Dietary Sugars Intake and Cardiovascular Health

A Scientific Statement From the American Heart Association

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on behalf of the American Heart Association Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism and the Council on Epidemiology and Prevention

Abstract—High intakes of dietary sugars in the setting of a worldwide pandemic of obesity and cardiovascular disease have heightened concerns about the adverse effects of excessive consumption of sugars. In 2001 to 2004, the usual intake of added sugars for Americans was 22.2 teaspoons per day (355 calories per day). Between 1970 and 2005, average annual availability of sugars/added sugars increased by 19%, which added 76 calories to Americans’ average daily energy intake. Soft drinks and other sugar-sweetened beverages are the primary source of added sugars in Americans’ diets. Excessive consumption of sugars has been linked with several metabolic abnormalities and adverse health conditions, as well as shortfalls of essential nutrients. Although trial data are limited, evidence from observational studies indicates that a higher intake of soft drinks is associated with greater energy intake, higher body weight, and lower intake of essential nutrients. National survey data also indicate that excessive consumption of added sugars is contributing to overconsumption of discretionary calories by Americans. On the basis of the 2005 US Dietary Guidelines, intake of added sugars greatly exceeds discretionary calorie allowances, regardless of energy needs. In view of these considerations, the American Heart Association recommends reductions in the intake of added sugars. A prudent upper limit of intake is half of the discretionary calorie allowance, which for most American women is no more than 100 calories per day and for most American men is no more than 150 calories per day from added sugars. (Circulation. 2009;120:1011–1020.)

Key Words: AHA Scientific Statements ■ cardiovascular diseases ■ carbohydrates, dietary ■ diet ■ beverages ■ carbonated beverages ■ lipids

New evidence on the relationship between intake of sugars and cardiovascular health has emerged since the last American Heart Association (AHA) scientific statement was published in 2002.1 In 2006, the AHA published revised diet and lifestyle recommendations that recommend minimizing the intake of beverages and foods with added sugars.2 The present statement expands on that recommendation by reviewing the evidence for recommending a specific upper limit of intake for added sugars. Because the focus of the present statement is on added sugars, recommendations for intake of naturally occurring sugars and complex carbohydrates are beyond its scope.

Consumption of Sugars in the United States

Sugars are a ubiquitous component of our food supply and are consumed as a naturally occurring component of many foods and as additions to foods during processing, preparation, or at the table.3 There are various definitions for sugar. Table 1
lists the common descriptions and definitions of sugars used in the literature.

As expected, a healthy, well-balanced diet contains naturally occurring sugars, because monosaccharides such as fructose and disaccharides such as sucrose and lactose are integral components of fruit, vegetables, dairy products, and many grains. In addition, sugars add desirable sensory effects to many foods, and a sweet taste promotes enjoyment of meals and snacks. In fact, when sugars are added to otherwise nutrient-rich foods, such as sugar-sweetened dairy products like flavored milk and yogurt and sugar-sweetened cereals, the quality of children’s and adolescents’ diets improves, and in the case of flavored milks, no adverse effects on weight status were found. However, deleterious health effects may occur when sugars are consumed in large amounts.

Food availability data (also called disappearance data), used in conjunction with self-reported food consumption data from nationwide surveys, provide information on consumption of sugars in the United States. According to the US Department of Agriculture’s Economic Research Service, between 1970 and 2005, sugars and sweeteners available for consumption increased by an average of 76 calories per day, from 25 teaspoons (400 calories) to 29.8 teaspoons (476 calories), which corresponds to a 19% increase. Bray et al estimated that intake of added sugars increased from 335 kcal/d per person in 1977 to 1978 to 318 kcal/d per person in 1979 to 1980, and high-fructose corn syrup intake increased from 80 to 132 kcal/d per person during the same time period.

