Relationship between Sugar Intake and Obesity among School-Age Children in Kaohsiung, Taiwan

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(Received February 23, 2016)

Summary In recent years, the prevalence and problem of overweight and obesity in Taiwanese children have increased. There are many reports that the excessive intake of sugar increases the risk of lifestyle-related disease. However, sugar intake in Taiwanese children is not known. In this study, we investigated sugar intake from sugar-sweetened beverages, snacks and desserts among school-age children in Kaohsiung, Taiwan. We also tried to determine the relationship between sugar intake and body mass index (BMI). We contacted all the public elementary schools (10 schools) in a district, Kaohsiung, and obtained permission from 3 schools. The survey subjects were 410 (210 boys, 200 girls) school-age children (7, 10 and 12 y old). A nutrition survey was conducted using 3 non-consecutive days of the 24 h dietary recall method for sugar-sweetened beverages, snacks and desserts. Height and weight were measured. Sugar intakes were not significantly different among the different genders or ages (p>0.05) and average intake of all was 51.6 g/d. Percentages of each sugar in total intake were sucrose 60%, glucose 18%, fructose 16%, and lactose 6%. The intake of glucose and fructose may have come from isomerized sugar. Contributions of sugar-sweetened beverages and snacks (desserts) were 83.5% and 16.5%, respectively. Among the sugar-sweetened beverages the top 3 sources were tea (22%), milk tea (19%) and milk beverages (18%). A relationship between sugar intake and BMI was not observed. In conclusion, sugar intake of the children was higher than the WHO recommendation due to the high intake from beverages; however, sugar was not the cause of the high obesity rate.

Key Words sugar intake, beverage, snacks, BMI, Taiwanese children

Sugars are easily absorbed and is an important source of energy. Many desserts provide few nutrients other than saccharide, but sugars are tasty and pleasurable and can easily satisfy the desire for food and also easily induce people to consume more, especially children (1). There are many reports that the excessive intake of sugar increases the risk of lifestyle-related disease, such as obesity and type 2 diabetes (2, 3). The intake of sugar has also been found to have some connection with dental caries (4–6).

There are reports about sugar intake among children and adolescents from various countries: United States boys consumed an average of 362 kcals (90.5 g/d) from sugars compared with 282 kcals (70.5 g/d) for girls (7). United Kingdom 84 g/d (8), Holland 135 g/d (9), Philippines 59 g/d (6), Cambodia 28 g/d (10), Vietnam 27 g/d (11) and Japan 25 g/d (1). However, sugar intake for Taiwanese children was not known.

In the United Kingdom and the United States, the rise in sugar intake correlates with the rise in obesity rates observed in these countries (12). The consumption of sugar-sweetened beverages also has been suggested as a contributory factor to the rising levels of childhood obesity in many countries worldwide. The rising prevalence of obesity in children in the United States has been reported to be linked in part to the intake of sugar-sweetened drinks (2, 12). In a prospective study of 548 children (average age 11.7 y), sugar-sweetened drink consumption was independently associated with both body mass index (BMI) (p=0.03) and frequency of obesity (p=0.02) after adjustment for anthropometric, demographic, dietary and lifestyle variables (2). Dubois et al. found that in about 2,000 preschool-aged children followed for 3 y, regular sugar-sweetened beverage consumption between meals had 2.4-fold greater odds of causing overweight compared with non-consumption (p<0.05) (13).

In recent years, the prevalence and problem of overweight and obesity in Taiwanese children have increased. According to the results of the Student Health Examination from the Ministry of Education, Taiwan, in 2013, 30.4% (boys 34.2% and girls 26.2%) of school-age children are overweight or obese, judging by BMI (14). The definition of overweight and obesity changed according to the sex and the age of the children. Overweight and obesity were defined as BMI ≥85th and ≥95th percentile, respectively (15). When the data are compared to
that of the World Obesity Federation (2013), the prevalence of overweight or obesity among Taiwanese boys is the highest in Asia (16). As it is, the problem of overweight and obesity is getting more serious in Taiwan. To our knowledge, there has been no report as to whether sugar intake is related to overweight and obesity among school-age children in Taiwan or not. Therefore, in this study, we tried to estimate the sugar intake and also tried to determine the relationship between sugar intake and BMI.

