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Effect of the AHA dietary counselling on added sugar intake among participants with metabolic syndrome

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Abstract

Background—High added sugar consumption has been associated with the development of metabolic syndrome (MetS). The American Heart Association (AHA) diet is designed to prevent and treat MetS, however, it remains unclear whether the AHA diet is effective on decreasing added sugar consumption. The aim of our study was to evaluate the effect of the AHA dietary counselling on added sugar consumption among participants with MetS.

Methods—The AHA dietary counselling was conducted among 119 participants with MetS from June 2009 to January 2014 ([ClinicalTrials.gov](https://clinicaltrials.gov):). Unannounced 24-hour recalls were collected at baseline, 3-, 6- and 12-months. Added sugar consumption patterns over time were examined using linear mixed models.

Results—After one-year dietary counselling, intake of added sugars decreased by 23.8 g/day (95% CI: 15.1, 32.4 g/day); intake of nonalcoholic beverages dropped from the leading contributor of added sugar intake to number 7 (from 11.9% to 4.4%); the Alternative Healthy Eating Index (AHEI) score increased by 5.4 (95% CI: 2.9, 8.0); however, added sugar intake for 48% participants still exceeded the recommendation. Added sugar intake per meal among different meal type was similar (24.2%–25.8%) at baseline. After the one-year dietary counselling,

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Statement of Authorship

YM, SP, and BO designed the research; LZ and YM conducted the analyses and wrote the draft of initial manuscript; All authors contributed to interpretation the data and preparation of manuscript.

Conflict of interest

None of the authors reported a conflict of interest related to the study.

breakfast became the major resource of added sugar intake (33.3%); the proportion of added sugar intake from snacks decreased from 25.8% (CI: 23.1, 28.5%) to 20.9% (CI: 19.6, 22.3%).

Conclusion—Although the consumption of added sugars in participants with MetS decreased after the one-year AHA dietary counselling, added sugar intake from majority of participants still exceed recommended limits. Actions of successful public health strategies focus on reducing added sugar intake are needed.

Keywords

Added sugar; Metabolic syndrome; AHA dietary counselling

Introduction

More than a third of U.S. adults suffer from a cluster of health problems—collectively classified as “metabolic syndrome (MetS)”, which increases the risk of developing chronic diseases, such as cardiovascular disease (CVD) and type 2 diabetes [1]. Nearly 35% of U.S. adults and 50% of those aged 60 y or older were estimated to have MetS in 2011–2012 [2]. MetS poses a significant risk of higher CVD morbidity and mortality [3]. The rising prevalence of MetS is a likely consequence of modern lifestyle and the overweight/obesity epidemic [4]. Many studies have demonstrated that high added sugar consumption is associated with development of MetS, sugar-sweetened beverages (SSB) and snacks are two important contributors [5]. Added sugar has been shown to raise blood glucose and insulin concentrations rapidly, which is associated with insulin resistance and MetS [6]. Therefore, changing dietary habits of individuals with MetS, by reducing their added sugar consumption, may help to alleviate MetS symptoms.

In the U.S., approximately 11.2% to 14.5% of total energy intake in adults and 13.1% to 14.5% in children are estimated to come from added sugars [7]. The Institute of Medicine reported that people whose diets are high in added sugars tend to have lower intakes of essential micronutrients such as Magnesium (Mg), vitamins A and E, as foods with high amounts of added sugar tend to have lower levels of these micronutrients [8]. Added sugars contain no essential nutrients, and if a reduction in energy intake is desirable, reducing added sugar consumption is an obvious place to start [9]. Recommendations for added sugar consumption vary substantially. The U.S. Departments of Agriculture (USDA) 2015–2020 Dietary Guidelines propose that no more than 10% of total energy intake should be from added sugars [10]. Although added sugar consumption in the U.S. decreased from 16.8% of total energy intake in 1999–2004 to 14.9% in 2005–2010, 71.4% of adults consumed 10% or more energy from added sugars [11]. The American Heart Association (AHA) dietary recommendations are designed to guide healthy diet and lifestyle behaviors of cardiometabolic patients, to prevent and treat MetS [12]. The 2009 AHA dietary recommends that American men and women limit added sugars to less than 150 and 100 calories per day, respectively [13]. Our previous research evaluating the AHA dietary counselling showed that it can assist in weight loss among individuals with MetS [14]; however, it remains unclear that whether dietary counseling based on the AHA dietary guidelines is effective in decreasing added sugar consumption.

