In adults, what is the association between intake of sugar-sweetened beverages and body weight?

Conclusion

A moderate body of epidemiologic evidence suggests that greater consumption of sugar-sweetened beverages is associated with increased body weight in adults.

A moderate body of evidence suggests that under isocaloric controlled conditions, added sugars, including sugar-sweetened beverages, are no more likely to cause weight gain than any other source of energy.

Grade: Moderate

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here.

Evidence Summary Overview

The Committee addressed this question by reviewing four systematic reviews (Gibson, 2008; Malik, 2006; Ruxton, 2010; Vartanian; 2007), four randomized controlled trials (RCTs) (Raben, 1997; Reid, 2007; Stanhope, 2009; Surwit, 1997) and three prospective observational studies (Chen, 2009; Dhingra, 2007; Palmer, 2008).

The studies included in the systematic reviews did not use consistent methods to evaluate added sugars. Typical search terms were soft drinks, sugar-sweetened beverages (SSB), liquid sugar and soda. The systematic reviews used different criteria to review the literature and three reviews (Gibson, 2008; Malik, 2006; Vartanian, 2007) included cross-sectional studies, as there were limited prospective studies on the topic. Malik et al, (2006), attempted a meta-analysis, but the degree of heterogeneity among study designs made a more qualitative assessment necessary. Vartanian et al, (2007) attempted to separate out the effects in different study designs. Studies with experimental designs (five studies) showed no association with added sugar intake for body weight for adults. Significant relationships were found in longitudinal studies (three studies) for a relationship between added sugar intake and body weight, although the effect size was small. Similarly, Malik et al, (2006) concluded that epidemiologic and experimental data indicated a greater consumption of SSB is associated with weight gain and obesity. In contrast, Gibson (2008) reviewed six longitudinal and one intervention study with adults and concluded that SSB are a source of energy, but that little evidence showed that they are any more obesogenic than any other source of energy. In a recent review, Ruxton et al, (2010) concluded that recent evidence does not suggest a positive association between body mass index (BMI) and sugar intake. However, some studies, specifically on sweetened beverages, highlight a potential concern in the relation to obesity risk. The methods used for these systematic reviews varied and may explain the discrepancies in results.

The four trials included in the Nutrition Evidence Library (NEL) systematic review varied greatly in design. In general, when calorie intake was controlled, there were no differences in weight gain when participants consumed diets with a higher percent of calories from added sugars, compared to diets with a lower percent of intake from added sugars (Raben, 1997; Stanhope, 2009; Surwit, 1997). When energy intake was not controlled, Reid et al, (2007) found a non-significant (NS) trend for weight gain among normal-weight women consuming four regular soft drinks per day, compared to those consuming diet soft drinks. In a trial by Stanhope et al, (2009) that included 25% of energy from beverages sweetened with glucose or fructose, weight gain was observed when participants consumed self-selected diets in an outpatient setting.

The Committee also reviewed three prospective studies. Lower consumption of soft drinks was linked to weight loss in the PREMIER study (Chen, 2009). A reduction in SSB intake of one serving per day was associated with a weight loss of approximately 0.5kg at six months and 18 months, and a significant dose-response trend between change in body weight and change in SSB intake also was observed. Over a mean follow-up of four years in the Framingham Heart Study (Dhingra, 2007), consumption of one or more soft drinks per day was associated with increased odds of developing obesity and increased waist circumference (WC) compared to drinking none.

Palmer et al, (2008) included sugar-sweetened soft drinks and fruit drinks in their analysis of type 2 diabetes (T2D) in a prospective cohort study of African-American women. Subjects gained weight during the study, but the lowest mean weight gain occurred among those who decreased their consumption of soft drinks.

Thus, there are mixed results on this topic. Randomized controlled trials report that added sugars are not different from other calories in increasing energy intake or body weight. Prospective studies report some relationship with SSB and weight gain, but it is not possible to determine if these relationships are merely linked to additional calories, as opposed to added sugars per se. The systematic reviews in this area are also inconsistent, probably based on different measures used to determine added sugars intake or intake of SSB.

