Added Sugars and the Childhood Obesity Epidemic in the United States

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Introduction

Childhood obesity is a current and persistent public health concern in the United States (US) that has the potential to impact the lives of millions. Over the last forty years, obesity rates have increased dramatically, this trend seems to be correlated with the rise of added sugars in the diets of American children and adolescents (Malik et al., 2006). In this paper, children, adolescents, or youth, are considered anyone ages 2 through 19 years old.

Obesity in adults is typically defined by body mass index (BMI) and is calculated as kilograms in body weight (kg) divided by height in meters squared (m^2), thus giving a value in kg/m^2. In the adult population, overweight is categorized as a BMI between 25 and 29.9 kg/m^2, and obesity is considered a BMI greater than 30 kg/m^2. In children and adolescents, this is not a very appropriate means of measuring health. Instead, the Center for Disease Control and Prevention (CDC) recommends using a specific BMI growth chart for the age and gender of the child. If the child falls at or above the 95^{th} percentile on their BMI growth chart, they are considered obese (CDC, 2017). This accounts for normal growth patterns in adolescence and the subsequent use of the normal BMI calculation at age 20 and beyond.

A study done by Ogden et al. (2014) discussed the current prevalence of childhood obesity in the US as it was reported in the NHANES (National Health and Nutrition Examination Survey) from the years 2011-2012. They found that during that time, 31.8% of youths fell into the category of overweight or obese, and of these, 16.9% were considered obese. These adolescent rates are lower than those for adults (34.9% of American adults). When examining the adult definition of obese, having a BMI of 30 kg/m^2 or greater, 13.9% of adolescents met the criteria. According to this data, while childhood obesity is slightly less prevalent than adult obesity, it is still highly prevalent with nearly one in every six children being categorized as obese (Ogden et al., 2014). Therefore, if it is a goal of public health concerns to limit the number of obese adults, the number of obese children must be reduced.

Obesity can have serious and long term effects on overall health outcomes. According to the CDC, those who are obese have an increased risk over their lifetime for the following: all causes of death, hypertension, high low-density lipoprotein (LDL) cholesterol, low high-density lipoprotein (HDL) cholesterol, high blood triglycerides, type 2 diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, and several other negative outcomes (CDC, 2017). Additionally, in 2008 it was estimated that obesity costs the US annually $147 billion in health care costs (CDC, 2017). With the current trends being what they are, these obese children are on track to become obese adults in their lifetime. Therefore, it is in the best interest for both individuals with obesity and the US government to prepare American youth for a healthy life by limiting rates of childhood obesity and promoting positive health outcomes.

One potential reason the obesity epidemic has taken such a rapid and drastic hold on the American population is due to the use of added sugars in food products. In the late 1970's and early 1980's there was a push in the mainstream media and by food companies for a reduction in fat in the diet. Thus, creating the task to make low fat foods palatable, giving rise to added sugars for taste (Nestle, 2003). Additionally, the consumption of sugar in beverages has increased considerably in the last four decades. In the 1970's, on average, sugars from beverage sources made up 4% of the daily caloric intake of an individual. In 2001, that number was up to 9% (Harvard, n.d.).

The purpose of this paper is to examine childhood obesity trends as they relate to added sugars, government school meal programs, and successful intervention trials.

Sugar: A bittersweet relationship

Sugars are found naturally across a wide variety of foods. In its most basic form, sugar is a molecule consisting of a base with 1 carbon, 2 hydrogens, and 1 oxygen. Monosaccharides are made up of one molecule of this CH_2O backbone that cannot be broken down into a simpler sugar by chemical processes. Three examples of monosaccharides include glucose, galactose, and fructose (Royal Society of Chemistry, n.d.). Even though these three have the same chemical formula ($C_6H_{12}O_6$), what sets them apart is their chemical structural differences that effect the way humans metabolize them. When combined in different ways, two monosaccharides give rise to a disaccharide; for example, a glucose and a fructose molecule combined create sucrose, table sugar. Both mono and disaccharides are considered simple sugars in the diet (Royal Society of Chemistry, n.d.). Typical natural food sources of these simple sugars include fruits, honey, dairy, and many others. These simple sugars or carbohydrates can play an important role in the functioning of critical systems in the body. They provide energy for the central nervous system, red and white blood cells, and muscles during high intensity exercise (Jeukendrup, 2004). When consumed responsibly and within the accepted macronutrient range (AMDR) these sugars, along with fiber (a polysaccharide), are critical for maintaining optimal health. However, when consumed irresponsibly or overindulgently in artificial or additive ways, these sugars can have negative health outcomes (Gross et al., 2004).