In this analysis, we investigated the effect of the AHA dietary counselling in reducing added sugar intake among individuals with MetS. We hypothesized that the AHA dietary counselling would decrease added sugar consumption. We also explored changes in added sugar in different meal types.

Methods

Participants and study design

Data for this investigation came from the “Can Do” study. Detailed study methodology is described elsewhere [15]. Briefly, the “Can Do” is a randomized controlled clinical trial of individuals with MetS recruited by the University of Massachusetts Medical School (UMMS) in May 2009, and completed in February 2013 (Clinical trial registration: [NCT00911885](#)). One hundred and nineteen subjects participated in a one-year AHA dietary counselling was used for this investigation. The study protocol was approved by the Institutional Review Board (IRB) at UMMS.

Participants enrolled in the study met the following conditions: 1) satisfied the diagnostic criteria for MetS [16]; 2) 21–70 y old; 3) body mass index 30–40 kg/m² and interested in losing weight; 4) non-smoker; 5) accessible by telephone; 6) able to speak, read, and write English and to provide informed consent; and 7) approved by his/her primary care physician to participate.

Exclusion criteria included: 1) clinically diagnosed diabetes, or fasting blood sugar ≥ 120 mg/dL; 2) acute coronary event within the last 6 months; 3) elevated depression or suicidal ideation; 4) pregnant or lactating; 5) a woman with polycystic ovary syndrome; 6) eating disorder diagnosis; 7) currently participating in a weight loss program; 8) planned to move out of the area within the one-year study period; 9) had bariatric surgery; or 10) was following a low-carbohydrate, high fat dietary regimen.

AHA dietary counselling

Participants were instructed to follow the AHA 2006 dietary guidelines [17], which included: 1) consume vegetables and fruits; 2) eat whole-grain, high-fiber foods (≥ 30 g/day); 3) eat fish twice weekly; 4) consume lean animal and vegetable protein foods; 5) reduce sugary beverages; 6) minimize sugar intake; 7) minimize sodium intake; 8) no alcohol intake; 9) obtain 50–55% of energy intake from carbohydrate; 10) obtain 15–20% energy intake from protein; 11) obtain 30–35% energy intake from fat; 12) limit saturated fat to $<7\%$ of energy, trans fat to $<1\%$ of energy, and 13) limit cholesterol to <300 mg/day. Each participant attended 2 individual sessions and 12 group sessions during the one-year counselling period [14]. Mean attendance was 7.9 sessions (SD=3.9) out of 14 sessions. Dietary counselling was delivered by a registered dietitian with a master degree in nutrition. The study’s Data Safety and Monitoring Board reviewed each adverse event and adverse events were reported to the UMMS IRB. No changes to the counselling protocols were required. Treatment fidelity was monitored by provider and auditor checklists. All sessions were audio-recorded, with a random selection of 10% of the sessions reviewed by an auditor.

Outcome measures

The Nutritional Data System for Research (NDS-R, 2010–2012, Minneapolis, MN) was used to assess participants' dietary intake. Three unannounced 24-hour dietary recalls were collected at baseline, 6- and 12-months, and one 24-hour recall 3-months after enrollment. The nutrient content of foods, including total energy, carbohydrates, proteins, total sugars, added sugars, and other nutrients, was determined by NDS-R, using food-composition data adapted from the USDA National Nutrient Database for Standard Reference [18]. Dietary quality was measured by the Alternative Healthy Eating Index (AHEI), an instrument designed to evaluate nine criteria of a healthy cardiovascular diet [19]. All individual component scores were summed for a total AHEI score ranging from 2.5 (worst) to 87.5 (best). The AHEI score was calculated the same as in our previous publications [14].

Statistical analyses

All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, North Carolina). Values were presented as means [95% confidence interval (CI)] for continuous variables. Linear mixed models were used to evaluate effect of AHA dietary counselling on change in added sugars, adjusted for gender, age, education levels, income and working status. For analyses of change in added sugar intake and other selected dietary nutrient intake, time-point was entered as a fixed effect, participant ID as a random effect. For analyses of meal location, independent variables included time-point, meal type, gender, meal location and the interaction of time-point and meal type. Meal time (weekday versus weekend) was also assessed, with independent variables including time-point, meal type, gender, meal time and the interaction of time-point, meal type and meal time. Additionally, analyses for added sugar (% of energy) were performed after adjusting for total energy intake.