The two main categories of sugars are monosaccharides and disaccharides; they include glucose, fructose and sucrose, lactose and maltose. Isomerized sugar is generally called high-fructose corn syrup (HFCS), because it is made from corn starch that has been processed by glucose isomerase to convert some of its glucose into fructose. HFCS is a fructose-glucose liquid sweetener alternative to sucrose first introduced to the food and beverage industry in the 1970s (17). Isomerized sugar use is increasing worldwide because it is sweeter and cheaper than regular sugar and highly soluble, which makes it easy to use in cold beverages, candy, and frozen snacks.

New Guideline of World Health Organization (WHO): Sugars intake for adults and children recommends reduced intake of free sugars throughout one’s life course (18). In both adults and children, the intake of free sugars should be reduced to less than 10% of total energy intake (roughly 50 g). A further reduction to below 5% of total energy intake (roughly 25 g) would provide additional health benefits. A 330 mL can of soft drink contains about 40 g of sugar. It’s easy to exceed those limits.

In recent years, sugar composition tables in Taiwanese have been constructed by Tseng et al. and published in the Journal of the Taiwan Dietetic Association (19). It is a database for monosaccharides and disaccharides in 145 representative beverages, snacks and desserts, and 49 homemade snacks. In the present study, sucrose, glucose, fructose and lactose intakes from sugar-sweetened beverages, snacks and desserts were calculated mainly by using the sugar composition tables.

The objective of this study was to investigate sugar intake from sugar-sweetened beverages, snacks and desserts among school-age children in Kaohsiung, Taiwan. We also tried to determine the relationship between sugar intake and BMI.

**METHODS**

**Study area and subjects.** Sample size was estimated by the following equation. We used mean and standard deviation (SD) reported in a previous study in Japan (1).  

\[ n > \frac{\sigma^2(\mu \times E)}{\sigma^2} = \frac{[35/(50 \times 0.05)]^2}{\pm 200} \]

Where \( n \) = sample size, \( \sigma \) = SD, \( \mu \) = mean value, \( E \) = maximum allowable error.

In this study, we understood that random sampling would be the best; however, at present in Taiwan, it is a very difficult task because of serious considerations about privacy, disturbance of education time and others. In light of such a background we selected public schools where usually children are from average families. For selecting schools, we contacted all the public elementary schools (10 schools) in a district, Kaohsiung, and obtained permission from 3 schools. We enrolled students of 7, 10 and 12 y old for comparison with the data reported from Japan (1, 10), Cambodia (10) and Vietnam (11). We obtained informed consent from about 60% of the students. The survey object of this study was conducted in about 441 school-age children (7, 10 and 12 y old) from the three public elementary schools who agreed to participate in the physique measurement (height and weight) and dietary survey. Thirty-one children were excluded due to a dietary survey of less than 2 d or unknown height or weight. Finally, the available data were for 410 (210 boys, 200 girls).

**Survey.** This survey was conducted from March to June of 2015. A cross-sectional nutrition survey was conducted using 3 non-consecutive days (2 weekdays and 1 weekend day) of 24 h dietary recall survey only for sugar-sweetened beverages, snacks and desserts. The physical measurements (height and weight) of subjects were obtained by trained interviewers, and the data were taken before and after the dietary survey. The questionnaire and instructions were provided to the subjects by trained interviewers before the survey, and they used the portion size of beverages and photos of snacks (desserts) to explain how to complete the questionnaire: the explanations were standardized and the comprehension of the subjects was ensured. The names of the sugar-sweetened beverages and snacks (desserts), their content and volume were recorded. After subjects finished the questionnaire, interviewers would check the content of questionnaire one-on-one with the subjects to complete anything that was missing or not clear in the questionnaire in order to enhance accuracy.

**Estimation of sugar intakes.** Sucrose, glucose, fructose and lactose intakes from sugar-sweetened beverages, snacks and desserts were calculated by using the sugar composition tables which have been constructed by Tseng et al. and published in the Journal of the Taiwan Dietetic Association (19).

**Assessment of weight status.** Weight (to the nearest 0.1 kg) and height (to the nearest 0.1 cm) of subjects were measured before and after the dietary survey by trained interviewers, using standard protocols with shoes removed. BMI was calculated as the subjects’ weight in kilograms divided by the square of their height in meters (kg/m²). Weight status was determined according to actual weight status as defined by new growth charts for Taiwanese children and adolescents based on WHO standards and health-related fitness records in Taiwan cut-offs (15). We defined underweight, normal weight, overweight and obese subjects by gender and the age-normalized BMI <5th, 5th–85th, ≥85th and ≥95th percentile, respectively.

