High Fructose Corn Syrup
PRACTICE ISSUE EVIDENCE SUMMARY

Best Practice Issue (state as a question, PICO):

Does regular consumption of foods containing high fructose corn syrup result in increased fatty deposits in the liver and/or contribute to obesity?

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Purpose: (goals, scope, intended users, settings, and patient/client groups)

Goal: To increase awareness of the health risks associated with consumption of foods and beverages containing high fructose corn syrup

Scope: Health risks that may be associated with high consumption of high fructose corn syrup, amounts of high fructose corn syrup in the diet that result in increased health risks, common foods and beverages that contian high fructose corn syrup and how to identify foods containing high fructose corn syrup on food labels.

Intended users: Health Care Professionals

Settings: Primary Care, Ambulatory Care

Patient/Client Group: All

Definitions:
BMI: Body Mass Index
HDL cholesterol: High density lipoprotein, otherwise known as 'good cholesterol'
HFCS: High fructose corn syrup
SSB: Sugar sweetened beverages - all beverages sweetened with sugar, including soft drinks and fruit juices
UK: United Kingdom
US: United States

Recommendations:

1. Consumption of HFCS has the potential to negatively impact energy consumption, body weight and the risk for developing metabolic syndrome.
2. Consumption of SSB should not be encouraged for any individual in response to thirst.
3. For individuals who do consume SSB, the American Heart Association guidelines of consuming less than one 12 oz serving per day (100 and 150 calories or less for women and men, respectively) should be encouraged.
4. Although no specific limit has been established in the literature, clients should be encouraged to limit their intake of HFCS through consumption of packaged foods.
5. To identify the presence of HFCS in packaged foods, awareness should be created among clients that the inclusion of 'glucose/fructose' on the nutrition label indicates the potential of the product containing HFCS.
6. Education surrounding the negative impact of consuming HFCS through SSB and packaged foods should begin with parents of infants/toddlers to establish favourable drinking and healthy eating behaviours in children.

Evidence Review: (Please list type and grade of evidence reviewed)

High fructose corn syrup (HFCS) is commonly found in soft drinks and juice beverages, as well as many pre-packaged foods such as breakfast cereals and baked goods. Historically, sucrose (table sugar) was primarily added to processed foods and beverages as the sweetening agent. In recent years, the use of HFCS has significantly increased in popularity due to its sweetness, ability to enhance flavour and shelf life, and its low cost (Hanover and White, 1993). High fructose corn syrup made by enzymatic isomerization of glucose to fructose was introduced as HFCS-42 (42% fructose and HFCS-55 (55% fructose) in 1967 and 1977, respectively, and opened a new frontier for the sweetener and soft drink industries. Using a glucose isomerise, the starch in corn can be efficiently converted to glucose and then to various amounts of fructose. The hydrolysis of sucrose produces a 50:50 molar mixture of fructose and glucose. The development of these inexpensive, sweet corn-based syrups made it profitable to replace sucrose (sugar) and simple sugars with HFCS in our diet (Bray, Neilson & Popkin, 2004). Over the past three decades, HFCS has largely replaced sucrose as the major sweetener used in sugar sweetened beverages (SSB) (Nielson and Popkin, 2004). The consumption of SSBs and rates of obesity have shown a parallel rise; both tripling in this time period (Tappy and Le, 2010). Since the 1970s, HFCS use has gone from representing 1% to more than 40% of caloric sweeteners available for consumption in food and beverages (Ferder, Ferder & Inserra, 2010). In the United States during 2005-2006, children consumed approximately 172 calories per day and adults 175 calories daily (per capita) from SSB (Brownell et al., 2009). Vos, Kimmons, Gillespie, Welsh & Blanck (2008) used data from the third National Health and Examination Survey (NHANES III) to estimate the mean daily consumption of fructose in 21 483 American children and adults at 54.7 grams, accounting for 10.2% of total calorie intake. This analysis saw the highest consumption among adolescents (12-18 years), whose daily intake was 72.8 grams, equating to 12.1% of total calories, while a quarter of the adolescent population consumed more than 15% of calories from fructose. The largest sources of fructose in the diet among all study participants was from SSB (30%), followed closely by grain products, including processed foods such as cakes, pies, snacks, plus breads and cereals (22%) and fruit or fruit juice (19%) (Vos et al., 2008).