Results

One hundred and nineteen subjects were included in the present investigation. The average age was 52.5 years old (95% CI: 50.7, 54.3 y) and 71% were women, average body weight was 99.6 kg (CI, 97.1, 102.1 kg). Added sugar intake stratified by demographic characteristics is presented in Table 1. At baseline, added sugar consumption was significantly higher among subjects who were younger than 40 y, unemployed, and whose household income was less than \$30,000 per year ($p=0.013$; $p=0.004$; $p<0.001$, respectively), but all of these differences were attenuated after the one-year AHA dietary counselling ($p>0.05$). A significant difference was observed between females [56.6 g/d, (95% CI: 42.1, 71.1 g/day)] and males [34.7 g/d, (95% CI: 25.9, 43.3 g/day)] ($p=0.012$) after the one-year counselling. Compared with baseline, added sugar intake was consistently reduced after the one-year dietary counselling ($p<0.001$) in all comparisons between baseline and the one year. Table 1 also presented added sugar intake as % of total energy, it showed that the 20–40 age group and the group of household income less than \$30,000 still consumed the higher added sugar (both $p=0.013$). These differences were attenuated after the one-year counselling ($p>0.05$).

At baseline, mean total sugar intake was 98.8 g/day (CI: 90.5, 107 g/day), mean added sugar intake was 62.9 g/day (CI: 56.4, 69.5 g/day), average energy intake was 1958 kcal/day (CI:

1845, 2070 kcal/day) and added sugar intake as % of total energy was 11.9% (CI: 10.8, 13.0%) (Table 2). For more details, see Table 2. According to the 2015 USDA recommendations, 40.3% of participants met the standard of added sugar consumption at baseline, and 52.2% met it after the one-year counselling (data not shown). At 3 months, mean change in added sugar intake was -21.3 g/day (CI: -28.1 , -14.5 g/day), this decrease was maintained at 6 months (-22.7 g/day, [CI: -29.7 , -15.8 g/day]) and 12 months (-22.3 g/day, [CI: -29.5 , -15.1 g/day]). Average change in added sugar intake as % of energy was: -2.0% (CI: -3.4 , -0.7%) at 3 months, -2.2% (CI: -3.5 , -0.9%) at 6 months and -1.8% (CI: -3.2 , -0.4%) at 12 months. Mean change in total energy was -466 kcal/day (CI: -578 , -353 kcal/day) at 12 months. AHEI scores increased by 6.0 (CI: 3.6, 8.4) at 6 months and by 5.4 (CI: 2.9, 8.0) at 12 months. Mean change in weight was -2.0 kg (CI: -2.8 , 1.1 kg) at 3 months, -2.8 kg (CI: -3.6 , -1.9 kg) at 6 months and -2.7 kg (CI: 0.5, 4.5 kg) at 12 months. AHEI scores increased by 6.0 (CI: 3.6, 8.4) at 6 months and by 5.4 (CI: 2.9, 8.0) at 12 months. Mean change in weight was -2.0 kg (CI: -2.8 , 1.1 kg) at 3 months, -2.8 kg (CI: -3.6 , -1.9 kg) at 6 months and -2.7 kg (CI: 0.5, 4.5 kg) at 12 months. Table 2 also presents the changes of several selected micronutrient intake, absolute intake including thiamin, Ca, Fe, Zn, niacin and riboflavin decreased significantly during the one-year period, while vitamin B₁₂, vitamin B₆ and Mg showed no significant differences at each follow up time point ($p>0.05$). Folate intake decreased by 49.2 µg/day (CI: 5.5, 92.9 µg/day) at 6 months, which was attenuated at 12 months ($p>0.05$). When self-reported energy intake was considered, energy-adjusted intake including vitamin B₆, Ca, Mg, niacin and folate increased significantly during the one-year period ($p<0.05$); while energy-adjusted intake including Fe, Zn and riboflavin increased significantly at 3 months ($p<0.01$), but was attenuated at 12 months ($p>0.05$).

At baseline, the biggest contributors of added sugars were nonalcoholic beverages (11.9%), followed by sugar, syrup, preserves and jelly (10.3%) (Table 3). After the one-year counselling, the contribution of added sugar from nonalcoholic beverages decreased to 4.4%; sugar, syrup, preserves and jelly (8.1%) was the largest contributor of added sugars; however, several food sources of added sugars, such as fruit juices, increased from 5% to 7.6%, ready-to eat cereals increased from 4.6% to 6.7%, and yogurt increased from 2.7% to 6.2% (Table 3).

