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Abstract

Artificial sweeteners have become a central component of the Western diet in order to facilitate weight loss and enhance glucose control. Despite their popularity, evidence supporting the benefits of artificial sweeteners remains contradictory; different trials have shown weight loss, weight gain or no change with artificial sweetener consumption. Multiple trials have correlated artificial sweetener usage, in the form of diet soda, with an increased risk of obesity, diabetes and/or metabolic syndrome. Hypotheses speculate that individuals who consume larger loads of artificial sweeteners may be more likely to make unhealthy lifestyle choices, putting them at an increased risk for the development of these disease states. Although the link between artificial sweeteners and developing obesity or diabetes remains unclear, it is important for the general public and health care professionals to be aware of this potential relationship in order to make educated decisions about the foods and beverages they consume.

Introduction

The prevalence of both obesity and diabetes has increased over the past 30 years, as has the use of non-nutritive sweeteners (NNS). NNS are sugar substitutes the body does not metabolize; therefore, they do not provide calories or energy. NNS also are referred to as artificial sweeteners, high-intensity sweeteners, non-sucrose sweeteners, sugar substitutes or sugar-free sweeteners. The safety of NNS remains questionable due to possible obesity and diabetes links, yet more than 6,000 currently marketed food, medication and cosmetic products contain a mixture of the five FDA-approved NNS (table 1).[1] Contradicting evidence exists regarding the role of NNS use in obesity and diabetes. This article will outline the debate regarding the relationship of NNS to obesity and diabetes and discuss other related lifestyle implications.

Obesity

From 1960-80, obesity rates in the United States remained constant, with approximately 14 percent of the population classified as obese.[2] In 2000, this rate jumped to 31 percent, and figures from 2008 estimated 34 percent of Americans were obese.[3] Obesity is defined as a having a body mass index (BMI) of 30 or greater and occurs when more calories are consumed than the body uses.[4] People may find it easy to unconsciously consume a large amount of calories when drinking beverages and eating foods low in nutrients, such as soft drinks and snacks that frequently contain NNS. There are opposing thoughts about the use of NNS in relation to weight loss. Hypothetically, NNS may reduce caloric intake without sacrificing taste, promoting weight loss; however, there also is evidence that NNS use may result in weight gain.

Non-nutritive sweeteners do not contain calories but still sweeten foods and beverages, reducing the amount of calories consumed. The American Dietetic Association suggested if added sugars were replaced with NNS, an average of 380 fewer calories would be ingested per day, resulting in a weight loss of approximately one pound over 10 days.[1] Raben observed this possible correlation between NNS and weight loss in a randomized, blinded, parallel study of 41 healthy overweight individuals.[5] After 10 weeks of taking a NNS or sucrose supplement, the sucrose group gained 3.5 pounds, whereas the NNS group lost 2.2 pounds.

Alternatively, when NNS are added to a patient-controlled diet, the benefits of weight loss do not necessarily occur. Rodin conducted a randomized, patient-controlled experiment of 12 men and 12 women, including both overweight and normal weight individuals.[6] Thirty-eight minutes before eating a buffet meal, researchers gave participants 500 ml of either water or a beverage sweetened with fructose, aspartame or glucose and subsequently calculated the number of calories each person consumed. Regardless of the pre-meal beverage, overweight participants consumed more calories than those of a normal weight,

Table 1. FDA approved artificial sweeteners[1]

Type	Other Names	Relative Sweetness (to Sucrose)	Description	Regulatory Status
Sucralose	Splenda®	600	Most popular; produces no glycemic response	General-purpose sweetener
Acesulfame potassium	Sunett®	200	Second most popular; often used in combination with other sweeteners; produces no glycemic response	General-purpose sweetener
Aspartame	Equal®	160-200	Third most popular; metabolism yields phenylalanine; allergic reactions reported; limited glycemic response	General-purpose sweetener
Saccharin	Sweet'N Low®, Hermesetas	200-700	Often used in combination with other sweeteners; produces no glycemic response	Additive to foods and beverages, tabletop sugar substitute, also used in gum, cosmetics and pharmaceuticals
Neotame	Not currently available	7,000-13,000	Metabolism yields phenylalanine; produces no glycemic response	General-purpose sweetener

indicating obesity is a complex disorder. Individuals who drank water or aspartame beverages consumed a similar amount of calories but ate more than those who had fructose- or glucose-sweetened drinks. The study demonstrated that aspartame alone did not cause the consumption of more calories. When calories from the pre-meal drink and the meal were added, the totals were similar in all groups; therefore, the participants given aspartame or water compensated for calories not contained in the drink.