Added sugars are defined as sugars and syrups that are added to foods during processing or preparation, including sugars and syrups added at the table. Between 1994 and 2002, Americans’ intake of added sugars remained high and unchanged among 6- to 19-year-olds and increased among those 20 years old and older (personal correspondence from A.J. Moshfegh, US Department of Agriculture, Food Surveys Research Group, October 2007). The National Cancer Institute recently estimated usual intakes of added sugars on the basis of data from the 2001 to 2004 National Health and

### Table 1. Common Definitions

<table>
<thead>
<tr>
<th>Type of Sugar</th>
<th>Definition</th>
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<td>Simple carbohydrates (sugars)</td>
<td>refers to monosaccharides and disaccharides. Monosaccharides include glucose, galactose, and fructose. Dextrose is synonymous with glucose. Fructose is the most common naturally occurring monosaccharide, found in fruits and vegetables. Common disaccharides include sucrose (glucose plus fructose), which is found in sugar cane, sugar beets, honey, and corn syrup; lactose (glucose plus galactose), found in milk products; and maltose (glucose plus glucose), found in malt.</td>
</tr>
<tr>
<td>Complex carbohydrates</td>
<td>refers to glucose-containing polysaccharides, such as starch.</td>
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<tr>
<td>Naturally occurring (intrinsic) sugars</td>
<td>refers to sugars that are an integral part of whole fruit, vegetable, and milk products.</td>
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<tr>
<td>Added (extrinsic) sugars</td>
<td>refers to sugars and syrups added to foods during processing or preparation and includes sugars and syrups added at the table.</td>
</tr>
<tr>
<td>Total sugars</td>
<td>are defined as all sugars (naturally occurring and added) in foods and beverages.</td>
</tr>
<tr>
<td>High-fructose corn syrup</td>
<td>is produced from corn syrup (nearly all glucose), which undergoes enzymatic processing to increase the fructose content and is then mixed with glucose.</td>
</tr>
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### Table 2. Usual Intake of Added Sugars (in Teaspoons),* 2001–2004

<table>
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<th>Age, y</th>
<th>n</th>
<th>Mean</th>
<th>SE</th>
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<tr>
<td>1–3</td>
<td>1515</td>
<td>12.2</td>
<td>0.33</td>
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<tr>
<td>4–8</td>
<td>1701</td>
<td>21.0</td>
<td>0.54</td>
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<tr>
<td>Males 9–13</td>
<td>1061</td>
<td>29.2</td>
<td>0.92</td>
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<tr>
<td>Males 14–18</td>
<td>1424</td>
<td>34.3</td>
<td>1.03</td>
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<tr>
<td>Males ≥19</td>
<td>4650</td>
<td>25.4</td>
<td>0.48</td>
</tr>
<tr>
<td>Females 9–13</td>
<td>1112</td>
<td>23.2</td>
<td>0.82</td>
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<tr>
<td>Females 14–18</td>
<td>1362</td>
<td>25.2</td>
<td>0.71</td>
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<tr>
<td>Females ≥19</td>
<td>5063</td>
<td>18.3</td>
<td>0.37</td>
</tr>
<tr>
<td>All persons ≥1</td>
<td>17 888</td>
<td>22.2</td>
<td>0.29</td>
</tr>
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</table>

n indicates number of persons in sample; SE, standard error of the mean (degrees of freedom = 30).

*Includes white, brown, and raw sugar; syrup; honey; and molasses, eaten separately or used as ingredients in processed or prepared foods such as breads, cakes, soft drinks, jams, and ice cream.

One teaspoon of added sugars has the same amount of total sugars as 1 teaspoon (4 g) of table sugar (sucrose).

Adapted from National Cancer Institute.9

Nutrition Examination Survey (NHANES). The mean intake for all persons was 22.2 teaspoons per day (355 calories); 14- to 18-year-old children had the highest intakes at 34.3 teaspoons per day (549 calories);2 Table 2). On the basis of principles elucidated in the 2005 US Dietary Guidelines,10 the MyPyramid World Wide Web site11,12 estimates that these intakes far exceed the allowance for discretionary calories, regardless of energy needs (Table 3).