Table 4 shows added sugar consumption by meal type, location, and meal time. For meals consumed at home, added sugar intake from snacks decreased significantly after the one-year counselling (from 15.1 g/meal [CI: 12.7, 17.5 g/meal] to 8.6 g/meal [CI: 6.0, 11.3 g/meal]). Added sugar consumption decreased in weekend snacks (from 18.2 g/meal [CI: 15.1, 21.3 g/meal] to 9.5 g/meal [CI: 5.8, 13.3 g/meal]), and in weekday snacks (from 12.4 g/meal [CI: 10.0, 14.8 g/meal] to 8.3 g/meal [CI: 5.6, 10.9 g/meal]). Although a small percentage of participants ate at restaurants/fast food chains, added sugar intake was higher at these places per meal (20.5 g/meal [CI: 14.0, 27.0 g/meal]) relative to meals at home (13.0 g/meal [CI: 9.0, 17.0 g/meal]) ($p<0.05$).

We further analyzed the mean proportions of total added sugar intake from different meal types within a day (Fig. 1). At baseline, the proportion of added sugar intake was similar among different meal types [from 24.2% (at lunch) to 25.8% (from snack)]. After the one-

year counselling, 33.3% of added sugar intake was consumed from breakfast, followed by 26.4% intake from dinner. Compared to baseline, added sugar intake from snack decreased by 5.7 g/day (CI: 3.2, 8.2 g/day) ($p<0.001$), from lunch decreased by 5.0 g/day (CI: 1.2, 8.8 g/day) ($p<0.05$) (data not shown).

Discussion

At one-year after the AHA dietary counselling, we found that added sugar consumption was moderately decreased from baseline, dietary quality score was significantly improved; however, added sugar intake for 48% participants still exceeded the dietary recommendation at one-year. The reasons would be twofold: dietary adherence is always a challenge for participants and is well-documented [20]; it might be some other factors beyond the consumer self-control patterns, such as food labeling, government and food manufacturing also affect the added sugar intake. Therefore, more effective counselling interventions directed toward added sugars should be developed.

Although the total energy intake was measured in our study, self-report-based estimates of energy intake offer inaccurate basis for scientific conclusions [21, 22]; therefore, both absolute and % of total energy intake of selected parameters were presented in this study. The decrease in added sugar consumption over the study period was observed across all age, gender, education level, income and currently working groups. Whether or not the total energy intake was considered, added sugar consumption appeared to be the higher among the lowest household income group, which is consistent with prior observations that diets higher in added sugars were associated with lower cost [7]. Prior observations found that added sugar decreased linearly with age [23]. Our results also indicated that participants in the younger age group consumed more energy from added sugars than in older age groups at baseline. Encouragingly, this difference was attenuated after the one-year counselling, which indicated that it was easier for young people to change their dietary habits than old people. As people age, they not only undergo physiological changes, but they also bring with them food behaviors that have evolved from the social, cultural, economic, and environmental history of their lifetime experiences [24].

Many studies have reported a relationship between added sugar overconsumption and low vital nutrient consumption in daily diet [25, 26]. In 2015, a systematic review indicated that in energy-adjusted analyses, micronutrient intake including thiamin, riboflavin, niacin, folate, Ca, Fe, Zn, and vitamins A, B₆, and B₁₂, were negatively associated with added sugar intake [27]. In the present study, the contribution of each micronutrient was taken into consideration. The absolute intake of several selected micronutrient decreased over the one-year intervention might be the result of reduced total energy intake since daily micronutrient density (*per 1000 kcal*) including vitamin B₆, Ca, Zn, niacin and folate increased significantly. In our study, added sugars from all sources accounted for approximate 11.9% of total energy intake on average at baseline, which was lower than the 14.1% observed in prior research [7]. At baseline, participants consumed most added sugars from snacks. During the counselling, they were encouraged to choose fruit, vegetables, nuts and beans as snacks, which contributed to the proportions of added sugar intake from snacks decreasing by more than 5% among a daily meal types. Moreover, AHEI score increased significantly

after the one-year counselling. These findings provide evidence that the AHA dietary counselling is an effective strategy in reducing added sugar consumption by optimizing dietary structure among individuals with MetS.

In addition, mean weight loss was 2.7 kg during the one-year period, which was not consistent with the decrease of 466 kcal/day self-reported energy. One reason might be that the physical activity among the participants was slightly decreased during the intervention (mean duration of total physical activity: 217 min/week at baseline versus 193 min/week at one-year); the other reason was that there might be some other “replacement” of added sugar. Therefore, we further investigated primary food sources of added sugars. In our study, nonalcoholic beverages dropped from the leading contributor of added sugar intake to number 7 after the one-year counselling; however, added sugar intake from fruit juices, cereal and yogurt increased among all primary food sources of added sugars, which indicated that participants consumed more discretionary foods that contained high added sugar in parallel with the decreasing intake of nonalcoholic beverages intake [28]. This finding also suggests that it is imperative to assess beverage consumption in the context of overall dietary behavior rather than in isolation.