Added sugars are those that are added to a food or beverage and may consist of sucrose, high fructose corn syrup (HFCS), honey, molasses, and other syrups not found naturally in food sources. HFCS was introduced into the American diet in 1970 as a cheap way to sweeten foods and beverages without losing the pleasurable taste of sugar (sucrose). Between 1970 and 2000 the total consumption of fructose in the diet increased by nearly 30% while the consumption of sucrose decreased by nearly 50% (Bray et al., 2004). When looking at HFCS alone, in 1970 it made up less than 1% of caloric sweeteners in the US, and by 2000, jumped to 42%. This increase in HFCS consumption occurred in parallel with the obesity epidemic observed in the same time frame (Bray et al., 2004). The reason this may be is due to the difference in digestion and metabolism of fructose compared to glucose. The absorption of fructose in the body occurs distally in the small intestine in the ileum and does not promote the same amount of insulin release compared to glucose. This reduction in insulin levels also decreases leptin release. Leptin is a hormone secreted by adipose tissue which causes a negative feedback loop in the brain during food consumption. When consuming a meal, leptin is released to signal that the body is no longer hungry and is content with the amount of food consumed. Increased hunger is associated with low leptin concentrations and therefore increased food intake and gains in body fat via the formation of triacylglycerols (Bray et al., 2004). The main difference between fructose and high fructose corn syrup is that high fructose corn syrup is not just made from the monosaccharide fructose, it usually consists of a molecule that is 55% fructose and 45% glucose (Taubes, 2011). Typical foods that contain HFCS include most soft drinks or sugar sweetened beverages (SSBs), fruit drinks, candied fruits, canned fruits, dairy desserts, flavored yogurts, most baked goods, many cereals, and jellies or jams. While HFCS may be present in all of these foods and beverages, it appears that about two-thirds of all HFCS consumption comes from SSBs (Bray et al., 2004).

Several studies have examined the longitudinal relationship between consumption of fructose, HFCS, SSBs, and obesity in adolescents. A study conducted by Ludwig et al. (2001) sought to observe sixth or seventh grade students and their SSB consumption over time as it relates to weight (categorized by the BMI growth chart). They followed 548 adolescents in Boston, Massachusetts with a mean age of 11.7 years over the course of two academic years.

Height and weight were measured in the lab to account for errors in self-reporting. They found that 57% of the students included showed an increase in SSB intake across the two year study, while only 7% of students showed no change in SSB consumption. Interestingly, they concluded that the odds of becoming obese increased significantly (1.6 times) for each additional serving of SSB drinks daily (Ludwig et al., 2001). While this study cannot prove causality, it does show a clear positive correlation between consumption of SSBs and an increased incidence and prevalence of adolescent obesity.

Another study by Berkey et al. (2004) observed adolescents (n=16,771), ranging in age from 9 to 14 at baseline, dispersed throughout the United States. They examined SSBs, fruit juices, diet sodas, and milk as sources of beverage intake. Subjects self-reported height and weight values because the study was too expansive to obtain these in the lab. Over a one year period, they found a strong positive correlation between boys who increased their SSB intake by one serving per day and weight/BMI gain. Results showed an increase in weight/BMI in girls who increased their consumption by one serving per day, however, the results were not as strong for the boys. Boys and girls who increased their SSB intake by 2 servings per day gained significantly more weight/BMI (Berkey et al., 2004) than other participants. These researchers hypothesized that the weight gain exhibited by both boys and girls is related to an increase in total energy intake, particularly from SSB sources.

When examining these two studies together, clearly there is a positive correlation between consumption of SSB drinks, containing added sugars like HFCS, and adolescent obesity and weight gain.

School meal programs: helpful or harmful?

The National School Lunch Program (NSLP) began in 1946 with the goal to serve students with nutritional deficiencies. Now 70 years later with the current obesity crisis, it may serve a vastly different purpose for the more than 30 million students participating every school day (Story et al., 2009). Along with the NSLP, the School Breakfast Program (SBP), requiring the same qualifications as the NSLP, provides breakfast for 14 million students daily. However, not every school currently participating in the NSLP has the SBP as well. With the potential for two out of three meals per day to come from the school and government funded programs, the diet of these children and adolescents can be heavily impacted. The meals served via the NSLP and SBP are at a reduced cost or free to children in public schools and certain nonprofit private schools and are required by the USDA to meet certain nutrition criteria as well as adhere to the current Dietary Guidelines for Americans (Story et al., 2009). While these criteria should be met by providing healthy options for students, many schools cannot afford to keep up with current standards. Financial motivations may result in the school choosing to sell items individually via vending machines or school stores that are likely to contain added sugars and fat (O'Toole et al., 2007).