Increases in the intake of soft drinks, fruit drinks, desserts, sugars and jellies, candy, and ready-to-eat cereals largely account for the increased energy intake from sugars/added sugars. Soft drinks and other sugar-sweetened beverages are the primary source of added sugars in Americans’ diets13 (Table 4). Between 1970 and 2000, per-person daily consumption of calorific soft drinks increased 70%, from 7.8 to 13.2 ounces.14

Currently, US food labels contain information on total sugars per serving but do not distinguish between sugars that are naturally present in foods and added sugars. Thus, it is difficult for consumers to determine the amount of added sugars in foods and beverages. In 2006, the US Department of Agriculture published a database for the added sugar content of selected foods.15 In addition, several voluntary food-labeling systems are in place or are being developed, some of which include criteria for limiting added sugars. These include the Smart Choices Program,16 the Hannaford’s grocery chain Guiding Stars program,17 the Overall Nutrient Quality Index,18 and the Nutrient Rich Foods Coalition nutrient density score.19

### Fructose

Originally proposed as the ideal sweetener for people with diabetes mellitus because of its inability to stimulate insulin secretion, fructose consumption has been indirectly implicated in the epidemics of obesity and type 2 diabetes mellitus.20–22 Fructose is a monosaccharide naturally found in fruits and honey. Many consumers mistakenly believe that

Fructose
Other grains (cinnamon toast and sweetened milk) (ice cream, sweetened yogurt, Dairy desserts and milk products punch) Fruit drinks (fruitades and fruit
Cakes, cookies, pies 12.9
Sugars and candy 16.1
Regular soft drinks 33.0
Sugars and candy 16.1
Cakes, cookies, pies 12.9
Fruit drinks (fruitedes and fruit punch) 9.7
Dairy desserts and milk products (ice cream, sweetened yogurt, and sweetened milk) 8.6
Other grains (cinnamon toast and honey-nut waffles) 5.8

Food groups that contribute more than 5% of the added sugars to the American diet are listed in decreasing order.

Data derived from Guthrie and Morton.13

Glucose-Insulin Response

Many factors influence the body’s glucose response to foods, including the composition of the food (fat, protein, sugar, starch, and fiber content), the method of food processing and preparation, the combination of foods eaten, and physiological factors including age and body composition.34–36 Glucose control is the net effect of metabolic processes that remove glucose from the blood for either glycogen synthesis or energy production and of gluconeogenesis and glycogenolysis, which return glucose to the blood. The rise in blood glucose after consumption of a carbohydrate triggers the release of insulin and at the same time reduces the secretion of glucagon.37

There is a common belief that consumption of sucrose results in higher blood glucose levels than consumption of starch; however, the form of starch (cooked versus uncooked) results in different glucose responses. Cooked starch, such as bread, rice, and potatoes, evokes glucose responses similar to glucose, whereas uncooked starch is more slowly absorbed than cooked starch, resulting in a lower glycemic response.38 However, cooked whole oats produce a relatively low glucose response, whereas most raw processed cereals produce very high responses. Thus, processing and preparation are key factors in the body’s glucose response to food consumption.

In a feeding study of 10 healthy adults, glucose and insulin responses were determined for high-sugar refined-grain snacks (chocolate-coated candy bar, cola drink with crisps) and whole-food snacks (raisins and peanuts; bananas and...
peanuts) of similar energy and fat content. Consumption of the sugary refined-grain snacks resulted in higher glucose and insulin levels than consumption of the whole-food snacks, which suggests that the glycemic response to food is influenced by the carbohydrate content and physical state of the food, such as processed or whole, liquid or solid. Fiber content was also higher in the whole-food snacks than in the high-sugar refined-grain snacks, which contributed to a reduced postprandial glucose response with the whole-food snacks compared with the refined-grain snacks.