The dietary counselling did not appear to reduce added sugar intake during restaurant eating. Various factors, such as longer dining time, socializing, and palatable foods with greater variety may contribute to excess energy and added sugar intake when eating in restaurants [29]. The USDA 2015 Dietary Guidelines recommend that when eating in restaurants, one should eat half portions or less of most meals, skip appetizers and desserts, ask not to receive the bread or chips, order low or no calorie beverages, and order vegetables instead of rice, potatoes or pasta as a side dish [30]. To achieve meaningful added sugar reductions and to help consumers improve their diet choices, public health strategies targeted toward the nutrition environment coupled with self-monitoring of diet weight should be encouraged [30].

Our study has several important strengths. First, we reported added sugar consumption and assessed the effect of the commonly utilized and respected AHA dietary counselling among MetS participants. Long-term management of MetS including a healthy dietary pattern plays an important role in improving quality-of-life outcomes [31]. Second, information from three 24-hour dietary recalls offers precise detail on individual dietary intake [32]. Third, detailed demographic variables were considered in assessing the effectiveness of the one-year AHA dietary counselling.

Our study also has several limitations. First, it was based on 24-hour dietary recalls, which is subject to recall bias. A more objective measure such as urinary sucrose and fructose in a 24-hour urine sample may be a promising biomarker for sugars intake should be considered in the subsequent study. Second, intake of added sugars in food was calculated rather than measured, which may have resulted in under- or overestimation. Third, we have adjusted for all known covariates, but it is possible that some residual confounding covariates may remain especially in a secondary analysis. Fourth, although the potential influence of energy density was taken into account when calculating the micronutrient intake, the results may not be accurate because self-report-based estimates of energy intake offer inaccurate basis

for scientific conclusions [21, 22]. Fifth, there was no control group in our study, which limited the interpretation of the results. Finally, the AHA dietary counselling has emphasized the goal of added sugar intake is less than 150 and 100 calories per day, but few people met this threshold, indicating that a more effective counselling that focuses on added sugar should be considered in future studies.

In conclusion, at one-year after the AHA dietary counselling, the consumption of added sugars decreased among participants with MetS. The biggest decrease was in the consumption of nonalcoholic beverages and snacks, which may reflect some success of consumers' behavior to limit sugar-sweetened beverage and sweet snacks. Continued high consumption of added sugars highlights the need to identify and build on successful public health strategies to further reduce added sugar intake, any single recommendation may have gotten insufficient attention.

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Figure 1.
Proportions of added sugar intake by meal types

Table 1
Added sugar intake (g and % of energy) at baseline and one-year by participants' characteristics