Trials Examining Relationship between *Added Sugars* and Body Weight in Energy-Balanced Setting

Study	Design: Trials	Added Sugars	Comparison	Time	Support a positive relationship between added sugars and body weight in an energy-balanced setting?
Raben, 1997 **(neutral-quality)**	Crossover case-control study with three diets (sucrose-, starch-, fat-rich) in normal weight adults	Sucrose-rich diet: 23% energy from sucrose	Starch- and fat-rich diets: Both with 2% energy from sucrose	14 days for each treatment	No
Stanhope, 2009 **(neutral-quality)**	Parallel-arm study with glucose- or fructose-sweetened beverages including both outpatient and inpatient phases	Beverages sweetened with glucose or fructose provided 25% of energy intake		10 wk	Inpatient energy-balanced diet: No
Surwit, 1997 **(positive-quality)**	Controlled feeding study with high vs. low sucrose weight-loss (hypoenergetic) programs	High-sucrose diet: 43% energy from sucrose	Low-sucrose diet: 4% energy from sucrose	Six weeks	No

Systematic Reviews Examining Relationship between *Sugar-Sweetened Beverages* and Body Weight

Study	Systematic Review / Meta-Analysis	Authors Conclusion

Gibson, 2008 **Quality rating:**	Systematic review of sugar-sweetened soft drinks (SSD) and body weight, BMI or adiposity (44 original studies [six *longitudinal and one intervention study with adults*]; six review articles)	(?) SSD are a source of energy, but there is little evidence that they are more obesogenic than any other source of energy
Malik, 2006 **Quality rating:**	Systematic review of SSB and body weight, obesity or both (30 original studies [four *prospective cohorts and three intervention studies with adults*])	(+) Epidemiologic and experimental evidence indicates that a greater consumption of SSB is associated with weight gain and obesity
Ruxton, 2010 **Quality rating:**	Systematic review of sugar consumption and health (eight studies in the section on SSB and obesity [three *intervention studies included in review-one with adults*])	(?) The possibility that considerable intakes of SSB contribute to obesity risk cannot be discounted
Vartanian, 2007 **Quality rating:**	Meta-analysis examined the association between soft drink consumption and nutrition and health outcomes (88 original studies [three *longitudinal and five experimental studies with adults*])	(+) Clear association of soft drink intake with ↑ body weight observed

*These reviews included cross-sectional studies.

Prospective Observational Studies Examining Relationship between *Sugar-Sweetened Beverages* and Body Weight

Study	Design: Prospective Observational	Sugar-sweetened Beverages	Comparison	Time	Support a positive relationship between SSB and weight gain?
Palmer, 2008 **Quality rating:**	Prospective cohort of African American women in the US examining change in soft drink intake over time	At least one soft drink per day	No more than one soft drink per day	Six years	Yes
Dhingra, 2007 **Quality rating:**	Prospective cohort (Framingham Heart Study) examining soft drink intake and obesity	• One soft drink per day • More than one soft drink per day • At least two soft drinks per day	Less than one soft drink per day	Four years	Yes
Chen, 2009 **Quality rating:**	Prospective cohort (PREMIER) examining Δs in beverage consumption and weight Δ	SSB	Diet drinks, milk, 100% juice, coffee/tea, alcoholic beverages	Six- and 18-months	Yes

Trials Examining Relationship between *Sugar-Sweetened Beverages* and Body Weight

Study	Design: Trials	Sugar-sweetened Beverages	Comparison	Time	Support a positive relationship between SSB and weight gain?
Stanhope, 2009 **Quality rating:**	Parallel-arm study with glucose- or fructose-sweetened beverages including both outpatient and inpatient phases	Beverages sweetened with glucose or fructose provided 25% of energy intake		10 weeks	Outpatient self-selected diets: Yes

Reid, 2007 **Quality rating:** +	Parallel-arm trial with four soft drinks added to daily diet	Regular soft drink	Diet soft drink	Four weeks	No (NS trend for weight gain)

Evidence Summary Paragraphs

Gibson, 2008 (neutral quality), a systematic review, examined the evidence from epidemiological studies and interventions regarding the association between sugar-containing drinks and body weight and obesity. Database searches up to July 2008 of Medline, Cochrane Reviews and Google scholar were conducted to examine the association of sugar-sweetened soft drinks (SSD) with body weight, BMI or adiposity in adults or children. Search terms were 'soft drinks'/'sugar-sweetened beverages'/'-soda'/'liquid sugars' with 'weight'/'body weight'/'obesity'/'adiposity'. In addition, a hand search of cross-references was conducted. Sugar-sweetened soft drinks were defined as all cold beverages containing added sugars, whether carbonated or still, including soda pop and fruit squash and drinks with a fruit component less than 100% pure fruit juice; hot beverages and diet drinks were not included. Forty-four original studies (23 cross-sectional, 17 prospective, four intervention) were included. Eleven of these studies were conducted with adults. In addition, six review articles were considered.