Weight Gain:

Dubois, Farmer, Girard & Peterson (2007) followed over 2000 Canadian children two and a half years of age for three years and found those who consumed SSBs between meals had more than double the risk of being overweight compared to non-consumers. Mrdjenovic and Levitsky (2003) reviewed 14 prospective cohort studies that examined the relationship between soft drink consumption and the risk of overweight in children and adolescents. Seven studies showed a significant positive relationship. The remaining studies did not, possibly due to the limitations of younger children having a lower mean soft drink intake, shorter follow-up periods, and small sample sizes. Johnson, Mander, Jones, Emmett & Jebb (2007) could not determine an association between SSB and weight gain when following five year old UK children for four years, possibly due to too low intake levels within this population, but Tappy and Le's (2010) review identified eight studies with children and adolescents (Bandini et al., 1999; Berkey, Rockett, Field, Gillman, & Colditz, 2004; Giammattei, Blix, Marshak, Wollitzer & Pettitt 2003; Liebman et al., 2003; Ludwig, Peterson & Gortmaker, 2001; Schulze et al., 2004, Troiano et al., 2000; and Welsh et al., 2005) showing a positive association between sugar-containing drink consumption and body weight, but also 4 studies (Blum, Jacobsen & Donnelly, 2005; Forshee and Storey, 2003; Kvaavik, Andersen & Klepp, 2005; and Rodriguez-Artalejo et al., 2003) that did not. Tappy and Le admit that several factors influence SSB consumption, and that these findings should be interpreted with caution.

Intervention studies have shown more consistent findings. A school-based intervention program in England aimed at discouraging carbonated beverage intake among seven to 11 year olds demonstrated a decreased consumption of these products and a significant decrease in the prevalence of overweight and obesity in the intervention group over one year, when compared to the control group (James et al., 2004). However, these effects were not sustained two years after the intervention was completed. In a separate study (Ebbeling, 2006), the delivery of calorie free beverages to participant homes for 25 weeks reduced the SSBs intake by 82% and resulted in weight changes in adolescents with BMI of >25.6. Future follow-up data was unknown. An intervention study trial completed by Muckelbauer et al. (2009) promoted water consumption while indirectly addressing SSB intake in 3000 elementary students. A reduced risk for overweight was identified after a one year study period. No significant change in BMI and no weight loss effect were observed which the authors contributed to the fact that children whose body weight was close to the cut off point for overweight experienced the greatest benefit.

Outcomes of cross-sectional studies reviewed by Bray (2010) depended on how body weight was expressed. Of studies focusing on the association between soft drink intake and BMI, two studies reported a significant positive relationship while nine did not. The Growing Up Today study consisted of more than 10 000 US children and adolescents and showed that consumption of SSB in girls was associated with a 0.06 unit increase in BMI per serving. This finding is also consistent with the NHANES study showing greater total energy with consumption of SSB (Hu and Mailk, 2010). Bray's review (2010) revealed that two studies showed a positive association between consumption and body fat percentage, while one failed to show the same result. Four additional studies reviewed by Bray (2010) showed that the risk for overweight or obesity was positively associated with soft drink consumption.
Studies in the adult population provide clear data for the relationship between SSB intake and weight gain. Hu and Malik (2010) reviewed large cohort adult studies with greater than two year study duration. The first study consisted of 50 000 women followed over two different four-year periods. Results indicated that participants whose SSB consumption increased during the first time period, and consumption of more than one serving SSB daily continued during the second time period, gained an average of 8.0 kg over the eight year study duration. This was in comparison to a 2.8 kg weight gain observed over the same time period by those who decreased SSB intake over the first period and maintained less than one serving SSB per day over the second four year period. A second study including 40 000 women over a six year follow-up period replicated these results. Findings indicated that those who increased their SSB intake from less than one serving weekly to more than one serving daily, gained the most weight (6.8 kg) compared to those who decreased their intake (4.1 kg gain). Both studies adjusted for potential cofounders by other diet and lifestyle factors. The PREMIER trial showed that decreasing the intake of SSB by one serving per day resulted in a weight loss of 0.5 kg over six months (Hu and Mailk, 2010).

Energy Compensation and Weight Gain:
Multiple review articles concluded that SSB consumption leads to weight gain for various reasons. Firstly, the consumption of these beverages results in a decreased satiety level. Unlike glucose, fructose does not provide satiety signals which may increase food intake. Glucose provides satiety signals to the brain that fructose is not able to provide as it is transported directly into the brain since they rely on different transporters (Ferder, Ferder, & Inserra, 2010). Secondly, fructose does not stimulate the production of insulin and leptin and decreases in these hormones may have negative effects on long term regulation of energy intake (Ferder et al., 2010). Thirdly, an increase in energy intake after consumption of SSB without a corresponding decrease in calories at subsequent meals can lead to weight gain (Libuda and Kersting, 2009 and Bray, 2010). A study reviewed by Hu and Malik (2010) showed people failed to compensate for additional calories when consuming liquid calories compared to calories consumed from solid foods. Two groups were instructed to consume either 450 calories per day from soft drinks or the same amount of sucrose from jelly beans. Those consuming jelly beans reduced their caloric consumption by more than the amount of calories contained in the jelly beans. This is in comparison to those drinking soft drinks who did not reduce their caloric intake and slightly increased consumption of other foods.

