The Role of Sugar-Sweetened Beverage Consumption in Adolescent Obesity: A Review of the Literature

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ABSTRACT: Soft drink consumption has increased by 300% in the past 20 years, and 56–85% of children in school consume at least one soft drink daily. The odds ratio of becoming obese among children increases 1.6 times for each additional can or glass of sugar-sweetened drink consumed beyond their usual daily intake of the beverage. Soft drinks currently constitute the leading source of added sugars in the diet and exceed the U.S. Department of Agriculture's recommended total sugar consumption for adolescents. With the increase in adolescent obesity and the concurrent increase in consumption of sugar-sweetened beverages (SSB), the assumption infers a relationship between the two variables. SSB, classified as high–glycemic index (GI) liquids, increase postprandial blood glucose levels and decrease insulin sensitivity. Additionally, high-GI drinks submit to a decreased satiety level and subsequent overeating. Low-GI beverages stimulate a delayed return of hunger, thereby prompting an increased flexibility in amounts and frequencies of servings. Single intervention manipulation, elimination, or marked reduction of SSB consumption may serve to decrease caloric intake, increase satiety levels, decrease tendencies towards insulin resistance, and simplify the process of weight management in this population.

KEY WORDS: adolescence, obesity, sugar-sweetened beverages, glycemic index

INTRODUCTION

Because of the global complexity of factors influencing the development of obesity and the speed at which adolescent obesity has become commonplace, society is unprepared to adequately address this crisis. The U.S. Congress and the Centers for Disease Control and Prevention (CDC) directed the Institute of Medicine (IOM) to develop a prevention-focused plan to decrease the prevalence of obesity in our youth. The IOM reaffirmed the magnitude of the problem, validated the belief that preventive efforts hold promise for future generations, and confirmed that for the millions of currently obese adolescents prevention comes too late. The report recommended using the best available evidence-based approaches to address this existing crisis (Kaplan, Liverman, & Kraak, 2005). Recommendations are clear, and the indications stress that the consumption of high-calorie, nutrient-poor beverages may very well add to the obesity epidemic (Striegel-Moore et al., 2006). A positive energy balance of 120 kcal per day (about one serving of a sugar-sweetened soft drink) produces a 50-kg increase in body mass over 10 years (Ebbeling, Pawlak, & Ludwig, 2002).

Obesity in children has reached epidemic proportions (Matayka, 2002). The prevalence of obesity among children in the USA has increased by 100% between 1980 and 1994 (Ludwig, Peterson, & Gortmaker, 2001). Obesity is the most pervasive medical condition of childhood, with the prevalence having more than doubled over the past 20 years (American Academy of Pediatrics, Committee on School Health, 2004). Despite the numerous medical and psychological consequences, effective prevention and treatment strategies are lacking. Research in this area has been conducted in numerous environments and with varied methodology and theoretical frameworks, yet the prevention and treatment of childhood and adoles-

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cent obesity has been difficult and frustrating. Data continues to be inadequate, and the treatments are not generalizable (Snethen, Broome, & Cashin, 2006).

Treatment of obesity in adolescents is characterized by modest weight loss and substantial frequencies of relapse (Epstein, Myers, Raynor, & Saelens, 1998). The comparatively few studies that have evaluated treatment of obesity in adolescents have incorporated a reduced-fat diet in combination with varying exercise prescriptions and behavioral strategies (Ebbeling, Leidig, Sinclair, Hangen, & Ludwig, 2003). Due to the layout of these studies, the independent effect of a low-fat diet on weight management has not been satisfactorily evaluated. However, despite the overall decrease in total fat consumption nationally, obesity in adolescents continues to increase. Although there is widespread agreement that dietary intervention is an important component of obesity treatment, optimal prescriptions for lasting weight loss remain evasive (Ebbeling et al., 2003). Systematic intervention reviews examining overweight/obesity in this population have found limited data on the effectiveness of treatment as well as prevention programs (Summerbell et al., 2003).