For the 11 studies with adults:

- Three cross-sectional studies showed a significant positive association between SSD and obesity; one cross-sectional study showed no association between SSD and BMI
- Three longitudinal studies showed a positive association between SSD and BMI in at least one subgroup; one longitudinal study showed a positive, but non-significant, association with BMI; two longitudinal studies showed no association with BMI
- One intervention study showed a positive association with body weight.

Most studies suggest that the effect of SSD is small except in susceptible individuals or at high levels of intake. Of the six reviews, two concluded that the evidence was strong, one that an association was probable, while three described it as inconclusive, equivocal or near zero. Gibson concluded that SSD are by nature a source of energy but there is little evidence from epidemiological studies that they are more obesogenic than any other source of energy. Further, the author noted that despite the large number of studies on this topic, the inconsistencies of definition, design, statistical treatment and interpretation make it difficult to draw definitive conclusions as to whether SSB are significantly implicated in weight gain.

Malik et al, 2006 (neutral quality), a systematic review, examined cross-sectional, prospective cohort, and experimental studies to determine whether an association exists between intake of SSB and weight gain and obesity. English-language MEDLINE publications from 1966 through May 2005 examining the relation between SSB and the risk of weight gain, obesity or both were examined. Key words such as "soda," "soda pop" and "sugar-sweetened beverage" hedged with "weight gain," "overweight" and "obesity" were used in the primary search strategy, as well as in a subsequent search using MeSH terms. Additional published reports were obtained by cross-matching references of selected articles. Sugar-sweetened beverages included soft drinks, soda, fruitades, fruit drinks, sports drinks, sweetened iced tea, squashes and lemonade. Thirty original studies (15 cross-sectional, 10 prospective and five experimental), including nine adult comparisons, were included in the review. A meta-analysis was attempted, but the degree of heterogeneity among study designs, particularly with respect to the age groups of participants and to outcome assessment, was prohibitive and therefore, a more qualitative assessment was used.

For the nine comparisons with adults:

- Two cross-sectional analyses showed a positive association
- Two prospective cohorts showed a positive association, one showed a non-significant positive association and one found no association
- Three experimental studies showed a positive association.

Findings from large cross-sectional studies, in conjunction with those from well-powered prospective cohort studies with long periods of follow-up, show a positive association between greater intakes of SSB and weight gain and obesity in both children and adults. Findings from short-term feeding trials in adults also support an induction of positive energy balance and weight gain by intake of sugar-sweetened sodas, but these trials are few. The authors concluded that epidemiologic and experimental evidence indicates that a greater consumption of SSB is associated with weight gain and obesity. Further, although more research is needed, sufficient evidence exists for public health strategies to discourage consumption of sugary drinks as part of a healthy lifestyle.

Ruxton et al, 2010 (neutral quality), a systematic review, considered whether current intakes of added sugars are harmful to health and evaluated published literature from 1995-2006. The Cochrane Library and MEDLINE were searched for epidemiologic studies, clinical trials, meta-analyses and systematic reviews. The search terms were "sugar (sucrose)" and various outcomes including "obesity" and "body weight." The search was limited to English-language, human studies of sugar and sugar-containing foods and beverages. Dates of publication were restricted to January 1995 to March 2006. This process was supplemented with a hand-search and a check of reference lists from pertinent reviews. All studies were ranked separately by two reviewers with the higher ranking prevailing in the case of disagreement. Eight studies were included in the review of SSB and obesity. Of these, three were considered primary studies and were included in the review, while five were tertiary and not considered in conclusions. The authors concluded that results from high quality obesity studies did not suggest a positive association between BMI and sugar intake. However, some studies, specifically on sweetened beverages, highlighted a potential concern in relation to obesity risk, although these were limited by methodological issues.

