, it sharply increased to 19% in 2021. Based on data from the Korea National Health and Nutrition Examination Survey, the prevalence of pediatric obesity gradually increased from 10.8% in 2017 to 13.6% in 2019. This trend, which accelerated sharply to 15.9% in 2020 and 19.3% in 2021, was especially severe in boys and older children. Pediatric obesity not only affects health during childhood but also increases the risk of developing obesity and associated health conditions in adulthood. Despite ongoing research on treatment options, obesity prevention and control remain challenging. Hence, prioritizing early intervention and prevention of pediatric obesity through healthy eating habits and lifestyles is crucial. This requires intervention at the individual, family, school, and community levels.

Keywords: Body mass index; Pediatric obesity; Prevalence; Prevention; Trends

Introduction

The incidence of pediatric obesity has steadily increased worldwide over the past several decades and has emerged as a significant public health issue [1,2]. It is primarily a lifestyle-related disease caused by an imbalance between energy intake and expenditure, leading to excessive fat accumulation [3]. Although numerous treatment methods for obesity are being investigated, effectively managing obesity can be challenging once it develops [4]. Importantly, a significant proportion of adult obesity originates in child-

hood, with infants and children who are obese having a higher likelihood of remaining obese into adulthood [5,6]. Moreover, beyond the health issues associated with pediatric obesity, the resulting adult obesity and its comorbidities lead to substantial medical expenses [7]. Knowledge of the prevalence of pediatric obesity would help accurately determine the extent of the current burden and facilitate the establishment of appropriate treatment and prevention measures. In this review, we aimed to discuss trends in the prevalence of pediatric obesity and effective prevention strategies.

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Changes in the prevalence of pediatric obesity

1. Trends in the prevalence of pediatric obesity

The global prevalence of pediatric obesity has markedly surged in recent decades. Over the last 30 years, the incidence of children who are overweight or obese has increased substantially in numerous high-income nations. The regions with the largest increases in such incidences are East Asia, the Middle East and North Africa, South Asia, and high-income English-speaking regions [8,9]. In the United States, the average weight of children increased by more than 5 kg during this period, resulting in approximately one-third of children being classified as overweight or obese [1,10]. Although a plateau in the trend of pediatric obesity rates was observed in developed countries such as northwestern Europe, high-income English-speaking countries, and the Asia-Pacific region during the early 2000s, these rates have remained elevated [11,12], and the occurrence of severe obesity has been increasing [13]. Additionally, overweight and obesity, which were thought to be problems in high-income countries, are now on the rise in low- and middle-income countries [9]. Southeast Asia, South Africa, and Latin America are experiencing a relatively rapid transition from underweight to overweight and obese populations. In Africa, the number of overweight children under 5 years of age has increased by almost 23% since 2000; in 2022, almost half of the children under 5 years of age who were overweight or obese lived in Asia. The proportional increase over the past decade was the lowest in high-income regions (on average, 30%–50% per decade) and the highest in South Africa (approximately 400% per decade) [8,9].

The prevalence of obesity varies depending on the definition of obesity, whether it is based on obesity grade or body mass index (BMI). Generally, BMI is used as a criterion to determine obesity. This varies depending on sex, age, and population group; thus, comparisons are made using standards specific to each population group. Differences may also arise depending on the time at which the standard weight is used. The prevalence of obesity in children and adolescents in Korea is analyzed based on the Korean national growth charts for children and adolescents published in 1967, 1975, 1985, 1998, 2007, and 2017 [14–19].

According to the 1998 growth charts, a survey conducted on school-aged children in Seoul revealed a higher prevalence of underweight than obesity in children in 1979 and 1981. However, with the gradual increase in BMI, the prevalence of obesity among boys increased from 6.2% in 1988 to 11.0% in 1997 and further to 17.9% in 2002. Similarly, the prevalence among girls increased consistently from 6.5% in 1988 to 9.0% in 1997, eventually reach-

ing 10.9% in 2002. As Korean society has advanced, the number of individuals who are obese has surpassed that of those who are underweight, and this disparity has widened over time. The incidence of obesity in children and adolescents, particularly in boys, has surged since the 1990s [20].