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The purpose of this article is to explore the relevant data related to a single-intervention treatment and management for adolescent obesity. Particularly, the focus is the effect of sugar-sweetened beverage (SSB) consumption as it relates to an increased glycemic index (GI). The intent is to explore the advantages and feasibility of a relatively simple, uncomplicated measure as an alternative treatment in the adolescent obesity epidemic.

METHODS

A computer search using the Cumulative Index to Nursing & Allied Health Literature and MedLine electronic databases was performed between 2000 and 2006. Keywords included in this electronic search were "adolescence and obesity," "interventions," "sugar-sweetened beverages," and "glycemic index." Interventional research studies were sought and then refined for single interventions. The interventions desired were single-method dietary treatments focusing on SSB and GI.

The CDC defines parameters of body mass index (BMI)-for-age and sex in children from 2 to 19 years of age. Classification defines *at risk of overweight* as a BMI ≥85th percentile and <95th percentile and *overweight* as a BMI ≥95th percentile. (Note that in actuality, there is no definition or criteria for adolescent obesity according to the CDC.) The purpose of this literature review is to explore the existence, effectiveness, and practicality of a single intervention treatment option for adolescent obesity. Prior research details reports of unsuccessful treatment plans and management of adolescent obesity. Some have raised the possibility that the implementation of a relatively simple (single intervention) treatment plan would add convenience and adherence for a workable strategy. The complexity of this problem, the sparseness of successful interventions, and the disappointing results of weight management in this population give persuading evidence of need for a slightly different plan of action.

The focus of this review can be summarized with the following two questions. Do SSBs encourage the propensity toward adolescent obesity? Will elimination of high glycemic dietary beverages, specifically SSBs, affect success with weight management for adolescents?

> Foods or beverages that evoke rapid increases in blood glucose levels are classified as high GI. The rate of absorption of carbohydrate foods or beverages into the blood stream is a critical factor in hyperinsulinemia.

LITERATURE REVIEW

The disappointment of low-fat diets to successfully generate a significant change in the obesity of adolescents has created an increased interest in the carbohydrate composition of diets, including the concept of glycemic load. Glycemic load is the arithmetic product of GI and carbohydrate amount (Ludwig, 2003). Glycemic load was developed as a way of comparing the glucose-raising effect of foods with widely differing amounts of carbohydrates. Glycemic load takes into account the amount of carbohydrates consumed as well as the food's ability to contribute glucose to the blood stream after ingestion (Kirk, Scott, & Daniels, 2005). GI is a measure of the food's effect on postprandial blood glucose levels compared with the effects of reference standards. It is defined as the area under the glycemic response curve after consumption of 50 g of carbohydrates from a test food divided by the area-under-the-curve after consumption of 50 g of carbohydrates from a reference standard, usually white bread or glucose (Food and Agricultural Organization, 1997).

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SSBs are classified as high-glycemic beverages. Those foods or beverages that elicit minimal glucose fluctuations are considered to have a low GI. Not only have low GI foods been shown to decrease postprandial blood glucose levels; they are also responsible for improved lipid profiles, increased insulin sensitivity, and reduced lipogenesis (Spieth et al., 2000). While voluntary energy intake was increased after a high-GI meal and fat oxidation lessened, the converse is true of low-GI foods or beverages (Brand-Miller, Holt, Pawlak, & McMillan, 2002). The increase in daily energy intake occurred because children failed to reduce the consumption of solid foods to adjust for the additional energy of sweetened drinks (Mrdjenovic & Levitsky, 2003). Additionally, since obese adolescents generally have higher insulin secretion rates than their leaner peers, one could surmise that low-GI foods could be of a considerable advantage to this population (Heptulla et al., 2000). One-day feeding studies have consistently reported increased hunger and voluntary food intake in subjects after eating high, as compared to low, GI foods (Ludwig, 2000). Despite the fact that satiety after a meal appears to be inversely related to glycemic and insulinemic responses, the long-term efficacy of reduced-GI diets in the treatment of adolescent obesity has not been adequately evaluated.