**Ethical consideration.** This study was conducted with the approval of the Human Research Ethics Committee at the National Cheng Kung University (NCKU HREC), and in accordance with the “Declaration of Helsinki—Ethical Principles for Medical Research Involving Human
Table 1. Body Characteristics of school-age children by age and gender.

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Gender</th>
<th>n</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>boy</td>
<td>65</td>
<td>124.4±5.0a</td>
<td>25.6±5.2a</td>
<td>16.5±2.6a</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>52</td>
<td>122.9±5.0a</td>
<td>24.6±5.4a</td>
<td>16.2±2.9a</td>
</tr>
<tr>
<td>10</td>
<td>boy</td>
<td>70</td>
<td>140.9±6.4b</td>
<td>38.1±10.9b</td>
<td>19.0±4.3bc</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>81</td>
<td>141.4±7.6b</td>
<td>36.2±9.4b</td>
<td>17.9±3.4ab</td>
</tr>
<tr>
<td>12</td>
<td>boy</td>
<td>75</td>
<td>154.2±8.4c</td>
<td>48.9±12.4c</td>
<td>20.4±3.9c</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>67</td>
<td>153.2±6.9c</td>
<td>47.2±11.9c</td>
<td>19.9±4.1c</td>
</tr>
</tbody>
</table>

Values are mean±SD.

Values in the same column with different superscript letters are significantly different as analyzed by one-way ANOVA and then Tukey’s multiple comparison test (p<0.05).

Table 2. Weight status of school-age children by age and gender.

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Gender</th>
<th>Underweight &lt;5th</th>
<th>Normal 5th–85th</th>
<th>Overweight &gt;85th</th>
<th>Obese &gt;95th</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>boy</td>
<td>9.2</td>
<td>66.2</td>
<td>15.4</td>
<td>9.2</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>9.6</td>
<td>71.2</td>
<td>5.8</td>
<td>13.5</td>
</tr>
<tr>
<td>10</td>
<td>boy</td>
<td>10.0</td>
<td>61.4</td>
<td>14.3</td>
<td>14.3</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>8.6</td>
<td>69.1</td>
<td>9.9</td>
<td>12.3</td>
</tr>
<tr>
<td>12</td>
<td>boy</td>
<td>4.0</td>
<td>54.7</td>
<td>20.0</td>
<td>21.3</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>9.0</td>
<td>59.7</td>
<td>11.9</td>
<td>19.4</td>
</tr>
</tbody>
</table>

All children 8.3 63.4 13.2 15.1

Values are %.

Weight status according to actual weight status as defined by new growth charts for Taiwanese children and adolescents based on World Health Organization standards and health-related physical fitness records in Taiwan cut-offs.

Table 3. Sugar intake of school-age children from sugar-sweetened beverages, snacks and desserts (g/d).

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Gender</th>
<th>n</th>
<th>Glucose (A)</th>
<th>Fructose (B)</th>
<th>Sucrose (C)</th>
<th>Lactose (D)</th>
<th>Total sugar (A+B+C+D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>boy</td>
<td>65</td>
<td>8.2±7.3a</td>
<td>7.3±7.1a</td>
<td>27.4±21.3a</td>
<td>4.4±4.2ab</td>
<td>46.6±32.2a</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>52</td>
<td>10.0±7.9a</td>
<td>8.7±6.9a</td>
<td>27.4±14.1a</td>
<td>5.3±4.1a</td>
<td>51.7±26.6a</td>
</tr>
<tr>
<td>10</td>
<td>boy</td>
<td>70</td>
<td>11.1±11.4a</td>
<td>9.5±8.7a</td>
<td>29.3±18.5a</td>
<td>2.9±2.5b</td>
<td>50.8±31.0a</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>81</td>
<td>7.8±7.3a</td>
<td>7.2±6.6a</td>
<td>28.2±16.2a</td>
<td>3.8±3.1ab</td>
<td>46.6±26.9a</td>
</tr>
<tr>
<td>12</td>
<td>boy</td>
<td>75</td>
<td>9.6±10.2a</td>
<td>8.5±10.7a</td>
<td>40.6±28.4b</td>
<td>3.4±3.0b</td>
<td>60.4±38.6a</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td>67</td>
<td>9.8±9.6a</td>
<td>7.5±7.4a</td>
<td>33.5±22.9ab</td>
<td>4.2±4.5ab</td>
<td>53.4±36.6a</td>
</tr>
</tbody>
</table>

Mean 410 9.4±9.2 8.1±8.1 31.3±21.4 3.9±3.6 51.6±32.8

Values are mean±SD.