Effects of Dietary Sugars on Blood Pressure, Lipids, and Inflammation

An emerging but inconclusive body of evidence suggests that increased intake of added sugars might raise blood pressure. Studies include animal studies in which rats were fed high doses of fructose, acute ingestion studies in which humans were fed high doses of different sugars, and more recently, epidemiological studies, such as the Framingham Heart Study, in which consumption of ≥1 soft drink per day significantly increased the odds of developing high blood pressure. Nonetheless, results from studies in humans are inconsistent, and the chronic effects of a high intake of simple sugars on blood pressure remain uncertain.

It is well established that when used to replace dietary fats, carbohydrates can elevate plasma triglyceride levels and lower levels of high-density lipoprotein cholesterol, however, the type of carbohydrate appears to influence lipid responses. A diet such as the DASH (Dietary Approaches to Stop Hypertension) diet that replaces fat with carbohydrate from fruits, vegetables, whole grains, and nonfat and low-fat dairy products does not increase triglycerides but still lowers high-density lipoprotein cholesterol somewhat. In the Women’s Health Initiative, the higher-carbohydrate diet had no effect on triglycerides or high-density lipoprotein cholesterol.

Elevations in fasting plasma triglycerides, principally very-low-density lipoproteins, are a consistent feature of diets high (>20% of energy) in sucrose, glucose, and fructose. The effects of sucrose or fructose on fasting triglycerides may be more marked in men than women, in sedentary overweight people or those with the metabolic syndrome, and in those eating low-fiber diets. Sucrose and fructose also increase postprandial triglyceride levels and may augment the lipemia associated with fat-containing meals. There are several mechanisms by which fructose increases fasting and postprandial triglyceride levels. These include increased de novo lipogenesis in the liver, increased hepatic triglyceride synthesis, and secretion of very-low-density lipoproteins, as well as reduced lipoprotein lipase activity at the adipocyte, which decreases the rate of peripheral triglyceride clearance.

Compared with other carbohydrate sources (starch or glucose), recent studies have not demonstrated an added effect of either sucrose or fructose to lower high-density lipoprotein cholesterol levels; however, these studies have not agreed on the effects on low-density lipoprotein cholesterol. In summary, although the mechanisms are unclear, relative to other carbohydrate sources, sugar intake appears to be associated with increased triglyceride levels, a known risk factor for coronary heart disease; however, relative to other sources of carbohydrate, the effects of sugar intake on high-density lipoprotein and low-density lipoprotein levels remain unclear.

In some but not all studies, a higher consumption of high-sugar beverages and foods is associated with evidence of increased inflammation and oxidative stress. Few studies have assessed the effects of long-term sugar consumption on inflammatory and oxidative stress markers.

Dietary Sugars and Obesity

Recent studies report a significant increase of energy intake with increased sugar-sweetened beverage consumption among children, adolescents, and adults; however, evidence is inconsistent regarding the positive association between sugar-sweetened beverage consumption and obesity. Because overweight and obesity are complex metabolic conditions, it is unlikely that a single food or food group is primarily causal. Many epidemiological studies, including those with cross-sectional and prospective study designs, have shown a positive relationship between higher intake of sweetened beverages and risk of overweight or obesity; however, other studies have shown evidence against this hypothesis.

Consumption of sugar-sweetened beverages ingested with meals has doubled. In a feeding experiment, increasing the size of sugar-sweetened beverages increased total energy intake from solid food. When the size of a regular cola was increased from 12 to 18 ounces, energy intake from food increased by 10% in women and by 26% in men. All things being equal, a small, persistent energy imbalance of 50 calories per day could result in up to a 5-pound weight gain over the course of 1 year.

Randomized clinical feeding trials have shown inconsistent results from testing the effects of sugar-sweetened beverages on weight gain. In a recently published intervention study to reduce sugar-sweetened beverage consumption among adolescents, there was no significant change in body mass index between intervention and control groups. However, in subgroup analysis, there was a net change in body mass index between intervention and control groups of −0.75 (0.34) kg/m² (P = 0.03) in adolescents who had a body mass index >25.6 kg/m² at baseline. Differences in study design, population studied, and study instruments and methods may have contributed to these inconsistent findings. Because added sugar was recently included as a nutrient or food compound in the US Department of Agriculture nutrient database, the number of studies examining added sugar as an exposure will most likely increase in the future.