Crapo, Reaven, and Olefsky (1976) discovered that foods with similar amounts of carbohydrates had differential effects on blood glucose. Jenkins and colleagues (1981) created the glycemic index to assist diabetics in choosing carbohydrate-containing foods that did not rapidly raise blood sugar. The food industry has increasingly replaced sucrose with fructose secondary to the development of inexpensive corn-derived high-fructose sweeteners (Wylie-Rosett, Segal-Isaacson, & Segal-Isaacson, 2004). High-fructose corn syrup is used extensively in soft drinks. The metabolism of fructose follows a completely different pathway than glucose. Unlike glucose, during the metabolism of fructose, insulin is not increased, leptin is reduced, and ghrelin is not suppressed (Wylie-Rosett et al., 2004). Leptin generally decreases with fasting, rises with food intake, and is thought to decrease appetite; ghrelin has been reported to generally rise with fasting and may increase hunger and simulate appetite (Teff et al., 2004). Fructose intake could increase overall food intake because of decreased satiety, resulting from its effects on ghrelin, leptin, and insulin.

The increase of high-fructose corn syrup (HFCS) in beverages in the United States mirrors the rapid increase in obesity. There is a distinct likelihood that the increased consumption of HFCS has a sequential relation to the epidemic of obesity (Bray, Nielson, & Popkin, 2004). Sweet corn-based syrups were developed during the past three decades and now represent close to one-half of the caloric sweeteners consumed by Americans. HFCS has become a favorite substitute for sucrose in carbonated beverages secondary to its comparatively increased sweetness and decreased cost. It is becoming increasingly clear that soft drink consumption may be an important contributor to the epidemic of obesity, in part through the larger portion sizes of these beverages and through the increased intake of fructose from HFCS and sucrose (Bray et al., 2004).

Prevention and treatment of obesity ultimately involves eating less and being more physically active. An energy imbalance is the reason for excessive weight gain (Lustig, 2001). Although these actions sound simple, long-term, effective weight loss is exceedingly difficult to achieve, particularly in the adolescent population. Given the relative intellectual and psychological immaturity of youth, successful implementation of weight management presents many obstacles. The complexity of growth and development in multiple realms is reflected in behaviors that may add risk to the health and safety of adolescents during this developmental phase (Rew, 2005). For this reason, a single environmental determinate in the form of a single intervention may be the most acceptable to this population and the most effective for a weight management strategy. In addition, the potential flexibility of a low-GI diet may have particular appeal to adolescents who have strong desires for autonomy. The lack of strict caloric limitations and restrictions, within the parameters of low-GI foods, may assist in the appeal of this dietary intervention for adolescents who are often less than eager to have any restrictions dictated to them by authority figures.

Consumption of SSBs may be a key contributor to the epidemic of obesity by virtue of their high sugar content, low satiety, high glycemic load, and subsequent incomplete compensation for total energy.

Modifying dietary, exercise, and behavioral strategies that have been effective in adult weight management programs for use with adolescents does not appear to be an optimal treatment of choice. Although these approaches have the most empirical support, the impact on weight control in this young population is extremely limited. Attempts to evaluate motivational stage to assess program readiness, modify carbohydrate content, develop an exercise protocol, or establish the use of daily diaries have all been relatively unsuccessful in the weight management of adolescents (Kirk et al., 2005).

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Table 1. Research on Glycemic Index

Reference	Design	Summary of Results
Ball et al. (2003)	n = 16 BMI ≥ 95%, >30 kg/m² 12–18 years 6 females, 6 males Randomized Crossover study design Replication study to study metabolic, hormonal, satiety responses after low- and high-GI meals in an obese adolescent population Snacks ad libitum weighed and recorded: 3–24-hour stays Serial blood samples: glucose, insulin, glucagon, IGF, IGFBP, TG Hunger scales	High-GI foods induced hormonal and metabolic changes that drive overeating in obese participants. Increase in satiety levels after consuming a low-GI meal.
Ebbeling et al. (2003)	n = 16 13–21 years 11 females, 5 males BMI ≥ 95% Randomized control trial: reduced GL or reduced fat diets 6-month intervention and 6-month follow-up To compare the effects of an ad libitum, reduced-GL diet to an energy-restricted, reduced-fat diet in obese adolescents BMI and insulin resistance measured at baseline, 6, 12 months Dietary counseling Social cognitive theory Two diets: *Reduced GL*: balance 45–30–25% consumption; eat to satiety: snack when hungry *Reduced fat*: negative balance of 250–500 kcal/d, 55–25–20%	Reduced GL group had significant decreases in BMI and fat mass at the end of 12 months. The reduced fat group did not have significant changes. There was no weight regain in the reduced GL group between 6 and 12 months. Weight gain in the reduced fat group. Insulin resistance increased significantly less in the reduced GL group. Change in dietary fat was not significant for change in body fat.