Lavin looked specifically at the total caloric intake of women over two days after drinking 330 ml of carbonated water, a drink containing aspartame, or a drink containing sucrose in a randomized, patient-controlled trial.[7] One week later, the women were given different beverages than the previous week, and the experiment was repeated. Participants consumed the beverage four times during the testing day; researchers measured all food eaten during the first day and relied on patients to self-report food eaten during the second day. The results showed no difference in the total amount of calories consumed on the first day when including the calories in the sucrose-sweetened beverage. Conversely, women who drank the aspartame-sweetened beverages consumed more calories during the second day, specifically in the form of carbohydrates. This study suggested that NNS may not be beneficial for weight loss because people tend to compensate for missing calories initially and actually eat more on subsequent days.

Diabetes

Non-nutritive sweeteners can be valuable to diabetic patients because they provide a sweet taste without sugar.[1] Grotz conducted a randomized, double-blind study in 128 subjects with type II diabetes that demonstrated the benefits of NNS in this population.[8] The results showed that sucralose consumption of 667 mg/day for 13 weeks had no effect on glycosylated hemoglobin (HbA1C), fasting plasma glucose, or fasting serum C-peptide. Based on individual body weight, daily sucralose consumption by participants in this study was calculated to be 7.5 ± 0.2 mg/kg/day, which is approximately three times higher than the estimated daily intake of 2.4 mg/kg/day. This study concluded that sucralose consumption of 7.5 mg/kg/day for 13 weeks had no effect on glucose homeostasis in type II diabetics, and sucralose-sweetened foods or beverages are beneficial for patients with diabetes.

Despite these positive findings, there are concerns that NNS use can increase the risk of developing type II diabetes and may be detrimental to people with diabetes. People with type II diabetes are at an increased risk for metabolic syndrome, defined as a group of cardiovascular risk factors including increased waist circumference, elevated blood pressure and insulin resistance.[9] Recent studies examined a possible link between NNS and the risk of developing diabetes. In the Multi-Ethnic Study of Atherosclerosis (MESA), diet soda consumption was evaluated by a food frequency questionnaire in 6,814 Caucasian, African American, Hispanic and Chinese adults aged 45-84 years. The study found that consumption of one or more servings of diet soda daily was associated with a 67 percent greater relative risk of developing type II diabetes and a 36 percent greater relative risk of developing two components of metabolic syndrome: high fasting glucose and increased waist circumference. The type of NNS used in diet soda manufacturing was variable throughout the study; therefore, results could not be attributed to one specific NNS. The study concluded that diet soda, either independently or in combination with other dietary and lifestyle behaviors, increased the risk of development of metabolic syndrome and type II diabetes.

In the Atherosclerosis Risk in Communities (ARIC) study, 9,514 participants, aged 45-64 years, were assessed using a food-frequency questionnaire at baseline and followed for a period of nine years.[10] Data collected at three-year intervals was used to evaluate the relationship between dietary intake and the development of metabolic syndrome. At the conclusion of the study, consumption of one serving of diet soda per day was associated with a 34 percent higher risk of metabolic syndrome. Mackenzie used data obtained in the third National Health and Nutrition Examination Survey (NHANES III) to examine the relationship between beverage consumption and glucose control in American adults with and without diabetes.[11] Diabetes status, glycosylated hemoglobin and a one-month recall food-frequency questionnaire were evaluated in 14,900 participants aged 18-75 years. The study found a correlation between diet soda consumption in adults with diabetes and poor glucose control, as measured by Hemoglobin A1C.

Lifestyle Choices

The development and progression of metabolic syndrome and type II diabetes also may be related to the consumption of soda. Dhingra examined the relationship between soft-drink consumption and metabolic syndrome in 6,039 Framingham Heart Study participants (mean age 52.9 years).[12] For inclusion, participants attended two consecutive examinations from 1987-2001 and reported the average number of 12-ounce servings of soft drinks consumed per day. This study concluded that the consumption of more than one soda per day, diet or regular, was associated with an increased incidence of multiple metabolic risk factors, indicating that the consumption of soft drinks, not necessarily NNS, is associated with metabolic syndrome and, possibly, diabetes. The researchers theorized that the intense sweetness of soft drinks may increase a person's preference for sweetened items and the consumption of soft drinks may be associated with other poor dietary and lifestyle behaviors.

In accordance with Dhingra's conclusion, other studies also have suggested that dietary and lifestyle choices may confound the relationship between artificial sweetener consumption and metabolic disease development. The authors of MESA speculated that artificial sweetener use may increase the desire for sweetness and energy-dense foods.[9] With diet soda consumption, overconsumption of other foods and beverages may result based on overestimation of the number of calories saved by substituting diet for sugar-sweetened beverages. An analysis of the NHANES III data suggested that consumption of diet beverages is more likely in those patients who have a tendency towards poor glucose control.[11]

Conclusion

A correlation exists between the use of NNS and the development of obesity and diabetes; however, many other factors, such as soda consumption, also could play a role. NNS are not the sole cause of the current obesity and diabetes epidemics, but they may be a contributing factor to the increasing prevalence of these diseases over the past 30 years. As with any healthy diet, moderation is imperative. It is important for the general public and health care professionals to be aware of the potential relationship between NNS and both obesity and diabetes in order to make educated decisions about the foods and beverages they consume.

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