Variable	Added sugar intake (g/day)				Added sugar intake as % of total energy			
	Baseline		One year		Baseline		One year	
	n(%)	Mean (95% CIs)	n(%)	Mean (95% CIs)	Mean (95% CIs)	Mean (95% CIs)	Mean (95% CIs)	P for time-points ²
Gender								
Female	85(71)	71.1 (59.3, 84.8)	68(74)	56.6 (42.1, 71.1)	12.5 (11.2, 13.7)	9.7 (8.4, 11.1)		0.223
Male	34(29)	59.3 (51.2, 67.4)	24(26)	34.7 (25.9, 43.4)	10.6 (8.6, 12.5)	11.7 (9.4, 13.9)		
<i>P</i> value		0.097		0.012	0.106	0.140		
Age group								
20–40 y	12(10)	102.4 (80.8, 123.9)	7(8)	38.6 (12.9, 64.4)	15.3 (12.0, 18.6)	11.0 (6.8, 15.1)		0.005
41–60 y	35(29)	63.8 (51.2, 76.4)	26(28)	42.7 (28.9, 56.6)	12.2 (10.3, 14.2)	10.9 (8.7, 13.0)		
51–60 y	46(39)	59.6 (48.6, 70.6)	38(41)	40.5 (28.9, 52.2)	11.8 (10.2, 13.5)	10.1 (8.3, 11.9)		
61–70 y	26(22)	49.5 (34.9, 64.1)	21(23)	34.9 (19.2, 50.5)	10.2 (7.9, 12.4)	9.2 (6.8, 11.7)		
<i>P</i> value		0.013		0.804	0.013	0.475		
Education								
High school diploma or less	13(11)	62.5 (41.2, 83.8)	12(13)	52.5 (30.7, 74.3)	10.4 (7.2, 13.6)	11.5 (8.2, 14.8)		0.096
Bachelor's degree or less	71(60)	63.6 (54.5, 72.7)	49(54)	37.6 (27.3, 47.9)	12.0 (10.7, 13.4)	9.9 (8.4, 11.5)		
Graduate/professional	34(29)	61.4 (48.2, 74.5)	30(33)	38.5 (24.8, 52.2)	12.4 (10.4, 14.4)	9.8 (7.7, 11.8)		
<i>P</i> value		0.931		0.284	0.298	0.384		
Household income								
\$0-\$30,000	12(10)	97.8 (76.4, 119.2)	8(9)	51.0 (26.4, 75.6)	14.4 (11.1, 17.7)	11.1 (7.2, 14.9)		0.004
\$30,001-\$50,000	19(16)	60.8 (43.8, 77.8)	15(16)	33.6 (15.2, 52.0)	12.7 (10.1, 15.3)	9.7 (6.8, 12.6)		
\$50,001-\$75,000	20(17)	71.9 (55.3, 88.4)	17(18)	43.4 (25.9, 60.9)	14.6 (12.0, 17.1)	11.8 (9.1, 14.5)		
More than \$75,001	43(36)	60.1 (48.8, 71.4)	34(37)	40.8 (28.6, 53.0)	11.2 (9.5, 12.9)	9.7 (7.8, 11.6)		
Unclear	25(21)	45.6 (30.8, 60.4)	18(20)	38.1 (21.5, 54.7)	9.3 (7.1, 11.6)	9.9 (7.3, 12.5)		
<i>P</i> value		<0.001		0.392	0.013	0.609		
Currently working								
Employed full-time or part-time	93(79)	43.0 (28.0, 57.9)	72(79)	30.9 (14.4, 47.3)	12.5 (11.3, 13.4)	10.2 (8.9, 11.5)		0.091
Others [†]	25(21)	68.2 (60.4, 75.9)	19(21)	42.2 (34.0, 50.9)	9.9 (7.7, 12.2)	9.7 (7.1, 12.2)		

Variable	Added sugar intake (g/day)				Added sugar intake as % of total energy			
	Baseline		One year		Baseline		One year	
	n(%)	Mean (95% CIs)	n(%)	Mean (95% CIs)	Mean (95% CIs)	Mean (95% CIs)	Mean (95% CIs)	P for time-points ²
		0.004		0.217	0.051		0.715	

Note. Values are presented as t means (95% CI). One gram of added sugars=3.87 calories.

[†]Other includes work as a volunteer, homemaker, disabled, retired, unemployed and student.

¹P values compared the differences between groups at the same time-point and were determined from LSMEANS of PROC MIXED model in SAS.

²P values for time-points were compared at baseline and 1-year and determined from mixed models fitting item, time-points and interaction between them.

Differences between at baseline and one-year, among different groups at the same time-point were compared using LSMEANS of PROC MIXED model in SAS.

Changes in added sugar intake and other selected nutrients during the one-year dietary counselling