Note. BMI = body mass index; GI = glycemic index; GL = glycemic load; IGF = insulin-like growth factors; IGFBP = insulin-like growth factor binding protein; TG = triglycerides.

quent incomplete compensation for total energy (Malik, Schulze, & Hu, 2006). SSBs may encourage increased energy intake and excessive weight gain since compensation of liquid calories is less complete than calories consumed in solid form (Ebbeling et al., 2002). Sugar seems to be less satiating when provided in liquid compared to solid form (Dimeglio & Mattes, 2000). In addition, an SSB has an attenuated thermogenic effect, indicating less nutrient oxidation and greater energy storage (Ebbeling et al., 2006). The term "thermic effect of food" pertains to the fact that energy is expended by the body to consume (bite, chew, and swallow) and process (digest, transport, metabolize, and store) food. Energy provided by a beverage containing only sugar is retained by the body to a greater extent than a beverage of equal volume and energy content that includes protein and fat (St. Onge et al., 2004).

RESULTS

Research on Glycemic Index

The GI has proven to be a more useful nutritional concept than the chemical classifications of carbohydrates as simple or complex, as sugars or starches, or as available or unavailable, permitting new insights into the relation between the physiologic effects of carbohydrate-rich foods and health. The GI is now widely recognized as a reliable, physiologically based classification of foods according to their postprandial glycemic effect and includes all types of foods and beverages from bakery, breads, and beverages to fruits, pastas, and vegetables (Foster-Powell, Holt, & Brand-Miller, 2002) (Table 1).

Ebbeling and colleagues (2003) conducted a relatively small study with 16 obese adolescents. The teens were randomized into two groups, one with conventional reduced-fat nutritional treatment and the other with low-to-moderate GI selections. Those with the reduced GI selections were not energy restricted and were instructed in the ad libitum approach, that is eating spontaneously and without limitation. The subjects were advised to eat to satiety and to snack when hungry from a selection of reduced glycemic load foods. The control group was given a meal plan designed to elicit a negative energy balance of 250–500 kcal/d. Food diaries were requested on four separate occasions from both groups: at baseline, 3 months, 6 months, and at the end of the study (12 months). Not only did BMI and fat mass decrease significantly in the low glycemic food group from 0 to 12 months, there was no weight regain between 6 and 12 months in this group. In contrast, the control group demonstrated a significant increase in insulin resistance. In addition, the low glycemic load group population appeared to benefit from the potential flexibility of an ad libitum diet. Adding potential diet flexibility for a population searching for autonomy seemed effective and beneficial.

Ball and colleagues (2003) designed a similar study design but added different glycemic variables. A randomized cross-over study was performed with 16 adolescents using a low-GI whole food, a low-GI meal replacement, and a high-GI meal replacement. The adolescents were admitted to three separate 24-hour overnight stays. The results showed the low-GI meal replacement (NutriMeal drink and NutriBar) demonstrated better satiety and lower glucose and insulin blood levels than the high-GI meal replacement (Maltodextrin drink and Ensure Bar). The low-GI whole food showed a remarkably smaller increase in insulin blood levels, a significant finding for obese individuals whose insulin secretion rates are generally higher than those of their leaner peers (Heptulla et al., 2000). The association of obesity with type 2 diabetes has been recognized for decades, and the major basis for this link is the ability of obesity to engender insulin resistance (Kahn & Flier, 2000). Differences in insulin response between the meal replacements occurred. Prolongation of satiety after the low-GI meal also became apparent. Extended satiety associated with low-GI foods may prove an effective method for reducing caloric intake and achieving long-term weight control. High-GI foods induce hormonal and metabolic changes that limit availability of metabolic fuels and drive overeating in obese participants (Ludwig et al., 1999). The differences in insulin responses between high- and low-GI meals were seen in the blood sample analysis. Prolongation of satiety between high- and low-GI meal replacements were based on the time differences related to additional food requests.