Long term, this may lead to energy imbalance and weight gain. A 12 oz serving of SSB contains 140-150 calories, which could lead to a 15 pound weight increase over one year if appropriate compensatory energy reduction is not taken into consideration (Hu and Kersting, 2010). The HFCS in beverages may not suppress the intake of solid foods to allow for maintenance of energy balance. However, review articles caution that SSB consumed with a meal or too close to meal consumption may lead to a more accurate energy intake adjustment compared to those SSB consumed as a snack. Younger children have been shown to be better able to compensate for SSB energy than older children (Brown, Dulloo, & Montani, 2008; Hu and Malik, 2010; Libuda and Kersting, 2009).

Adiposity and Metabolic Syndrome:
Fructose, found in equal parts in sucrose and high fructose corn syrup is readily absorbed and rapidly metabolized in the liver. The metabolism of fructose differs from that of glucose. Unlike glucose, fructose

bypasses an important rate-limiting step in glycolysis. When fructose is consumed in high amounts, substrate production for triglyceride synthesis is initiated. Exposure of the liver to high amounts of fructose leads to enhanced rate of lipogenesis and triglyceride synthesis contributing to dyslipidemia and accumulation of visceral adiposity. These metabolic changes can in turn result in reduced insulin sensitivity and insulin resistance (Bray, 2010; Libuda and Kersting, 2009; Brown et al., 2008). A 10 week study comparing fructose SSB to glucose SSB consumption showed similar weight gain between the two beverage groups but the fructose group showed a significant increase in visceral adiposity. Another study compared glucose, fructose, sucrose and HFCS in rat models and showed that while a comparable energy intake was seen, a faster weight gain was observed with HFCS consumption (Hu and Kersting, 2010). Reviews by Bray (2010) and Tappy and Le (2010) state that free fructose consumption found in HFCS rather than bound fructose in sucrose is the major factor contributing to obesity. However, no direct evidence exists for more serious metabolic consequences of HFCS in comparison to sucrose. The question remains whether soft drinks with HFCS are more adipogenic than soft drinks made with sucrose and whether the prevalence of obesity would be lower if HFCS had not vastly replaced sucrose in SSB. (Brown et al., 2008; Libuda and Kersting, 2009).

Recent data in the adult population suggests that there is a link between SSB consumption and the development of metabolic syndrome, hypertension and coronary heart disease. The evidence is suggestive of a relationship between metabolic syndrome and SSB consumption, however few studies have assessed the specific relationship. Hu and Malik (2010) reviewed a study of 6000 adults who consumed one or more soft drinks over four years and showed a 39% greater risk of developing metabolic syndrome. In a review by Brown et al. (2008) consumption of more than one soft drink per day among middle aged women resulted in a 48% prevalence of metabolic syndrome compared to those who consumed less than one drink per day.
It has been observed that acute fructose administration increased blood pressure over a 10 week period when participants consumed SSB compared to aspartame sweetened beverages. Glucose did not have this same effect (Bray, 2010). In a sample size of 6000 participants, the risk of developing hypertension has been found to range between 22-44% with greater than or equal to one soft drink daily to four plus soft drinks daily, respectively. A study with a smaller sample size of 4000 participants found a small effect of SSB consumption (Hu and Malik, 2010). These participants exhibited a 28% greater risk of developing hypertriglyceridemia and low HDL cholesterol after daily consumption of one or more SSB. Over a 24-year time period, 88 000 female study participants who consumed two or more SSB daily had a 35% greater risk of coronary heart disease than non-consumers after unhealthy lifestyle factors were taken into consideration (Hu and Malik, 2010).

How to identify High Fructose Corn Syrup on Ingredient Lists

In Canada, the ingredient ‘high fructose corn syrup’ is not listed as such on the ingredient lists of food packages. Instead, the term ‘glucose/fructose’ is used to identify the presence of this food ingredient in food and beverages. The Canadian Food Inspection Agency states that “glucose syrups and isomerized glucose syrups, singly or in combination, where the fructose fraction *does not exceed* 60 percent of the sweetener on a dry basis” is referred to as glucose/fructose. “Glucose syrups and isomerized glucose syrups, singly or in combination, where the fructose fraction *exceeds* 60 percent of the sweetener on a dry basis” is referred to as fructose syrup. Ingredients and their components (ingredients of ingredients) must be declared by their common names in the ingredient list on food labels. Therefore, if glucose/fructose syrup is used in a product, it must be declared as such (Canadian Food Inspection Agency).

Recently, the American Heart Association has come out with recommendations regarding a caloric upper limit for calories from added sugars. The Association states calories from added sugars (which includes those from SSB) be half of the discretionary calorie allowance, meaning no more than 100 calories per day for women and no more than 150 calories per day for men (Ferder et al., 2010). No specific guidelines have been established for children and youth, or for an acceptable limit of HFCS from packaged foods.

Practice Changes:

Dietitians will use this information to inform their clients and other heath care professionals as appropriate.

Anticipated Impact:

None

Recommendation for implementation:

These guidelines are to be used as reference when educating clients and other health care professionals on HFCS.

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These recommendations are being reviewed by:

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