Based on the 2007 growth charts, the prevalence of pediatric obesity increased approximately 1.7 times from 5.8% in 1997 to 9.7% in 2005. Notably, there was an increasing trend among boys aged 13 to 18 years [21]. Although there were some differences depending on the data source and included age groups, the prevalence of obesity among children aged 6 to 18 years, based on the National School Health Examination (NSHE) data, increased from 8.7% in 2007 to 15.0% in 2017. Moreover, according to data from the Korea National Health and Nutrition Examination Survey (KNHANES), the prevalence of obesity among children aged 2 to 18 years increased slightly from 8.6% in 2001 to 9.8% in 2017. This increase was significant among both male students and high school students [22]. When severe obesity was defined as a BMI exceeding 120% of the 95th percentile, the prevalence of severe obesity in Korean individuals aged 2 to 19 years increased from 1.2% in 2001 to 2.1% in 2013 to 2014 according to KNHANES data. Notably, this increase was especially pronounced among adolescent boys in their teens [23,24].

2. Current status of overweight and obesity prevalence in Korea based on the 2017 growth charts

The prevalence of childhood obesity has been evaluated using data from the NSHE, conducted annually by the Ministry of Education, and KNHANES, administered by the Ministry of Health and Welfare [25,26]. To accurately discern these trends, uniform standards must be consistently applied for comparison. However, analyzing historical data within a singular standard framework presents challenges. Consequently, our analysis aimed to elucidate the current trend in the prevalence of pediatric obesity in Korea by utilizing the most recently published standard reference (2017), which is categorized by age and height. Using the 2017 growth charts, KNHANES data from 2017 to 2021 and NSHE data from 2014 to 2022 were available (Fig 1). In the 2007 growth charts, overweight was defined as BMI \geq 85th percentile and $<$ 95th percentile, and obesity was defined as BMI \geq 95th percentile or BMI \geq 25 kg/m² by age and sex [18]. In the new 2017 growth charts, the definition of overweight remained unchanged, but the definition of obesity was changed to BMI \geq 95th percentile by sex and age [19].

In the NSHE data from 2014 to 2022 (elementary, middle, and high school children), based on 2017 growth charts, there was a gradual increase yearly from 11.5% in 2014 to 15.1% in 2019. Ow-

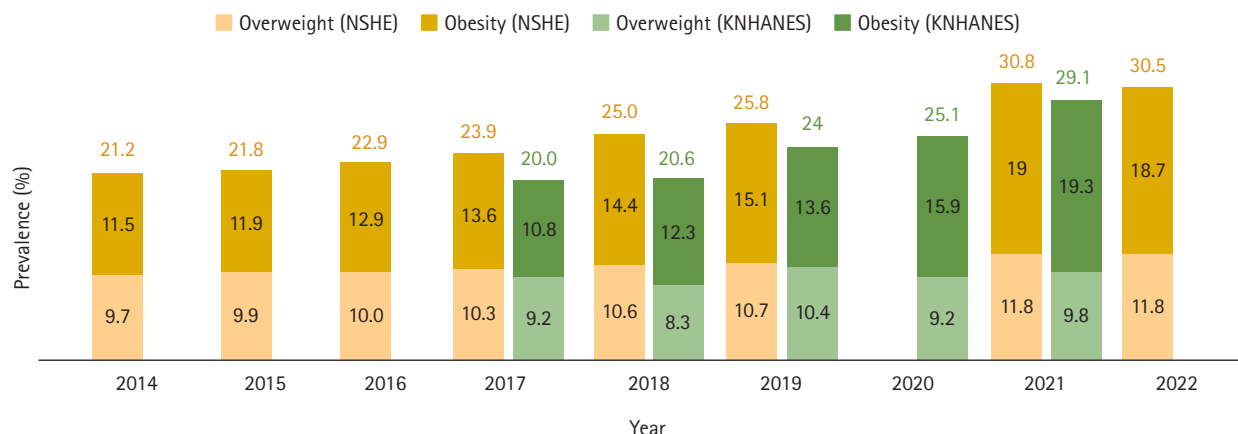


Fig. 1. Prevalence of overweight and obesity among Korean children and adolescents aged 6 to 18 years from 2014 to 2022. NSHE, National School Health Examination; KNHANES, Korea National Health and Nutrition Examination Survey.