Research on Sugar-Sweetened Beverages

Nine studies were identified from the search that endorsed single intervention manipulations related either to GI or SSBs in adolescent obesity treatment and management (Table 2). Of these nine studies, two were randomized studies that addressed glycemic load in obese adolescents. The remaining seven studies examined the effect of SSBs on the energy balance of adolescents. The two randomized studies were the only randomized trials in the literature with the two variables examined in this review: adolescent obesity and SSBs. Both concurred that increased consumption of SSBs had a positive relationship and detrimental effect on BMI. The evidence in these two randomized studies illustrates the strong argument that high-GI beverages and foods contribute to adolescent obesity by limiting satiety, increasing insulin resistance, and providing an abundance of excess energy storage.

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The other five studies were either an analysis of secondary data or observational descriptive designs. These five studies confirmed results showing that soft drink consumption increased among adolescents, and increases in adolescent weight were correlated with increases in consumption of SSBs. These studies analyzed information gathered from a variety of sources. Berkey, Rockett, Field, Guillman, and Colditz (2004) administered self-report questionnaires to the offspring of the Nurses' Health Study II participants. (The Nurses' Health Study II was established in 1989 by Dr. Walter Willett. It is one of the most significant prospective investigations into the risk factors for major chronic diseases in women.) For 3 consecutive years, these children (9–14 years of age at the start) filed surveys related to accounts of food recall, physical activity, performance habits, Tanner maturation stage, and BMI calculation with assistance from their nurse mothers. Data from this cohort was statistically significant for small BMI gains with increased sugar-sweetened beverage consumption over the 3-year period.

Ludwig and colleagues (2001) published the first longitudinal analysis of sugar-added beverage intakes and body weight changes. These investigators followed 548 ethnically diverse 11- and 12-year-old children in a Boston area public school system for 19 months. They found significant positive associations among consumption of SSB intake, weight change, and incident of obesity. Data for this study were obtained as part of the Planet Health intervention project. Information was gathered via student questionnaires completed in the classrooms under the supervision of teachers and anthropometric measurements. One of the strengths of this study was the addition of controls for physical activity and inactivity. The hypothesis stated that change in consumption of SSBs could directly predict a rise or fall in BMI over 2 academic years. The conclusion from this prospective observational analysis upheld the positive relationship between increase in SSB intake and BMI.

Table 2. Research Related to Sugar-Sweetened Beverages

Reference	Design	Summary of Results
James et al. (2004)	*n* = 644 7–11 years 6 primary schools in England Cluster randomized control study To determine if a school-based educational program aimed at reducing consumption of carbonated drinks can prevent excessive weight gain in children Focused educational program on nutrition 1 school year duration: "Ditch the Fizz" Anthropometric measurements at 6-month intervals 3-day diet recalls at baseline and at finish	Modest reduction in carbonated drinks consumed was associated with a reduction in overweight and obese children. Small increase in BMI in control group and small decrease in intervention group.
Ludwig et al. (2001)	*n* = 548 11–12 years Females and males Ethnically diverse Prospective observational Analysis (Planet Health) Examine the relation between the consumption of SSBs and childhood obesity Observational Questionnaires (self-reporting) Youth food frequency and youth activity questionnaire BMI	For each additional serving of SSB consumed, BMI and frequency of obesity increased after adjustment for confounding variables. Baseline consumption of SSBs was independently associated with change in BMI.
Nielsen & Popkin (2004)	*n* = 73,345 ≥2 years Stratified groups Four independent U.S. surveys Information seeking To examine American beverage consumption trends and causes Data collection through recall interviews and self-reporting	For all age groups, SSB consumption increased and milk consumption decreased.
French et al. (2003)	*n* = 8,908 and *n* = 3,177 6-17 years From two national surveys Information seeking To examine national trends in soft drink consumption among youth Data collection through recall interviews Interviewer administered dietary recalls: one from each survey	Fast food and restaurants increase market share of soft drinks. Dramatic increases in proportion of youth who consumed soft drinks and the amounts they consumed.
Ebbeling et al. (2006)	*n* = 103 13–18 years Pilot Study Comparative descriptive design To examine the effect of decreasing SSB consumption on body weight Intervention group received weekly deliveries of noncaloric beverages of their choice (environmental) Monthly phone calls to intervention group to answer questions and provide motivational counseling BMI at beginning and end of 6-month study period Two 24-hour diet and activity recalls at baseline and at the end of the study	Significant difference in BMI between the intervention group and control group for upper baseline BMI tertile (BMI ≥ 25.6).

