# Sugar-sweetened Beverages and Obesity Among Children: A Review

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*ABSTRACT:* Over the last decades the prevalence of overweight and obesity throughout the world has increased in children. The rising incidence of childhood obesity poses an important public health challenge worldwide due to the increasing burden of chronic non-communicable diseases. However, there were growing evidences that increased consumption of sugar-sweetened beverages over time was associated with increased obesity among children and adolescents. Therefore, increasing public awareness of the health hazards associated with high intake of sugar-sweetened beverage in the diets of children should be of great concern to public health workers. This is especially important in children, because dietary habits in childhood track into adulthood.

## INTRODUCTION

Over the last decades the prevalence of overweight and obesity throughout the world has increased in children (Luger *et al.,* 2017). It was estimated that the prevalence of obesity in children will be around 9.1% in 2020 (de Onis *et al.,* 2010). Childhood obesity has an important significance in health and well-being during childhood and also in later adult life (WHO, 2003; Freedman *et al.,* 2007; Reilly and Kelly, 2011). As because, obesity not only affect the metabolic and psychosocial status in the short term but also contribute to a higher risk for consequent cardiovascular diseases in adulthood (He *et al.,* 2018). Due to the rapid economic growth as well as radical shifts in dietary pattern and lifestyle, the prevalence of obesity and obesity-related cardiovascular risk factors in children including abnormal lipid, hypertension and elevated blood glucose levels have increased worldwide in the recent decades (Fagot-Campagna *et al.,* 2001; Lee *et al.,* 2016; He et al., 2018). Moreover, a considerable proportion of children who are obese remain so in adulthood also (WHO, 2016).

Therefore, the rising incidence of childhood obesity poses an important public health challenge throughout the world due to the increasing burden of chronic non-communicable diseases (Lakshman *et al.,* 2012). One potential factor, which is temporally related with the rise in overweight and obesity, is an increased drinking of refined carbohydrate (Slyper *et al.,* 2004). It is well established that the trends toward growing obesity rates worldwide have paralleled an increase in sugar in food sources (Duffey and Popkin, 2007). However, the most common source of excess sugar consumption is sugar-sweetened beverages (De Boer *et al.,* 2013), which is an established risk factor for overweight and obesity (Morenga *et al.,* 2013; He *et al.,* 2018). Though, the consumption of sugar-sweetened beverages has increased intensely over the past decades in all ages including children (Scharf and De Boer, 2016), concerns regarding sugar-sweetened beverages consumption in children have gained significant attention recently. It was observed that added sugars, specifically in the form of sugar-sweetened beverages contribute to excess calories, which is an important factor for the development of obesity as sugars in liquid form induce less satiety

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than in dense form (Di Meglio and Mattes, 2000) and thus promote the over consumption of calories (Zhang *et al.,* 2020).

## WHAT IS SUGAR SWEETENED BEVERAGES?

A significant consequence of the rise in sugar availability has been the rise in drinking of beverages sweetened with added sugars, frequently referred to as sugar-sweetened beverages (Scharf and De Boer, 2016). Sugar sweetened beverages are a category of beverages that contain added sugars, including regular soft drinks, fruit drinks, sports drinks, energy drinks, and sweetened coffees and teas (Godin *et al.,* 2018). Sugar-sweetened beverages are high calorie beverages with little nutritional content (Lasater *et al.,* 2011). Sugar-sweetened beverages also includes soda and fruit-flavored drinks, which is a major contributor to added sugars in children's diets and have been shown to be associated with obesity (Tasevska *et al.,* 2017).

## WHAT IS OBESITY?

Obesity is a common and preventable disease of clinical and public health importance (Ofei, 2005). Obesity is characterizes by an abnormal or excessive fat accumulation that may impair health and is commonly assessed by Body mass index (BMI) (WHO, 2020). BMI is calculated by dividing a person's weight in kilograms by the square of height in meters. Obesity in children is defined as a BMI at or above the 95$^{th}$ percentile for children and teens of the same age and sex (CDC, 2020).

### *Sugar sweetened beverages and obesity*

The increase in availability of sugar has paralleled the increase in BMI in the developing world (Scharf and De Boer, 2016). Historically, when safe drinking water was not readily accessible, beverage companies have promoted their products as safe alternatives, and in many places today, sugar-sweetened beverages remain a safer alternative (Scharf and De Boer, 2016).The consumption of sugar-sweetened beverages has significantly increased globally including Asian populations over the past decades (Shin *et al.,* 2018). Over the last two decades there has been a similar increasing trend of consumption of sugar sweetened beverages in Indian children also (Gupta *et al.,* 2018). A survey conducted among children aged between 9 to 14 years demonstrated that 68% children consumed packaged sugar sweetened beverages more than once a week (Bhushan *et al.,* 2017). It was observed that in some places sugar-sweetened beverages contribute to over 20% of children's added sugar consumption (Azais-Braesco *et al.,* 2017). However, energy-dense sugar-sweetened beverage, as a consequence of improved economic conditions was considered to be one of the primary factors of the rapid escalation of obesity (Johns *et al.,* 2015).