A recent meta-analysis examined 88 cross-sectional and prospective studies exploring the relationship between soft drink intake and nutrition or health outcomes. Higher intake of soft drinks was associated with greater energy intake, higher body weight, lower intake of other nutrients, and worse health indices. Subsequent analyses from a large trial confirmed these findings, namely, greater weight loss as sugar-sweetened beverage intake decreased.
Both lean and obese adults responded similarly to beverage and solid food intake; the liquid form resulted in greater energy intake than the solid form of food. Subsequently, in observational analyses from an 18-month trial, a reduction in liquid calorie intake had a stronger effect on weight loss than a reduction in calories from solid food.72 Thus, an increase in calorie consumption from energy-containing beverages is associated with greater energy intake and may be contributing to the increase in overweight and obesity in the US population. Further research concerning these issues is needed.

### Energy Density

Short-term, laboratory-based studies repeatedly have documented that individuals consume fewer calories when presented with lower-energy-density foods than with similar higher-energy-density foods.92–98 Lower energy intakes have also been associated with lower-energy-density diets in cross-sectional studies.99–102 In a recent prospective analysis from a completed trial, reductions in energy density were associated with both weight loss and improved diet quality.103 In aggregate, these data support reductions in energy density as a means to lower energy intake and control weight. A reduction in added sugars is one means to achieve a reduction in energy density.

### Nutrient Adequacy

The effects of excess intake of sugars on nutrient adequacy are of concern. The association between added sugars and micronutrient intakes were examined with data from NHANES III. Although the trends were not consistent for all age groups, reduced intakes of calcium, vitamin A, iron, and zinc were observed with increasing intake of added sugars, particularly at intake levels that exceeded 25% of energy. Largely on the basis of these data, the Dietary Reference Intakes report on macronutrients suggests that no more than 25% of energy should be consumed as added sugars104, however, as discussed below, these recommendations were not consistently supported by subsequent literature. More importantly, the Dietary Reference Intakes approach to nutrient adequacy, based on the intake of selected individual nutrients, was subsequently superseded by an alternative construct, discretionary calories, which considers recommendations for all nutrients in the context of energy balance.

A subsequent review, published after the Dietary Reference Intakes report, concluded that there was some evidence that diets that contain a high proportion of added sugars are slightly lower in micronutrients than diets that contain a moderate proportion of added sugars.105 Another review found that studies examining the percentage of people who achieve the recommended daily allowance for micronutrients across categories of sugar intake often found nonlinear relationships, such that higher levels of intake were observed in the moderate categories of added sugar intake than in the low and high categories of intakes. These authors concluded that there was no clear evidence of micronutrient dilution or of a threshold at which a quantitative amount of added sugars intake could be set.106
The form in which added sugars are consumed appears to be an important modifier of the impact of dilution. Soft drinks, sugar, and sweets are more likely to have a negative impact on diet quality, whereas dairy foods, milk drinks, and presweetened cereals may have a positive impact. Of particular concern is the relationship of the intake of sugars with fiber intake. Intake of sugars is inversely associated with fiber intake; a majority of intervention studies testing the efficacy of the influence of fiber on weight regulation have shown increased fiber intake to be associated with decreasing energy intake, which translates into weight loss.

### Summary and Recommendations

Over the past 30 years, total calorie intake has increased by an average of 150 to 300 calories per day, and approximately 50% of this increase comes from liquid calories (primarily sugar-sweetened beverages). At the same time, there has been no apparent change in physical activity. Hence, it is likely that weight gain over the same period must be related in part to increased intake of added sugars, even though research tools thus far have been insufficient to confirm a direct link. This likely results both from the fact that obesity is a multifactorial condition and because it is extremely difficult to identify, much less quantify, the relative contributions of each factor in epidemiological studies. Given these considerations, it is prudent to advocate a multifaceted approach, one component of which is reducing energy intake from added sugars.