Values in the same column with different superscript letters are significantly different as analyzed by one-way ANOVA and then Tukey’s multiple comparison test (p<0.05).

Subjects” with special attention paid to the following: To prevent the identification of individuals, each subject’s personal information was carefully coded and obtained data were strictly managed. We obtained informed consent that the participation in the research was by free will from the participants and their guardians by providing explanations about the objectives and details of the survey and the intention to use the results for oral and written presentations. Even after commencement, subjects were free to drop out, either of their own volition or at the guardian’s behest and no subjects were penalized in any way.

Statistical analysis. Data were assessed by one-way ANOVA and Tukey’s multiple comparison test. The level of significance was set at p<0.05. Regression analysis was used to find a relationship between sugar intake and BMI. Data were arranged by Microsoft Excel 2010 and statistical analyses were carried out using SPSS version 18.0 for Windows.

RESULTS

A total of 410 school-age children (7 y, 10 y, and 12 y old), 210 boys and 200 girls, were included in this study. Table 1 shows the height, weight and BMI of the subjects in this study. We took the average of the data which were taken before and after the survey because they were similar.

Table 2 shows the weight status of school-age children by age and gender. Prevalence of overweight and obesity for all the children in this study was 28.3% (13.2% and 15.1%, respectively). It means that 1 in 3 subjects was overweight or obese in this study. Cut-off points for the weight status were established according to new growth charts for Taiwanese children and adolescents based on WHO standards and health-related physical fitness records in Taiwan.

Table 3 shows sugar intake. Sugar intake was not significantly different among the different genders or ages (p<0.05). The mean intake of sugar from sugar-sweetened beverages, snacks and desserts for all the children was 51.6 g/d, and the intake of glucose, fructose, sucrose and lactose were 9.4 g/d, 8.1 g/d, 31.3 g/d and 3.9 g/d, respectively.

Figure 1 show the percentages of each sugar to total intakes were sucrose 60%, glucose 18%, fructose 16% and lactose 6%. The results showed that mean intake of glucose and fructose was similar, and possibly came from isomerized sugar (also called HFCS), because of the...
ratio of glucose to fructose in isomerized sugar is nearly 1:1 and isomerized sugar is the main source of both glucose and fructose. Isomerized sugar has become very common in beverages, because it is cheap and soluble.

Figure 2 shows the contributions of various food groups to total sugar intake. Contributions of sugar-sweetened beverages and snacks (desserts) were 83.5% and 16.5%, respectively. Sugar-sweetened beverages included tea (22%), milk tea (19%), milk beverages (18%), juice (7%), soda (6%), sports drinks (0.5%) and other (11%), and snacks and desserts included bread (4%), cake (3%), ice cream (2%), cookies (1%), chocolate (1%), candy (0.5%) and other (5%).

Figure 3 shows the relationship between sugar intake and BMI for 7-, 10-, and 12-y old school-age children. With regression analysis we could not find a relationship between sugar intake and obesity in any group.

Figure 4 shows the sugar intake by body weight of all 410 school-age children. In children who were underweight, normal, overweight and obese, the sugar intake was 45.9±23.5 g/d, 51.9±33.7 g/d, 51.1±38.5 g/d and 54.1±28.0 g/d, respectively. There was no statistically significant difference between the groups.

**DISCUSSION**

We found in this study that the main intake of sugar by school-age children (7 y, 10 y, and 12 y) from sugar-sweetened beverages, snacks and desserts was 51.6±32.8 g/d, and more than the WHO recommendation (less than 10% of energy intake for children) (18). Prevalence of overweight and obesity was 28.3% in 7 y, 10 y, and 12 y-old children. However, we could not observe any relationship between sugar intake and BMI.

In the present study, children (410 subjects; 210 boys and 200 girls) were from average families. The results showed that 13.2% were overweight, and 15.1% were obese, a total of about 28%. We defined overweight and obese subjects as having sex- and age-normalized BMI ≥85th and ≥95th percentile, respectively. The results of the present study were similar to the data of the Student Health Examination from the Ministry of Education, Taiwan in 2013; 30.4% of school-age children were overweight or obese (14). These facts support the contention that the subjects in this study were representative of children in Taiwan.