Vartanian et al, 2007 (positive quality), a systematic review and meta-analysis, examined the association between soft drink consumption and nutrition and health outcomes. MEDLINE and PsycINFO were searched to find articles that examined the association between soft drink consumption and nutrition and health outcomes. Key words used included "soft drink," "soda" and "sweetened beverage" along with four primary outcomes (energy intake, body weight, milk intake and calcium intake) and two secondary outcomes (nutrition and health). Additional articles were identified by searching each article's reference section and the Web of Science database. Finally, authors were contacted to request unpublished or in-press work. Eighty-eight studies were included in the meta-analysis; approximately 30 comparisons were available for soft drinks and energy intake or body weight in adults. Analysis of primary outcomes revealed a significant degree of heterogeneity of effect sizes, and thus, studies were separated according to research design.

Average body weight effect sizes for adults:

- Overall: r=0.11 (95% CI: 0.10, 0.12; P<0.0056; N=11)
- Cross-sectional: r=0.06 (95% CI: 0.05, 0.08; P<0.0056; N=5)
- Longitudinal: r=0.14 (95% CI: 0.13, 0.16; P<0.0056; N=3)
- Experimental (long): r=0.15 (95% CI: 0.05, 0.24; NS; N=5).

The authors concluded that they found clear associations of soft drink intake with increased energy intake and body weight. Further, they stated that recommendations to reduce population soft drink consumption are strongly supported by the available science.

Chen et al, 2009 (positive quality), a prospective cohort study conducted in the US, examined how changes in beverage consumption affect weight change among adults. Participants were 810 adults (62% female; age 50.0±8.9 years; BMI=33.1±5.8kg/m^2) from the PREMIER study. Dietary intake was estimated by the average of two multiple pass 24-hour recalls conducted at baseline, six and 18 months to determine changes in volume, kcal intake and percentage of calories from beverages both overall and from seven categories (SSB; diet drinks; milk; 100% juices; coffee and tea with sugar; coffee and tea without sugar or with artificial sweeteners; and alcoholic beverages). Weight and height were measured at each time point. Of the individual beverages, only intake of SSB was significantly associated with weight change. A reduction in SSB intake of one serving per day was associated with a weight loss of 0.49 kg (95% CI: 0.11, 0.82; P=0.006) at six months and of 0.65kg (95% CI: 0.22, 1.09; P=0.003) at 18 months. Participants were divided into tertiles based on their six- or 18-month change in consumption of SSBs. At both six and 18 months, participants in the first tertile had a greater mean weight loss than did those in the second (six-month change: 0.7kg; P=0.006; 18-month change: 1.6 kg; P<0.001) and third (six-month change: 2.4kg; P<0.001; 18-month change: 3.6kg; P<0.001) tertiles. A significant dose-response trend between change in body weight and change in SSB intake was observed at both six months (P<0.001) and 18 months (P<0.001). The authors concluded that their data support recommendations to limit liquid calorie intake among adults and to reduce SSB consumption as a means to accomplish weight loss or avoid excess weight gain.

Dhingra et al, 2007 (positive-quality) related the incidence of metabolic syndrome and its components to soft drink consumption in participants in the Framingham Heart Study (6,039 person-observations, 3,470 in women; mean age 52.9 years). Information on daily consumption of soft drinks was collected via a physician-administered questionnaire at each study visit from the fourth (1987-1991) through the sixth (1995-1998) examination cycles. Participants reported the average number of 12-ounce servings of soft drinks consumed per day in the year preceding the examination. The examination questionnaire did not elicit information regarding consumption of regular vs. diet soft drinks; however, such information was available from the self-administered food frequency questionnaire (FFQ) completed by participants at the fifth (1992-1995) and sixth examination cycles. Individuals were categorized as consuming less than one, one, at least one or at least two soft drinks per day. Analyses on components of metabolic syndrome were done with soft drink intake, including regular and diet. Anthropometrics were measured by study personnel. Over a mean follow-up of four years, consumption of at least one soft drink (including regular and diet) per day was associated with increased odds of developingobesity (multivariable adjusted OR=1.31; 95% CI: 1.02, 1.68) and increased waist circumference (multivariable adjusted OR=1.30; 95% CI: 1.09 to 1.56) compared to drinking none. The authors concluded that, in middle-aged adults, soft drink consumption is associated with a higher prevalence and incidence of multiple metabolic risk factors.