Table 2. Continued

Reference	Design	Summary of Results
Berkey et al. (2004)	n = >10,000 9–14 years: females and males Prospective cohort study Longitudinal To evaluate the relationship between BMI changes and intakes of SSBs Observational Questionnaires (self-reporting) 24-hour recalls ×3 Food frequency questionnaire Physical activity questionnaires Self-reported height, weight, ethnicity, and Tanner maturation	Consumption of SSBs was associated with small BMI gains.
Mrdjenovic & Levitsky (2003)	n = 30 6–13 years old Longitudinal Design Dietary intakes collected over 4 to 8 weeks: anthropometric measurements at the beginning and end of the study Examined the relationship between SSB consumption and BMI	Consumption of > 16 oz. of SSB significantly increased BMI. Excessive sweetened food/drink consumption is associated with the displacement of milk from children's diets, higher daily energy intake, and greater weight gain.

Note. BMI = body mass index; SSB = sugar-sweetened beverage.

French, Lin, and Guthrie (2003) and Nielsen and Popkin (2004) both analyzed data from the Nationwide Food Consumption Survey (1977–1978) and the Continuing Survey of Food Intake by Individuals (1991). The surveys numbered in the thousands. Each study examined slightly different clusters of populations according to age and sex and throughout different points in the longitudinal queries. The strength of these two studies was the large nationally representative sample with comprehensive dietary intake measurements. Inquiries were answered related to prevalence, amounts, and sources of soft drink consumption. Both research studies corroborated each other's results showing that soft drink consumption is on the rise and is a significant contributor to total caloric intake for many adolescents. The trends identified in both studies were associated with an increased number of people consuming large portion sizes, more servings of SSBs per day, and reductions in these same measures for milk. Moreover, during this time period, the prevalence of soft drink consumption among youth from 6 to 17 years of age increased 48%, with the home environment being the largest source of soft drinks (French et al., 2003).

Mrdjenovic and Levitsky (2003) studied the effects of excessive sweetened drink consumption on daily energy balance and nutrient intake. The results of this study provided additional evidence of the adverse effects of excessive SSB consumption on the quality of children's diets. In addition to the greater total daily energy intake, the displacement of milk from the diet resulted in insufficient daily intakes of calcium and zinc. Dairy consumption has been shown to be inversely associated with the incidence of all insulin resistance syndrome components among individuals who are overweight (Pereira et al., 2002). The displacement of milk intake may also inhibit the possible obesity-reducing role of calcium (Bachman, Baranowski, & Nicklas, 2006).

The critical factor under scrutiny may be the sugar, calories, or behaviors related to beverage consumption. SSBs may encourage additional energy intake because of their high GI (Ludwig, 2002). The consumption of SSBs could lead to obesity secondary to the imprecise and incomplete compensation for energy consumed in liquid form. An increase in liquid carbohydrates leads, perversely, to even greater caloric consumption because when individuals increase liquid carbohydrate consumption, they are not likely to reduce their solid food consumption in response (Dimeglio & Mattes, 2000).