ing to the coronavirus disease 2019 (COVID-19) pandemic, the survey was not conducted in 2020 because of the difficulty in securing a sufficient sample size, which then increased rapidly in 2021, reaching 19%. Based on the 2007 growth charts, the prevalence of pediatric obesity from 2014 to 2017 was 12.9%, 13.4%, 14.3%, and 15.0%, respectively [22]. The prevalences showed minor discrepancies compared with those based on the new 2017 growth charts. The prevalence increased with age, and boys exhibited a higher prevalence than girls (Table 1). Owing to the absence of height and weight measurements, data for children aged 6 to 9 years from KNHANES were omitted, leading to the exclusion of the initial period data. Furthermore, data spanning 2001 to 2009 were omitted because calculating the monthly age was not feasible. By utilizing the 2017 growth charts, there was a gradual increase in prevalence across the 5th to 7th cycles (5th period [2010–2012], 10.2%; 6th period [2013–2015], 10.3%; and 7th period [2016–2018], 11.6%) and a marked increase in the 8th period (2019–2021) to 16.2%. A steady annual increase was observed between 2017 and 2020, followed by a significant surge between 2020 and 2021. Moreover, the prevalence was notably higher in the 12 to 18-year age group than in the 6 to 11-year age group, with boys surpassing girls in prevalence, and the rate of increase was greater (Table 2).

While the NSHE offers the benefit of a large sample size, it has a margin of error stemming from the variance in actual height and weight measurements across schools. Furthermore, it excludes children who are not enrolled in school. The KNHANES data are representative of the country and have the advantage of being measured by experts. Nonetheless, it has the disadvantage of a relatively small number of pediatric participants each year. Although slight variations in prevalence exist depending on the data source, the

prevalence of obesity in Korea has gradually increased since the 2010s, exhibiting a sharp increase. This trend aligns with the reported plateauing of pediatric obesity prevalence in numerous developed countries, with the rapid escalation post-2020 likely attributable to lifestyle changes induced by the COVID-19 pandemic [27,28]. Both datasets were collected cross-sectionally; therefore, a nationwide longitudinal cohort study is warranted. In addition, unlike adults, pediatric obesity is defined by BMI percentiles by sex and age, showing differences in prevalence depending on the standard growth chart. To accurately examine the prevalence of recent growth and developmental trends, it is necessary to continuously update childhood growth charts in the future.

Prevention of pediatric obesity

Obesity in children and adolescents not only leads to comorbidities such as hypertension, dyslipidemia, diabetes, and nonalcoholic fatty liver disease but also contributes to mental and psychological issues, including depression and a negative self-image [29-34]. Furthermore, obesity in this demographic is highly likely to persist into adulthood, posing a risk for various diseases, including cardiovascular disease [35-37]. This situation incurs significant socioeconomic costs [38,39].

Therefore, to effectively address pediatric obesity, it is crucial to appropriately diagnose and evaluate comorbidities [40]. Obesity in childhood and adolescence is mainly caused by the consumption of cheap, energy-dense, and low-nutrition foods and drinks, along with a Western diet and commercial interests that lead to a sedentary lifestyle. Intrauterine and postnatal environments, a lack of sleep, and adverse childhood experiences also have an impact. These factors are modifiable [41,42]. The main approaches for

Table 1. Prevalence of overweight and obesity among Korean children and adolescents aged 6 to 18 years from 2014 to 2022 based on NSHE data

Year	No. of subjects	NSHE (aged 6–18 yr)											
		Overweight (%)						Obesity (%)					
		Elementary school	Middle school	High school	Boys	Girls	Total	Elementary school	Middle school	High school	Boys	Girls	Total
2014	82,581	9.7	9.7	9.7	9.8	9.6	9.7	10.6	11.4	12.9	12.9	10.1	11.5
2015	84,815	10.0	10.1	9.8	10.0	9.9	9.9	10.8	11.4	14.2	13.3	10.4	11.9
2016	82,883	10.0	10.3	9.9	10.5	9.6	10.0	11.4	13.0	15.1	14.9	10.8	12.9
2017	80,460	10.5	10.0	10.2	10.6	9.9	10.3	12.0	13.0	16.7	15.4	11.7	13.6
2018	107,954	10.8	10.3	10.6	11.0	10.2	10.6	13.3	14.3	16.6	16.4	12.3	14.4
2019	104,281	11.1	10.7	10.0	11.0	10.4	10.7	13.7	14.9	18.0	17.6	12.5	15.1
2020 ^{a)}													
2021	97,787	12.7	11.6	10.3	12.7	10.9	11.8	18.7	19.1	19.5	22.8	15.0	19.0
2022	92,689	12.1	11.1	11.7	13.3	10.2	11.8	17.7	21.7	18.3	21.6	15.6	18.7

NSHE, National School Health Examination.