Palmer et al, 2008 (positive-quality) examined the association between consumption of SSB, weight gain and incidence of type 2 diabetes (T2D) in a prospective cohort study of 43,960 African American women (age 21 to 69 years) in the US. Food and beverage intake were obtained through a modified, 68-item Block FFQ. Three items were targeted for this article: “Regular soft drinks (not diet soda),” “orange juice or grapefruit juice” and “other fruit juices, fortified fruit drinks, Kool-Aid”. Data from questionnaires were used to assess the relation of changes in consumption patterns to changes in weight for the six years from 1995 to 2001. Participants were classified into five mutually-exclusive categories: Those who consumed no more than one drink per week in 1995 and had not changed their intake; those who consumed no more than one drink per week in 1995 and increased to at least one drinks per day; those who consumed at least one drink per day in 1995 and did not change; those who consumed at least one per day in 1995 and reduced their intake to no more than one drink per week in 2001; and those who did not fit into any of the previous categories. Height and weight were self-reported. The majority of participants gained weight during the six-year interval. In multivariate models that included terms for change in other risk factors, the greatest weight gain was seen in those who increased their consumption of soft drinks (mean weight gain, 6.8kg). The lowest mean weight gain (4.1kg) occurred among those who decreased their consumption of soft drinks ($P<0.001$ for the comparison of those with the greatest and lowest mean weight gains). Weight loss in the six-year interval was most common (24%) among women who decreased their intake of SSD and least common (16%) among those who increased consumption or were already consuming one or more soft drinks per day and did not cut back. The association between changes in consumption and weight gain was weaker for sweetened fruit drinks. The authors concluded that reducing consumption of soft drinks is a concrete step that women may find easier to achieve than other approaches to weight loss.

Reid et al, 2007 (positive quality) compared the effects of supplementary soft drinks added to the diet over four weeks on dietary intake, mood and BMI in normal-weight women (N=133; age 20 to 55 years; BMI 17 to 24.9kg/m^2). The study took place over five weeks including one week of baseline data collection followed by four weeks of drink supplementation. Drinks contained either sucrose or aspartame. Participants were either informed that they were receiving sugary drinks or ‘diet’ drinks, meaning that half were correctly informed about the drink content and half misinformed. In addition, participants were recruited according to whether they were or were not currently watching their weight. This resulted in a 2 x 2 x 2 design (sucrose vs. aspartame, drinks labeled sugar vs. labeled aspartame or diet, watcher vs. non-watcher). Subjects received four 250ml bottles of drink per day in uniform bottles with the labeling manipulated. Each week of the four-week intervention, participants were given one week’s supply of 28 test drinks and were instructed to drink the agreed amount each day at the specified times (11.00, 14.00, 18.00 and 20.00 hours). Sucrose supplements provided 1,800kJ per day and aspartame supplements provided 67kJ per day. Food intake was measured with a seven-day diary during each week of the five-week study. Height and weight were measured by study personnel. There were no significant effects of restraint (watching/non-watching) status on any of the experimental analyses. For this reason, results were presented without ‘watching’ as a factor. For those consuming the sucrose drink, energy intake was higher at week one (t (67 df)=6.44; $P<0.001$) and at week four than at baseline (t (67 df)=3.82; $P<0.001$) and week one and week four did not differ (t (67 df)=1.81; P=0.075). Women in the sucrose group consumed about 800kJ more energy per day; the supplements contained 1,800kJ. Mean body weight at baseline was 61.35±8.37kg. There was a marginal effect of drink on body weight (F(10•20, 1.86)=4.509; $P<0.05$), with more women who received the sucrose drink gaining some weight during the study and more women receiving aspartame losing weight. There was a non-significant trend for those receiving sucrose to gain weight. The authors concluded that compensation was only partial for added sucrose so were sucrose to be added to the diet, some weight gain might result in normal-weight individuals.