Table 2

Selected Parameters	Baseline	Change from baseline		
		3 month	6 month	12 month
Daily dietary intake				
Sugar intake, g	98.8 (90.5, 107.0)	-25.2 (-33.4, -17.0)***	-23.8 (-32.2, -15.4)***	-23.8 (-32.4, -15.1)***
Added sugar intake, g	62.9 (56.4, 69.5)	-21.3 (-28.1, -14.5)***	-22.7 (-29.7, -15.8)***	-22.3 (-29.5, -15.1)***
Added sugar, %	11.9 (10.8, 13.0)	-2.0 (-3.4, -0.7)**	-2.2 (-3.5, -0.9)**	-1.8 (-3.2, -0.4)*
Sodium intake, mg	3063.1 (2864.5, 3261.6)	-709.8 (-921.0, -498.6)	-598.5 (-814.6, -382.4)	-644.9 (-867.1, -422.7)
Total energy intake, kcal	1957.7 (1845.0, 2070.3)	-409.5 (-516.1, -303.0)***	-422.1 (-531.2, -313.0)***	-465.6 (-577.8, -353.4)***
Fat, g	74.8 (69.5, 80.0)	-18.8 (-24.3, -13.3)***	-18.1 (-23.7, -12.5)***	-20.8 (-26.6, -15.0)***
% calories from fat	33.1 (31.8, 34.4)	-2.0 (-3.5, 0.5)**	-1.2 (-2.8, 0.3)	2.0 (-3.6, -0.4)*
Protein, g	80.2 (75.6, 84.8)	-5.3 (-10.7, 0.1)	-9.7 (-15.2, -4.2)**	-10.6 (-16.3, -5.0)**
% calories from protein	17.1 (16.2, 18.0)	3.1 (2.0, 4.2)***	2.1 (0.9, 3.3)**	2.1 (0.9, 3.3)**
Carbohydrate, g	236.6 (221.3, 252.0)	-48.9 (-63.2, -34.5)***	-50.5 (-65.2, -35.9)***	-52.7 (-67.8, -37.6)***
% calories from carbohydrate	47.2 (45.6, 48.9)	-0.7 (-2.5, 1.0)	-0.5 (-2.3, 1.3)	0.6 (-1.2, 2.5)
AHEI score	37.2 (35.1, 39.3)	3.0 (0.9, 5.7)**	6.0 (3.6, 8.4)***	5.4 (2.9, 8.0)***
Daily intake of selected micronutrient				
Vitamin B ₁₂ , µg	5.8 (4.3, 7.2)	-0.7 (-2.5, 1.1)	-0.7 (-2.5, 1.1)	-1.3 (-3.1, 0.6)
Vitamin B ₆ , mg	1.8 (1.7, 2.0)	0.1 (-0.1, 0.4)	-0.1 (-0.3, 0.1)	-0.1 (-0.3, 0.1)
Thiamin, mg	1.7 (1.6, 1.8)	-0.3 (-0.4, -0.2)***	-0.4 (-0.5, -0.3)***	0.4(-0.5, -0.3)***
Calcium, mg	918.6 (853.9, 983.3)	194.0 (-266.8, -121.2)***	-169.9 (-244.3, -95.4)***	-176.2 (-252.7, -99.7)***
Magnesium, mg	294.8 (274.3, 315.3)	8.8 (-11.8, 29.3)	-6.1 (-27.1, 14.9)	-12.5 (-34.2, 9.1)
Iron, mg	15.5 (14.2, 16.8)	-1.0 (-2.5, 0.5)	-2.4 (-3.9, 0.8)**	-3.2 (-4.8, -1.6)***
Zinc, mg	10.8 (9.9, 11.7)	-0.4 (-1.3, 0.7)	-1.1 (-2.3, 0.0)	-1.5 (-2.7, -0.3)*
Niacin, mg	23.8 (22.0, 25.5)	0.8 (-1.3, 2.8)	-2.7 (-4.8, -0.6)*	-3.3 (-5.5, -1.1)**
Folate, µg	419.6 (384.8, 454.4)	-5.5 (-48.2, 37.3)	-49.2 (-92.9, -5.5)*	-37.3 (-82.1, 7.6)
Riboflavin, mg	2.2 (2.1, 2.4)	-0.3 (-0.5, -0.2)***	-0.4 (-0.6, -0.2)***	-0.4 (-0.6, -0.3)***

Selected Parameters	Baseline	Change from baseline		
		3 month	6 month	12 month
Selected anthropometric measure				
Weight, kg	99.6 (97.1, 102.1)	-2.0 (-2.8, -1.1) ***	-2.8 (-3.6, -1.9) ***	-2.7 (-3.6, -1.9) ***

AHEI=Alternate Healthy Eating Index; HbA1c=hemoglobin A1c; Values are presented as mean 95% Confidence intervals (95% CI).
Change at each time point from baseline of added sugar intake and other selected nutrients were estimated by LSMEANS of PROC MIXED model in SAS.
Added sugars as a percentage of total calorie intake was computed as = (grams of added sugars*3.87/total energy intake)*100%.
, *P*value compared with baseline and one year* *p*<0.05, ** *p*<0.01, *** *p*<0.001.

Table 3
Comparison of primary food sources of added sugars from 20 contributors at baseline and one-year