There were growing evidences that increased consumption of sugar-sweetened beverages over time was associated with increased obesity among children and adolescent (De Boer *et al.,* 2013; Pereira, 2014). Consumption of sugar-sweetened beverages among children is particularly concerning because dietary habits in childhood track into adulthood (Kaikkonen *et al.,* 2013). In a study Masse *et al.* (2014) demonstrated that sugar-sweetened beverages were significantly associated with higher odds of being obese compared to normal weight among Canadian adolescents. De Boer *et al.* (2013) also demonstrated higher odds for being obese among children aged 5 years, who drank sugar-sweetened beverages regularly compared with infrequent or nondrinkers. Studies also demonstrated that regular consumers of sugar sweetened beverages between meals had a higher risk of being overweight or obese compared to non-consumers in children (Ludwig *et al.,* 2001; Dubois *et al.,* 2007). A meta-analysis (Malik *et al.,* 2009) also demonstrated significant positive association between sugar-sweetened beverages intake and weight gain. Ludwig *et al.* (2001) showed that an extra cup of sugar-sweetened beverages per day increases the risk of obesity by 1.6 times in American children. A study among Chinese children aged 7–18 years revealed that excessive sugar-sweetened beverages consumption greatly contributed to increased BMI, waist circumference and triglyceride levels as well as increased risk of both general and abdominal obesity, and hypertriglyceridemia (He *et al.,* 2018). Berkey *et al.* (2004) demonstrated a linear relationship between the amounts of sugar-sweetened beverage consumed and BMI in girls. Te *et al.* (2013) also demonstrated an

association between sugar-sweetened beverage consumption and BMI. Grimes *et al.* (2013) in a large cohort of Australian children demonstrated that those drinking sugar-sweetened beverage were more likely to be overweight. Ariza *et al.* (2004) demonstrated that children who drank sugar-sweetened beverages had an odds ratio of 3.7 for obesity. Moreover, the study also demonstrated that overweight children were more likely to be sugar-sweetened beverage drinkers. In a study among US pre-school children it was observed that number of servings of sugar-sweetened beverages were significantly associated with BMI *z*-score as well as with overweight and obesity, even after adjustment for confounding variables, including sex, socio-economic status, and ethnicity (De Boer *et al.*, 2013). A study in children at 10 years from the Bogalusa Heart study demonstrated an odds ratio of 1.33 for overweight among sugar-sweetened beverage drinkers compared to non-drinkers (Nicklas *et al.*, 2003). National longitudinal study in UK children demonstrated that regular consumption of sugar-sweetened beverage was associated with greater increases in BMI as well as in percentage body fat (Laverty *et al.*, 2015). Costa *et al.* (2018) also demonstrated an association of higher consumption of sugar-sweetened beverages with higher levels of body fat. Other studies also demonstrated similar positive associations between sugar-sweetened beverages consumption and weight gain among children (Ludwig *et al.*, 2001; Malik *et al.*, 2006).

Similar results were also observed in longitudinal studies. A recent longitudinal study demonstrated that sugar-sweetened beverage consumption at 4 and 5 years were associated with a risk of obesity at 7–8 years (Macintyre *et al.*, 2018). High cumulative consumption of sugar-sweetened beverage at the pre-school stage also increases the risk of obesity in later childhood and early adolescence (Cantoral *et al.*, 2016). Pan *et al.* (2014) determined that sugar-sweetened beverage consumption during infancy had an odds ratio of 1.71 for obesity at the age of 6 years, compared with no consumption children. Dubois *et al.* (2007) found that children who drank sugar-sweetened beverages between the ages of 2.5–4.5 years had a higher odds ratio of 2.4 for being overweight at the age of 4.5 years, compared with non-drinkers of sugar-sweetened beverages. De Boer *et al.* (2013) in a follow up study among children between ages 2 and 5 years demonstrated that children who consumed more than equal to one sugar-sweetened beverages serving daily had a higher change in BMI *z*-score and were more likely over the next 2 years to become overweight and obese, compared with those who drank less. Studies also demonstrated a potential link to increased long-term consumption of sugar-sweetened beverage and its contribution to greater weight gain (Nissinen *et al.*, 2009; Bae *et al.*, 2011). Berkey *et al.* (2004) also demonstrated similar association of increased sugar-sweetened beverage consumption and higher gains in BMI in children. A longitudinal study also indicated that children consuming one sugar-sweetened beverage each day are 55% more likely to be overweight compared to those with limited consumption (Morenga *et al.*, 2013).