Stanhope et al, 2009 (neutral quality) assessed the effects of the consumption of glucose- or fructose-sweetened beverages providing 25% of energy requirements for 10 weeks among overweight and obese adults (N=32; 50% female; age 40 to 72 years; BMI 25-35kg/m^2). This was a double-blinded parallel arm study that used matched subjects and consisted of three phases:

1. A two-week inpatient baseline period during which subjects consumed an energy-balanced diet
2. An eight-week outpatient intervention period during which subjects consumed either fructose- or glucose-sweetened beverages providing 25% of daily energy requirements along with their usual ad libitum diet
3. A two-week inpatient intervention period during which subjects consumed fructose- or glucose-sweetened beverages providing 25% of daily energy requirements with an

energy-balanced diet.

Sugars were provided to the subjects as three daily servings of glucose- or fructose-sweetened beverages flavored with an unsweetened drink mix (Kool-Aid; Kraft). During the outpatient intervention, subjects were instructed to drink three servings per day, one with each meal and not to consume other sugar-containing beverages including fruit juice during the study protocol. Body weight was stable during the two-week inpatient periods at both the beginning and end of the study. However, during the eight-week outpatient intervention period, when the subjects consumed 25% of daily energy requirement as glucose- or fructose-sweetened beverages along with ad libitum self-selected diets, both groups exhibited similar significant increases in body weight. Percent changes in body weight after consumption of glucose- or fructose-sweetened beverages for 10 weeks were +1.8±0.5 ($P<0.01$) and +1.4±0.3 ($P<0.001$), respectively. A variety of outcomes were considered in this study. In an energy-balanced inpatient setting in which participants consumed 25% of energy as glucose- or fructose-sweetened beverages, body weight remained stable; however, when these beverages were consumed in an outpatient setting along with usual dietary intake, body weight increased.

Raben et al,1997 (neutral quality) investigated ad libitum energy intake, changes in body weight, 24-hour energy expenditure and sympathoadrenal activity when replacing dietary fat with sucrose or starch during a 14-day period. Participants were 20 healthy, normal-weight women (nine post- obese [PO] and 11 controls [C], closely matched for age, weight, height, fat mass and fat-free mass). Each subject completed three 14-day dietary periods, a sucrose-rich (sucrose), a starch-rich (starch) and a fat-rich (fat). The order of the periods differed, but subjects in the PO and C groups were 'paired' (except for two controls) so that the diet order was similar in the two groups. The dietary periods were separated by two to six weeks. Participants were supplied ad libitum amounts of the experimental diets to be consumed at home. The subjects collected the food twice a week and returned all leftovers for weighing and recording. The planned macronutrient composition of the sucrose and starch diet was similar with 59% carbohydrate (CHO), 28% fat and 13% protein, while the fat diet contributed 45-50% fat, 37-42% CHO and 13% protein. Sucrose contributed 23% energy on the sucrose diet and 2% on the starch and fat diets. Body weight was measured on days one and 15 of each treatment. On the fat, starch and sucrose diet the actual intake of CHO averaged 40.8, 59.1 and 58.6% ($P<0.0001$), of sucrose 2.2, 2.6 and 23.2% ($P<0.0001$), of fat 46.1, 28.0 and 28.6% ($P<0.0001$) and of protein 13.1, 13.4, and 13.2% ($P<0.05$), respectively. Average 14-day energy intake for all subjects was lowest on the starch diet (9.1±0.4 MJ per day) compared with both the sucrose (10.3±0.4MJ per day) and fat diet (10.2±0.4MJ per day) ($P<0.05$). Compared to a change of 0.0kg, total body weight decreased on the starch diet by 0.7±0.2kg ($P<0.05$), but was unchanged on the fat (-0.3±0.3kg) and sucrose diet (0.2±0.2kg). The changes were significantly different between the starch and sucrose diets ($P<0.05$). The authors concluded that the present study showed that a starch-rich diet resulted in a significantly lower energy intake and a small but significant reduction in body weight after 14-day ad libitum intake in both previously obese and normal weight subjects; in contrast, no significant (NS) changes in either of these parameters were observed on the sucrose-rich diet.