Contradictory evidence exists when examining the different outcomes from use or lack of a school lunch program. A study by Briefel et al. (2009) studied dietary behaviors of 2,314 American students, ranging from first through twelfth grade. They found that elementary school participants utilizing the NSLP were less likely (38% of NSLP participants) to consume SSBs compared to nonparticipants (80% consumed SSBs) as seen in the results from their 24-hour diet recall reports. This finding was consistent in secondary school participants as well (Briefel et al., 2009). These results lead researchers to believe that the link between SSBs and obesity may then show that those participating in the NSLP would have a lower BMI than non-participants.

However, research from Schanzenbach (2009) found that students who participate in the SLP may have a higher likelihood of being categorized as overweight or obese. Similarly, a study by Gleason & Dodd (2009) found that participants in the SBP but not the NSLP were more likely to have a lower BMI than non-participants.

This evidence suggests that perhaps these programs have a potential to influence diet directly but require the assistance of supporting programs. School lunch programs may lower added sugar intake; perhaps, the most effective way to reduce total added sugar consumption along with a decrease in BMI is through a combined school lunch program and education initiative. Educating children about nutrition and the healthy types of food they can consume may have a lasting impact on their diets. When looking at nutrition education across the country, the annual median time spent teaching nutrition education and dietary behavior in elementary schools was found to be 3.4 hours and 5 hours in middle and high schools (Story et al., 2009). This is not enough time devoted to a topic that has direct consequence on everyday lives and long term health. Therefore, studies suggest that all students, given the opportunity, should receive adequate nutrition education to best prepare themselves for the inevitable choices they will have on school grounds when consuming a meal or snack (Briefel et al., 2009). Ideally this nutrition education should aim at teaching students to reduce added sugar intake, especially through reduction of SSBs.

Intervention programs and efficacy

Regardless if a government funded school lunch program is effective at reducing overweight tendencies, certain nutrition programs may efficiently combat long term obesity rates in adolescents (James et al., 2004; Reinehr et al., 2006). Targeting the reduction of SSB intake is an imperative step in a nutritional intervention aimed at improving overall health outcomes

(Ebbeling et al., 2006). While physical activity is likely an important factor in reducing childhood obesity, the focus of this section is on nutrition-based intervention programs and their successes and limitations.

A true intervention may be necessary to target key dietary habits rather than telling children or adolescents to simply stop eating poorly or drink less SSBs. Three studies from different countries, utilized separate approaches in how to enact intervention programs. The American study by Ebbeling et al. (2006) looked specifically at reducing sugar intake from beverages in an older adolescent population; the German study by Reinehr et al. (2006) addressed nutrition, physical activity, and psychological therapy in a younger adolescent population; and the British study by James et al. (2004) aimed at reducing sugar intake from beverages via education programs in schools of younger adolescent students.

In the randomized controlled study by Ebbeling et al. (2006), researchers aimed to remove SSBs from the homes of adolescents and reduce overall consumption of SSBs with the hopes of altering weight status. This study followed 103 adolescents ages 13 to 18 years old for a total of 25 weeks. The inclusion criteria were consumption of one or more servings of SSB's per day and living in one permanent household. The study excluded those who fell below the 25th percentile for BMI, smoked at least one cigarette per day, and dieted for weight loss. Students were recruited from a local Massachusetts high school and received consent from their parents. Of the 103 participants, 53 were randomly assigned to the intervention group and 50 were assigned to the control group, and all remained throughout the study. Over the course of 25 weeks, students in the intervention group received a weekly shipment of non-caloric beverages that were equal to 5 servings per week for the subject and 3 per week for each of their additional family member living in the home. Subjects were given suggestions to simply drink bottled water, but other options including non-caloric sodas and teas were offered. Subjects received a phone call every month intending to provide them with motivational counseling and discuss their satisfaction with the program.

At the end of the 25 weeks, energy intake from SSBs decreased significantly (82%) for the intervention group but did not change for the control group. The greatest changes in BMI were seen in the groups that, at baseline, fell in the upper third of BMI's (BMI > 25.6 kg/m^2). Of those individuals, BMI decreased significantly in the intervention group (-0.63 ± 0.23 kg/m^2) compared to the same upper third in the control group (+0.12 ± 0.26 kg/m^2). It was also found that a BMI reduction was greatest in those who drank more SSB's at baseline, and therefore, had the most to lose in reducing that habit. A weakness of this study was the lack of discussion of other diet quality outcomes that could affect BMI. This study suggests that a change in the environment and accessibility of SSBs of obese and overweight adolescents can alter weight status for the better. Therefore, one recommendation is to reduce access to SSBs and provide water or non-caloric beverages as replacements to reduce weight in adolescents (Ebbeling et al., 2006).