The AHA’s “Diet and Lifestyle Recommendations Revision 2006” recommended minimizing the intake of beverages and food with added sugars. The present statement expands on that recommendation by proposing a specific upper limit of intake for added sugars. A prudent upper limit of intake is half of the discretionary calorie allowance that can be accommodated within the appropriate energy intake level needed for a person to achieve or maintain a healthy weight based on the US Department of Agriculture food intake patterns (Table 3). In Table 3, discretionary calories are approximately equally divided between solid fats and added sugars. If a person chooses to consume alcohol as well, then intake of solid fats and added sugars should be further reduced to accommodate the additional calories from alcohol. Depending on the calorie level, recommendations for added sugars vary from 5 teaspoons per day (or 80 calories) for a daily energy expenditure of 1800 calories for an average adult.

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**Table 5. Calorie Allowances for Discretionary and Added Sugars Based on a Variety of Age, Sex, and Physical Activity Levels**

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
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<tbody>
<tr>
<td>21–25</td>
<td>3000</td>
<td>46–50</td>
<td>5100</td>
<td>51–55</td>
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<tr>
<td>Physical activity level*</td>
<td>Active</td>
<td>Sedentary</td>
<td>Moderately active</td>
<td>Sedentary</td>
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<tr>
<td>Energy needs, kcal†</td>
<td>2200</td>
<td>1800</td>
<td>2200</td>
<td>1600</td>
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<tr>
<td>Discretionary calories, kcal‡</td>
<td>512</td>
<td>290</td>
<td>195</td>
<td>132</td>
</tr>
<tr>
<td>Added sugars, teaspoons§</td>
<td>18</td>
<td>9</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Added sugars, kcal</td>
<td>288</td>
<td>144</td>
<td>80</td>
<td>48</td>
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* Sedentary indicates a lifestyle that includes only the physical activity of independent living; moderately active, a lifestyle that includes physical activity equivalent to walking approximately 1.5 to 3 miles per day at 3 to 4 miles per hour, in addition to the activities of independent living; and active, a lifestyle that includes physical activity equivalent to walking >3 miles per day at 3 to 4 miles per hour, in addition to the activities of independent living.
† Energy needs to maintain current weight; this will not promote weight loss in overweight/obese people.
‡ Recommended limit for discretionary calories per the 2005 US Dietary Guidelines.
§ Recommended limit for added sugars per the 2005 US Dietary Guidelines.

Data derived from US Department of Agriculture\textsuperscript{10,11} and Britten et al.\textsuperscript{12}
woman and 9 teaspoons per day (or 144 calories) for a daily energy expenditure of 2200 calories for an average adult man. For reference, one 12-ounce can of cola contains \( \approx 8 \) teaspoons of added sugar, for \( \approx 130 \) calories.\(^{114} \)

In conclusion, to achieve and maintain healthy weights and decrease cardiovascular risk while at the same time meeting essential nutrient needs, the AHA encourages people to consume an overall healthy diet that is consistent with the AHA’s 2006 diet and lifestyle recommendations.\(^2 \) Most American women should eat or drink no more than 100 calories per day from added sugars, and most American men should eat or drink no more than 150 calories per day from added sugars.

**Acknowledgment**

The authors thank Bethany Yon, MS, for her assistance with the preparation of this statement.

**Disclosures**

**Writing Group Disclosures**

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<th>Writing Group Member</th>
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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be “significant” if (1) the person receives $10 000 or more during any 12-month period, or 5% or more of the person’s gross income; or (2) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be “modest” if it is less than “significant” under the preceding definition.

*Modest.  †Significant.

**Reviewer Disclosures**

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Dietary Sugars Intake and Cardiovascular Health: A Scientific Statement From the American Heart Association

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on behalf of the American Heart Association Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism and the Council on Epidemiology and Prevention

Circulation. 2009;120:1011-1020; originally published online August 24, 2009;
doi: 10.1161/CIRCULATIONAHA.109.192627

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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