The severity of lifelong health risk factors under consideration with increases in adolescent obesity confounds the evidence. The suggestion that a simple, single manipulation in SSB consumption may be beneficial merits further research. Cost savings, nutritional benefits, and long-term health advantages are all supported by the proposition of a decreased intake of these high-GI beverages, especially in this young adolescent population.

In the first randomized pediatric trial related to SSB and weight management, James and colleagues (2004) reported a significant decrease in the incidence of obesity after 1 year among 7- to 11-year-old children who received an educational intervention to decrease carbonated beverages sweetened with sugar compared with a control group. This study was conducted in the United Kingdom, where 70% of adolescents consume energy-dense, high-GI drinks on a daily basis. The simple message delivered to the intervention group was

"Ditch the Fizz." Four 1-hour-long classes were held for preadolescent students, and 3-day recall food diaries were requested at baseline, 6 months, and 12 months. The nutritional educational intervention group showed a modest reduction in the number of carbonated sweetened drinks at the end of each 3-day diary collection period, as well as a reduction in obesity and overweight at the end of the 12-month study. The results of this study emphasized the fact that a small dietary change, as seen in the small decrease in carbonated sweetened beverage intake, seemed to have a major impact on obesity risk, with only a slight decrease in BMI.

The second randomized trial was conducted in Boston. This study was constructed with changes realized from the findings and limitations seen in the James study (2004). The research by James and colleagues showed a minimal interventional decrease in consumption of SSBs. Consequently, the results reflected a minimal result in weight decrease. Although the risks of obesity are decreased with only a slight decrease in BMI, this second study aimed to increase the weight reduction by increasing the effect of the intervention. Ebbeling and colleagues (2006) hypothesized that a simple environmental intervention in the form of sugar-free beverage delivery to the home would significantly decrease the BMI among the heaviest adolescents. The purpose was to almost completely eliminate SSB consumption in a diverse group of adolescents. The beneficial effect on body weight of reducing SSB consumption increased with increasing baseline body weight. The mechanisms underlying this susceptibility of the heaviest adolescents remains speculative and likely involves complex interactions, despite the published data indicating that overweight adolescents obtain a larger portion of their total energy intake from soft drinks than their lean peers (Troiano, Briefel, Carroll, & Bialostosky, 2000).

Ebbeling's pilot study was the framework for a current clinical trial being funded by the National Institute of Diabetes and Digestive Kidney Diseases, and recruitment initiated in September 2006. In Ebbeling's pilot study, 103 adolescents, 13 to 18 years of age, were randomly assigned to an intervention group or a control group. The change in SSBs was the primary intervention, and the change in BMI was the primary outcome. The intervention group received weekly home deliveries of noncaloric beverages of their choosing for 25 weeks. Participants and their families were contacted by phone at baseline and then monthly to provide motivational counseling, to assess satisfaction with beverage choices, and to discuss beverage consumption patterns. In addition, four diet recall and activity diaries were conducted over the telephone. Baseline demographics, anthropometric measurements, and behavioral characteristics were compared between the intervention and control groups. The outcome was a significant beneficial effect on body weight by reducing SSBs in the intervention group. The greatest impact of the intervention was seen among the adolescents with the highest BMI. The single environmental intervention of noncaloric beverage delivery to the home is particularly attractive for adolescents. This population characteristically desires increased independence, resistance of adult authority, ambivalence related to dietary change, and decreased response to conventional nutrition classes and behavioral counseling.

IMPLICATIONS FOR SCHOOL NURSING PRACTICE

As we began the 21st century, soft drink vending machines were located in over 60% of U.S. middle schools and high schools (Starke, 2001). In 2002, an estimated 240 U.S. school districts had entered into exclusive "pouring rights" contracts with soft drink companies (Channel One, 2002). These arrangements stipulated that these companies give the schools cash and other incentives in return for the right to sell sodas in vending machines and to advertise on scoreboards, in hallways, and on book covers. These contracts rewarded schools for selling more soda to students. Some contracts even directly linked the schools' revenues to the amount of beverages sold (Fried & Nestle, 2002).