Surwit et al, 1997 (positive quality) studied the comparative effects of high- and low-sucrose, low-fat, hypoenergetic diets on a variety of metabolic and behavioral indexes in a six-week weight-loss program. Participants were assigned to a high-sucrose diet (N=20; age 40.6±8.2 years; BMI 35.93±4.8kg/m^2) or low-sucrose diet (N=22; age 40.3±7.3 years; BMI). Both diets contained approximately 4,606kJ energy per day with 11% of energy as fat, 19% as protein and 71% as CHO. The high-sucrose diet contained 43% of the total daily energy intake as sucrose; the low-sucrose diet contained 4% of the total daily energy intake as sucrose. The trial was conducted as a controlled feeding study in which subjects were provided with all meals and snacks for the six-week period.

Subjects also received a list of beverages and seasonings that could be consumed freely. Weekday dinners were served in a communal dining room; all other meals were precooked and packaged as "take-out meals." Mixed-design analysis of variance showed a main effect of time (P<0.001), with both diet groups showing decreases in weight. Group-by-time interactions were non-significant, indicating that the groups did not differ in the magnitude of this decrease over the duration of the study, ie, there were no treatment effects. The authors concluded that a high sucrose content in a hypoenergetic, low-fat diet did not adversely affect weight loss compared to a low-sucrose diet.

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

Chen L, Appel LJ, Loria C, Lin PH, Champagne CM, Elmer PJ, Ard JD, Mitchell D, Batch BC, Svetkey LP, Caballero B. Reduction in consumption of sugar-sweetened beverages is associated with weight loss: the PREMIER trial. *Am J Clin Nutr.* 2009 May;89(5):1299-306. Epub 2009 Apr 1.

Dhingra R, Sullivan L, Jacques PF, Wang TJ, Fox CS, Meigs JB, D'Agostino RB, Gaziano JM, Vasan RS. Soft drink consumption and risk of developing cardiometabolic risk factors and the metabolic syndrome in middle-aged adults in the community. *Circulation*. 2007 Jul 31;116(5):480-8.

Gibson S. Sugar-sweetened soft drinks and obesity: a systematic review of the evidence from observational studies and interventions. *Nutr Res Rev.* 2008 Dec;21(2):134-47.

Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. *Am J Clin Nutr* 2006 (84):274-88.

Palmer JR, Boggs DA, Krishnan S, Hu FB, Singer M, Rosenberg L. Sugar-sweetened beverages and incidence of type 2 diabetes mellitus in African American women. *Arch Intern Med.* 2008 Jul 28;168(14):1487-92.

Raben A, Macdonald I, Astrup A. Replacement of dietary fat by sucrose or starch: effects on 14 d ad libitum energy intake, energy expenditure and body weight in formerly obese and never-obese subjects. *Int J Obes Relat Metab Disord.* 1997 Oct;21(10):846-59.

Reid M, Hammersley R, Hill AJ, Skidmore P. Long-term dietary compensation for added sugar: Effects of supplementary sucrose drinks over a four-week period. *Br J Nutr.* 2007 Jan; 97(1): 193-203.

Ruxton CH, Gardner EJ, McNulty HM. Is sugar consumption detrimental to health? A review of the evidence 1995-2006. *Crit Rev Food Sci Nutr.* 2010 Jan; 50 (1): 1-19.

Stanhope KL, Schwarz JM, Keim NL, Griffen SC, Bremer AA, Graham JL, Hatcher B, Cox CL, Dyachenko A, Zhang W, McGahan JP, Seibert A, Krauss RM, Chiu S, Schaefer EJ, Ai M,

Otokozawa S, Nakajima K, Nakano T, Beysen C, Hellerstein MK, Berglund L, Havel PJ. Consuming fructose-sweetened, not glucose-sweetened, beverages increases visceral adiposity and lipids and decreases insulin sensitivity in overweight/obese humans. *J Clin Invest.* 2009 May;119(5):1322-34. Epub 2009 Apr 20.

Surwit RS, Feinglos MN, McCaskill CC, Clay SL, Babyak MA, Brownlow BS, Plaisted CS, Lin PH. Metabolic and behavioral effects of a high-sucrose diet during weight loss. *Am J Clin Nutr.* 1997 Apr;65(4):908-15.

Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. *Am J Public Health.* 2007 Apr;97(4):667-75. Epub 2007 Feb 28.