We did not observe any relationship between sugar intake and BMI. The sugar intake from meals was not estimated, because the survey was conducted only for sugar-sweetened beverages, snacks and desserts in the present study. On the other hand, the mean sugar (sucrose) intake from meals was 4.2 g/d; this has been reported by the 2001–2002 Nutrition and Health Survey in Taiwanese Elementary School Children (2001–2002 NAHSIT) which was conducted using one day’s 24-h dietary recall survey and the subjects of which were 2,405 school-age children (1,290 boys, 1,115 girls) between 6 and 12 y old. The sum of sugar intake was estimated as 55.8 g/d from our results and those of NAHSIT 2001–2002 (20).

According to NAHSIT 2001–2002, the total energy intake of boys and girls in these age groups was about 2,000 kcal (21). The WHO recommendation for sugar is less than 10% of energy intake, which is about 200 kcal for the subjects. This is the equivalent of 50 g of sugar (18). The average sugar intake of our subjects was 51.6 g, suggesting that half of the subjects took more than the WHO recommendation of 10% energy from sugar.

About one-third of school-age children were overweight or obese in Taiwan and in our subjects. However, we did not know whether the problem is linked to the high intake of sugar and sugar-sweetened beverages. We could not observe a relationship between sugar intake and BMI among school-age children in the present study. In contrast, there are many studies suggesting that the intake of sugar, especially the intake of sugar-sweetened beverages, may promote weight gain and obesity (22–24). The systematic review by Te Morenga...
and colleagues (24) on the association between intake of dietary sugars and body weight in adults and children included 30 trials and 38 cohort studies. The review found that of 21 cohort studies (reported in 22 articles) of children, assessing the effect of increasing intake of sugar on body fat, 15 reported a positive association between increased sugar intake and a measure of obesity. The results indicate that for the relationship to intake of sugar-sweetened beverages after a 1-y follow-up in prospective studies, the odds ratio for being overweight or obese increased 1.55 (95% confidence interval 1.32 to 1.82) among the highest intake
children compared with the lowest intake children. As a result, although we understand that overweight and obesity are linked to a high intake of sugar-sweetened beverages, we could not clearly understand the quantity of sugar intake involved. Most studies showed only how many servings or how many times the children drank sugar-sweetened beverages per day. Only one of these reported the intake of total sugar and intake of beverage sugar. The sugar intake of normal children was 84.6±16.1 g/d and that of overweight children was 97.1±19.4 g/d. From these results together with data from our present study (51.6±32.8 g/d) and from Japanese (24.7±15.5 g/d) (1), we suggested the cut-off values of sugar intake for the prediction of overweight were about 90 g/d. The mean sugar intake added by 1SD (32.8 g) could cover 85% of the population. The reason why there was not a relationship between sugar intake and overweight in our study was perhaps that the sugar intake was 51.6±32.8 g/d, which was less than 90 g.

On the other hand, the WHO recommendations (18) were based on the relationship among free sugar intake, body weight and dental caries. It is notable that the recommendation to limit free sugar intake to less than 10% of total energy intake is based only on observational studies of dental caries. In addition, the recommendation to further limit free sugar intake to less than 5% of total energy intake is based on ecological studies in which a positive dose–response relationship between free sugar intake and dental caries was observed at a free sugar intake of less than 5% of total energy intake (18). Therefore, even the intake of sugar was above 10% of total energy intake in the present study, it was not the key contributor to the incidence of overweight and obesity for Taiwanese children.

Perhaps sugar intake above 10% was not the primary cause of obesity in Taiwanese children, but actually it has been found to have some connection with dental caries. The prevalence of dental caries was 87.7% among elementary school children in Taiwan from the 2001–2002 NAHSIT. By using logistic regression to adjust risk factors for dental caries such as sex, age, region, dental care and the use of fluoride it has been shown that there is a significant correlation between frequent intakes of ice cream (p=0.0307), candy and chocolate (p=0.0257) and the incidence of dental caries (20).

In conclusion, in the present study we did not observe any relationship between sugar intake and BMI. However, judging from the WHO recommendation that sugar intake should be less than 10% of total energy intake, and a further reduction to below 5% or roughly 25 g would provide additional health benefits (18), sugar intake of Taiwanese children is at the upper limit and it is now the important time to control the intake before high intake becomes habitual.

Acknowledgments

We thank the school authorities, parents and children of three public elementary schools in Kaohsiung, the hard-working survey team of Fooyin University and many other cooperators. We also thank Dr. Andrew Durkin, Professor Emeritus of Indiana University, for editing the English. This was partially supported by the US-Japan Medical Science Program.

REFERENCES