^{a)}Due to the coronavirus disease 2019 pandemic, the survey was not conducted in 2020.**Table 2.** Prevalence of overweight and obesity among Korean children and adolescents aged 6 to 18 years from 2017 to 2021 based on KNHANES data

Year	No. of subjects	KNHANES (aged 6–18 yr)									
		Overweight (%)					Obesity (%)				
		6–11 yr	12–18 yr	Boys	Girls	Total	6–11 yr	12–18 yr	Boys	Girls	Total
2017	1,083	8.8	9.5	8.4	10.1	9.2	10.6	10.9	10.5	11.1	10.8
2018	993	9.3	7.5	8.9	7.6	8.3	11.0	13.3	14.0	10.6	12.3
2019	1,062	10.5	10.3	10.7	10.0	10.4	11.2	15.7	14.8	12.3	13.6
2020	873	9.4	9.0	11.7	6.4	9.2	15.0	16.7	18.2	13.5	15.9
2021	806	12.5	7.6	10.2	9.5	9.8	18.7	19.9	25.9	12.3	19.3

KNHANES, Korea National Health and Nutrition Examination Survey.

treating obesity involve lifestyle modifications, medication therapy, and bariatric surgery in rare cases [34]. As it is difficult to obtain adequate and long-lasting outcomes once obesity develops, the main goal should be ensuring early prevention of pediatric obesity and improving healthy eating habits, physical activity, and living environment [40] (Table 3). Interventions at various levels, including individuals, families, schools, and society, are essential to achieve this goal [43].

1. Attention to body mass index and early detection of obesity

Regularly checking and monitoring a child's height and weight are the first steps toward prevention. In Korea, there is a comprehensive infant health examination program conducted over seven stages from 4 to 71 months of age. Additionally, during the school-age years, a school health program involves annual measurement of height and weight, with referrals to medical institutions in cases of abnormalities.

2. Promoting healthy diet and physical activity

Healthy eating habits should be promoted and harmful eating hab-

its should be discouraged. Consuming fresh vegetables and fruits while reducing the intake of refined carbohydrates can help reduce caloric intake, thereby decreasing the risk of obesity [44]. It is recommended to limit the intake of sugar-sweetened beverages and consume whole fruits, which contain fiber that can provide a sense of fullness, rather than fruit juices [45,46]. Moreover, selecting low-energy-density foods, consuming a healthy breakfast daily, sharing meals with family, minimizing dining out, and educating oneself on portion sizes are essential strategies for maintaining appropriate meal sizes [47-50].

Physical activity is a critical factor in preventing and managing obesity, and increasing the amount of activity and reducing inactive time are crucial [51]. Children and adolescents should engage in moderate-to-vigorous physical activity for at least 20 minutes per day (aiming for 60 minutes) at least five times per week, along with reduced caloric intake, to improve metabolism and reduce the likelihood of developing obesity [40]. Preschool children should engage in outdoor play and games, whereas school-aged children and adolescents should engage in structured physical activities, including exercises [48,52]. Prolonged screen time (e.g., on a television [TV], computer, or tablet) diminishes physical activity,

Table 3. Obesity-prevention strategies for different age groups in children and adolescents

Age	Strategy
Neonatal period and infancy	Early initiation of breastfeeding Exclusive breastfeeding for at least 6 months Providing baby food with a balanced diet
Early childhood	Nutrition counseling in screening programs Nutritional education to form healthy dietary habits Increasing physical activity during daily life and playtime Close monitoring of weight gain to prevent early adiposity rebound
Late childhood and adolescence	Encouraging the formation of healthy dietary habits through nutritional counseling and school meals Maintaining daily physical activity and education on the necessity of exercise Utilizing physical education programs and facilities such as playgrounds

heightens the likelihood of exposure to fast food advertising through the media, and may correlate with irregular sleep patterns. These factors are significantly associated with an increased risk of being overweight and obese [53-56]. It is advisable to curtail screen time to 1 to 2 hours daily and enhance physical activity. Furthermore, a TV should not be placed in the child's sleeping area and watching TV during mealtime should be avoided [57].

The association between breastfeeding and pediatric obesity has long been a matter of debate. A meta-analysis showed that breastfeeding is an essential factor in preventing obesity in children [58]. A longer breastfeeding duration was associated with a decrease in pediatric obesity [59]. In particular, when breastfeeding continued for more than 7 months, the risk of obesity significantly decreased [60].

The risk of obesity doubles with shorter sleep duration [61]. Notably, sleep duration was inversely correlated with diet energy density and the consumption of sugar-sweetened beverages [62]. Irregular sleep patterns can adversely affect appetite and reduce insulin sensitivity [63]. Thus, reduced sleep duration is associated with the development of obesity, highlighting the importance of promoting healthy sleep patterns. Psychosocial stress and adverse childhood experiences are increasingly being identified as risk factors for obesity [42]. Maintaining emotional stability and managing stress can also improve dietary and lifestyle habits [64].