Contrary to that, some studies also demonstrated lack of association between sugar-sweetened beverages and weight gain. For example, Keller *et al.* (2009) in a small cohort of children aged between 3 and 7 years did not observed higher BMI among children who drunk sugar-sweetened beverages. Forshee and Storey *et al.* (2003) also did not found any differences in BMI among different categories of sugar-sweetened beverage intake in a large cohort of children aged 6–19 years.

However, the exact biological mechanisms linking sugar-sweetened beverage consumption and weight gain remain unknown, a number of possible hypotheses have been proposed which indicated that energy from sugar-sweetened beverage bypass the homeostatic regulatory systems, that control appetite and energy intake and as a consequence hunger increased and satiety decreased, which leads to excessive energy consumption (Hafekost *et al.*, 2011) and results in weight gain (Pereira, 2014; Popkin and Hawkes, 2016) and obesity (He *et al.*, 2018).

Studies demonstrated that family environments including socio-demographic characteristics are associated with sugar-sweetened beverage consumption in children (Rompay *et al.*, 2015). It was observed that children whose parents regularly consumed sugar-sweetened beverages were almost three times more likely to consume sugar-sweetened

beverages regularly, compared to the children whose parents were not regular consumers of sugar-sweetened beverages (Grimm *et al.*, 2004). Average consumption of sugar-sweetened beveragewas also higher among children whose parents had lower levels of education (Hafekost *et al.*, 2011). Similarly, national longitudinal study in UK children also demonstrated that sugar-sweetened beverage consumption was lower among children of mothers with higher educational qualifications (Laverty *et al.*, 2015). A study among multi-ethnic children showed that highersugar-sweetened beverage intake was associated with lower socioeconomic status, higher total energy intake, lower fruit, vegetable intake and more sedentary time (Rompay *et al.*, 2015). De Boer *et al*. (2013) also demonstrated significant association of sugar-sweetened beverage consumption with socioeconomic status. Sugar-sweetened beverage consumption also varied by ethnic group (De Boer *et al.*, 2013). Consumption of sugar-sweetened beverage was also associated with unhealthy eating behaviors, such as eating at fast food restaurants, low vegetable consumption, high consumption of unhealthy meats, French fries and desserts (Ranjit *et al.*, 2010; Park *et al.*, 2012).

Although most of the studies on sugar-sweetened beverage consumption had focused on its relationship to unhealthy weight, some studies also demonstrated the association of sugar-sweetened beverages with other adverse outcomes in children. It was observed that higher intake of sugar-sweetened beverage was associated with dental caries (Marshall *et al.*, 2003), poor growth (Smith and Lifshitz, 1994), digestive problem (Committee on Nutrition, 2001), higher plasma triglyceride (Rompay *et al.*, 2015), higher blood pressure (Nguyen *et al.*, 2009), type-2 diabetes (Hu and Malik, 2010; Malik *et al.*, 2010), cardiovascular disease (Ambrosini *et al.*, 2013), neurological, psychiatric symptoms and cardiac dysrhythmias (Bedi *et al.*, 2014) as well as it was also increased the risk of cancer due to carcinogenic and allergenic properties of some food additives (Keshari and Mishra, 2016). Frequent consumption of sugar-sweetened beverage was also related to lower intake of vitamins and nutrients (Frary *et al.*, 2004), poor academic grades (Park *et al.*, 2012) and earlier timing of puberty (Vandeloo *et al.*, 2007). Furthermore, sugar-sweetened beverage consumption is negatively associated with physical activity and positively associated with sedentary behaviors, such as watching television (Ranjit *et al.*, 2010; De Boer *et al.*, 2013; Laverty *et al.*, 2015; Cervi *et al.*, 2017).

## CONCLUSION

These findings suggested that increased consumption of sugar-sweetened beverage was closely linked with weight gain and higher prevalence of obesity in children. Therefore, increasing public awareness of health hazards associated with high intake of sugar-sweetened beverage in the diets of children should be of great concern to public health advocates. This is especially important in children because dietary habits in childhood track into adulthood (Kaikkonen *et al.*, 2013). However, more systematic studies are needed to understand the factors associated with unhealthy dietary habits and to promote healthy lifestyle in children for the prevention and management of childhood obesity.

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