In contrast, another study by Reinehr et al. (2006), examined a slightly younger population (ages 6-14) and a different means of executing a nutrition intervention. During this 12-month intervention, 174 obese children ages 6-14 were selected based on their BMI status to participate in the intervention group. Two control groups existed, consisting of 12 normal weight children of similar age, and another group of 37 obese children who did not have regular access to the center where the study took place and therefore, could not participate in the full intervention.

The design of this study is based on the Obeldicks intervention program and centers around physical exercise, nutrition education, and behavioral therapy (Reinehr et al., 2006). The structure of this program consisted of four 3-month long phases for a total of one year. The first phase, the "intensive" phase, included a parent's course, behavior therapy, a nutrition course, and exercise therapy. During this time, the children and their parents attended nutrition courses centered around the "optimized mixed diet" consisting of a reduction in fat and sugar in the diet. Ideally, the optimized mixed diet contains 30% of energy as fat, 15% as protein, and 55% as carbohydrate (5% coming from sugar and 50% from other sources). This diet plan is well within the American guidelines as established by dietary reference intakes (DRIs) and MyPlate recommendations, making it a reasonable intervention to try with American children as well. Outcome measures of this study included BMI as established norms for children (obesity was defined as a BMI >97th percentile), blood pressure, and samples from blood draws that indicate risk for cardiovascular disease (CVD) including: triacylglycerol, HDL and LDL cholesterol, blood glucose, and insulin levels. These measures were taken at baseline, at the end of the 1 year intervention, and post intervention program 1 year after.

The results suggest that the intervention program was effective at reducing BMI and maintaining weight loss for one year (Reinehr et al., 2006). Of the 174 children in the intervention group, 126 (72%) exhibited a reduction in BMI after the one year intervention. These same children kept the weight off one year after the end of the intervention. Those children who had a reduction in BMI also showed improvement in CVD risk factors at the end of the intervention and again one year later. These sustained changes suggest that the skills and tools surrounding diet and exercise learned from the program were helpful in maintaining weight loss and promoting health outcomes beyond the intervention.

A similar population was studied in Great Britain by James et al. (2004) consisting of grade school children ages 7 to 11. This was a school-based education program implemented with the goal of discouraging the consumption of "fizzy" drinks such as sugary sodas and encouraged consuming a balanced, healthy diet. The study examined 29 different classes or "clusters" of children, 14 assigned to the control and 15 to the intervention group. The children in the intervention group (n=325 students) were counseled on the benefits of natural sugars found in fruits and were further told about the dangers regarding sugary beverages and dental hygiene (a unique approach this research team included). Drink diaries were collected from each of the children to monitor how their habits changed over time. This intervention lasted for one year and aimed at reducing weight in students who had higher BMIs at baseline. After a year, researchers found that students in the intervention group significantly increased water consumption and decreased total carbonated drink intake. This may have resulted in the significant reduction in BMI score seen within this population (James et al., 2004). Overall, this study suggests a school-based intervention approach may be an effective way to target weight loss in grade school children.

Although these three intervention programs take slightly different approaches, it is clear that adolescents respond to positive changes in their environment that may improve health outcomes and reduce obesity beyond the short term. This is seen especially when targeting the use of SSB consumption and changing the beliefs and behaviors surrounding them.

Conclusion

Now is an important time to take action because the childhood obesity epidemic is at a historic high in the United States. With work, this crisis can be solved based on evidence from intervention studies. Nutrition-based education coupled with the removal of added sugars from the diet and school meal programs, should serve as a model to fight childhood obesity. Physical activity was not examined in great length in this paper but it is also recommended that children remain active to avoid sedentary patterns, such as excessive screen time (Story et al., 2009). To achieve this, The American College of Sports Medicine recommends children engage in 60 minutes of physical activity daily, ranging from moderate to vigorous as characterized by increased sweating, heart rate, and breathing (ACSM, 2015). Physical activity in conjunction with positive dietary changes may have the potential to improve obesity rates in years to come.

Future research should seek to determine where the source of nutrition education should originate from in a child's life. A large part of fighting the obesity epidemic must be preventative care that is taught and exemplified in the home. While these school-based intervention trials have shown to be effective at reducing BMI, it should be noted that if these children had improved diet quality earlier in their lives, the rate of obesity may not be as high as it is today. After examining these studies, it appears that a successful method to reduce obesity is to remove added sugars, such as HFCS and SSBs from the diets of children and adolescents.

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