3. Creating a health-promoting environment

Comprehensive behavioral interventions are required to prevent pediatric obesity. This requires the involvement of the family, school, and community surrounding the child.

The home environment provides a crucial setting for shaping the lifestyle behaviors of children such as dietary habits, physical activity, and sleep patterns. Owing not only to genetic characteristics but also the shared obesogenic environment, a child's BMI significantly correlates with the parents' BMI [65]. Furthermore, the higher the parental BMI, the greater the pediatric obesity rate [66].

Participation by the entire family, rather than by individuals alone, is essential to ameliorate the obesogenic environment. Family-based lifestyle modifications, encompassing enhanced nutrition and physical activity, have demonstrated positive outcomes in managing the weight of children [67]. Notably, high parental involvement has been effective in preventing obesity and overweight in children [68].

Schools serve as crucial environments in which children and adolescents spend a substantial portion of their time. Schools offer exceptional opportunities to deliver quality meals through school lunches and nutritional education, thereby playing a pivotal role in preventing obesity by fostering a healthy living environment. Furthermore, there are experts, such as teachers, counselors, health educators, and nutritionists, and facilities, such as classrooms, gyms, and playgrounds, that can be effectively utilized. Notably, education about healthy eating has been shown to decrease the consumption of unhealthy foods and sugary drinks [69]. Moreover, exercise interventions facilitated by physical activity programs in school settings have been shown to reduce the BMI of children [70]. School-based obesity-prevention programs significantly contribute to weight loss and are instrumental in promoting health by encouraging healthy eating habits and physical activity. Psychosocial support systems are needed to reduce stress and overcome adverse childhood experiences [42].

Families and schools are community members that can influence the social environment. Ultimately, the environment for healthier choices should be improved through community-based obesity-prevention programs. Healthy foods and beverages should be incentivized, whereas harmful foods should be taxed to encourage accessibility to healthy options. By introducing a sugar tax and imposing a tax based on sugar content, companies were incentivized to reduce sugar content, and consumers were encouraged to reduce sugar-sweetened beverage consumption [71,72]. Additionally, restricting food advertising targeting children in mass media can limit the promotion of high-energy-density foods and beverages.

es to children, who are easily influenced by TV commercials and similar platforms. Attaching nutritional labels to food products and regulating portion sizes can also help reduce caloric intake, thus lowering the incidence of pediatric obesity [73,74]. Enhancing the accessibility and economic viability of sports facilities, along with the expansion of public open spaces in urban centers, facilitates physical activity during leisure time [75].

It is important that a diverse group of experts with a wealth of experience in pediatric obesity, such as healthcare professionals, nutritionists, psychologists, social workers, and exercise specialists, collaborate to coordinate community facilities and resources. Currently, national organizations such as the Ministry of Health and Welfare; Ministry of Education; Ministry of Culture, Sports, and Tourism; and Ministry of Food and Drug Safety are carrying out various projects and policies to prevent obesity in children and adolescents; however, these primarily focus on improving individual lifestyle modifications. In addition, some initiatives are implemented temporarily or provide overlapping support to the same targets; therefore, establishing effective policies through cooperation between institutions is important [76]. This will facilitate the development of a healthy community environment where nutritious food can be purchased affordably and conveniently and where opportunities for vigorous physical activity are available. Stress management and emotional support should be improved by increasing access to mental health services and strengthening education. These community-level strategies are crucial for the long-term prevention of pediatric obesity and require sustained focus.

Conclusion

The prevalence of obesity in children and adolescents has been increasing, leading to the development of comorbidities. This trend significantly increases the likelihood of obesity persisting into adulthood, thereby escalating the risk of metabolic syndrome and obesity-related complications. First, to solve the problem of pediatric obesity, it is necessary to understand its current status and trends. Obesity is a preventable disease. However, once it occurs, successful treatment becomes challenging, making its prevention crucial. To prevent obesity in children and adolescents, promoting healthy diet and physical activity through a multidisciplinary approach is important. Furthermore, cooperation and policy support from local communities, including families and schools, are essential. Effective prevention and active management of obesity in children and adolescents are crucial to ensure growth into healthy adults. Importantly, this would not only enhance individual health by increasing life expectancy and quality of life but also potentially diminish the socioeconomic costs associated with the transition of

childhood and adolescent obesity into adult obesity, thereby benefiting the nation.

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Conflicts of interest

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