Several concerns are related to these pouring rights contracts, in addition to the nutritional factors of SSBs. School nurses need to be aware of the implied endorsements that their schools may be making by entering into these generally 5- to 10-year "no opt-out" contracts with beverage companies. Seventy-six percent of surveyed school principals perceived that parents were not concerned with "commercial companies going into schools and seducing their children into buying specific products for the economic improvement of the schools" (Price, Murnan, & Moore, 2006, p. 309). As of 2003, no court had reviewed pouring rights contracts (Almeling, 2003).

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In May 2006, the American Beverage Association (ABA, 2006) and the Alliance for a Healthier Generation adopted School Beverage Guidelines that recommended the reduction of calories present in beverages sold in elementary, middle, and high schools. According to these guidelines, full-calorie sodas would not be sold, and smaller-portion, lower calorie options would be available instead. According to the guidelines posted on the ABA website, the intent was all part of an effort to provide an opportunity for children to learn the importance of a balanced diet and exercise. An analysis was commissioned by the ABA in 2005 to calculate the average per capita beverage purchased by students throughout the time span of a normal school day. The results suggested that substantial changes had already taken place in both the volume of soft drink sales in schools and in the product mix that bottlers were delivering to schools, such as declines in deliveries of carbonated sugar drinks and increases in bottled water, diet drinks, and 100% juices (Wescott, Wise, & Brownback, 2005).

The ABA policy recommendation is just that, a recommendation to its member bottlers who represent 85% of bottlers (ABA, 2006). However, local bottling companies are independently owned and are free to ignore their national organization's recommendations (Price et al., 2006). Thus, there is a continuing need for school nurses to educate students, parents, and school personnel about the contribution of soft drink vending in schools to adolescent obesity.

According to the American Academy of Pediatrics (2004), the preferred nutritional advantage and method for dealing with soft drinks at school would be to ban them completely from the school environment. The Child Nutrition and WIC (Women, Infants and Children) Reauthorization Act of 2004 required all school districts with federally funded meal programs to develop and implement wellness policies that addressed nutrition. A recent survey of California school board members' perceptions of factors influencing school nutrition policy found that the majority (56%) felt inadequtely prepared to develop, monitor, review, or revise nutrition policies (Price et al., 2006). The 2000 SHPPS (School Health Policies and Programs Study) survey found that 55% of schools reported offering nutrition and dietary behavior counseling (Brener et al., 2001). Of the schools that offered health education, they averaged about 5 hours per year on nutrition and dietary behaviors (Kann, Brener, & Allensworth, 2001). School nurses can play critical roles in monitoring and educating students regarding the health effects of being overweight, as well as how to prevent and treat it. Information about student weight and BMI status sent home to parents is essential as research indicates only about 1 in 10 parents of overweight children actually perceive their child's weight status accurately (Etelson, Brand, Patrick, & Shirali, 2003).

School nurses can play critical roles in monitoring and educating students regarding the health effects of being overweight, as well as how to prevent and treat it.

CONCLUSION

The decrease in dietary fat observed at a population level has been accompanied by a compensatory increase in carbohydrate consumption. Rates of obesity continue to rise, suggesting that other dietary factors may play a critical role in body weight regulation. One such factor may be GI. Beverages with a high GI have been shown to cause a fairly significant increase in postprandial blood glucose concentrations and overstimulation of appetite and eating, especially in adolescents (Bjorck, Granfeldt, Liljeberg, Tovar, & Asp, 1995).

The effectiveness of low-GI foods in weight control accentuates the rationale for the elimination of SSBs, a simple environmental intervention with major implications on the obesity epidemic of adolescents. Public health interventions to prevent and treat obesity in adolescents have generally taken a comprehensive approach, targeting multiple behaviors believed to promote positive energy balance. Conceptually, such an approach could be more efficacious than an intervention focused on just one behavior. However, most comprehensive programs have not shown a substantial effect on body weight. It is obvious from this review that although the data about the function and benefits of SSB consumption and the role of the GI is compelling, it is too sparse. Pending additional research and clinical trials in this area, support for the American Academy of Pediatrics' (2004) guidelines that recommend limiting SSB consumption should be implemented. School nurses are well positioned to publicize and recommend these guidelines.

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