Food	Baseline			One-year		
	% Added sugar	Cumulative % added sugar	Food	% Added sugar	Cumulative % added sugar	
Nonalcoholic beverages (includes soda)	11.9	11.9	Sugar, syrup, preserves and jelly	8.1	8.1	8.1
Sugar, syrup, preserves and jelly	10.3	22.2	Fruit juices and drinks	7.6	15.7	15.7
Cookies	7.0	29.2	Ready-to-eat cereals	6.7	22.4	22.4
Ice cream, ice milk, sherbet, nondairy frozen dessert and milkshakes	6.9	36.1	Ice cream, ice milk, sherbet, nondairy frozen dessert, and milkshakes	6.5	28.9	28.9
Chocolate candy	5.1	41.2	Yogurt	6.2	35.1	35.1
Sweet rolls, fruit breads, doughnuts, muffins and other related products	5.0	46.2	Cookies	4.9	40.0	40.0
Fruit juices and drinks	5.0	51.2	Nonalcoholic beverages (includes soda)	4.4	44.4	44.4
Ready-to-eat cereals	4.6	55.8	Breads, rolls, biscuits, and other related products (i.e. non-sweet breads)	4.0	48.4	48.4
Cakes	3.4	59.2	Diet, fruit and granola bars	4.0	52.4	52.4
Breads, rolls, biscuits, and other related products (i.e. non-sweet breads)	3.4	62.6	Sweet rolls, fruit breads, doughnuts, muffins, and other related products	3.9	56.3	56.3
Frozen treats	2.8	65.4	Cooked cereals, prepared and unprepared	3.1	59.4	59.4
Yogurt	2.7	68.1	Chocolate candy	2.8	62.2	62.2
Diet, fruit and granola bars	2.2	70.3	Meat, poultry, and fish recipes	2.6	64.8	64.8
Non-chocolate candy	2.2	72.5	Gravy and sauces	2.6	67.4	67.4
Meat, poultry, and fish recipes	2.0	74.5	Yogurt - frozen	2.6	70.0	70.0
Alcoholic beverages	1.9	76.4	Frozen treats	2.3	72.3	72.3
Polyunsaturated vegetable fat - creamers	1.8	78.2	Fruits, dried	2.2	74.5	74.5
Gravy and sauces	1.8	80.1	Milk-based meal replacement/supplement beverages	1.9	76.4	76.4
Tea	1.8	81.9	Polyunsaturated vegetable fat - creamers	1.9	78.3	78.3
Miscellaneous desserts	1.4	83.3	Cakes	1.7	80.0	80.0

Table 4

Added sugar intake by meal type, weekday and location at baseline and one year

Location	Breakfast		Lunch		Dinner		Snacks	
	Baseline	One-year	Baseline	One-year	Baseline	One-year	Baseline	One-year
At home								
Added sugar intake (g/day)	13.9 (10.3, 17.4) <i>n</i> =123	14.8 (11.5, 18.2) <i>n</i> =146	13.0 (9.0, 17.0) <i>n</i> =93	8.4 (4.4, 12.5) ² <i>n</i> =91	13.5 (10.6, 16.4) <i>n</i> =194	10.5 (7.4, 13.6) [#] <i>n</i> =176	15.1 (12.7, 17.5) <i>n</i> =346	8.6 (6.0, 11.3) ^{1,2} <i>n</i> =262
Added sugar (%)	15.5 (12.2, 18.8) <i>n</i> =30	16.3 (13.3, 19.4) <i>n</i> =24	8.3 (4.6, 12.0) <i>n</i> =55	7.4 (3.7, 11.1) <i>n</i> =64	6.7 (4.1, 9.4) <i>n</i> =7	6.9 (4.1, 9.7) <i>n</i> =10	20.5 (17.9, 22.4) <i>n</i> =131	19.4 (16.9, 21.8) <i>n</i> =109
Away from home								
Added sugar intake (g/day)	14.5 (7.7, 21.3) <i>n</i> =15	11.2 (3.6, 18.9) <i>n</i> =5	11.1 (6.0, 16.3) <i>n</i> =33	9.2 (4.4, 14.0) <i>n</i> =23	14.7 (0.85, 28.5) <i>n</i> =30	16.2 (4.6, 27.8) <i>n</i> =24	14.1 (10.5, 17.6) <i>n</i> =78	10.8 (6.8, 14.6) <i>n</i> =4
Added sugar (%)	14.9 (8.5, 21.2) <i>n</i> =15	14.4 (7.3, 21.5) <i>n</i> =5	8.3 (3.5, 13.0) <i>n</i> =33	6.4 (2.0, 10.8) <i>n</i> =23	10.7 (-2.1, 2.4) <i>n</i> =30	10.1 (-0.7, 21.0) <i>n</i> =24	4.2 (20.8, 27.6) <i>n</i> =78	9.1 (15.3, 22.9) <i>n</i> =4
Restaurant/fast food								
Added sugar intake (g/day)	14.2 (4.7, 23.7) <i>n</i> =102	5.4 (-10.9, 21.6) <i>n</i> =124	20.5 (14.0, 27.0) ⁴ <i>n</i> =115	10.7 (2.9, 18.5) <i>n</i> =123	19.2 (13.0, 25.3) <i>n</i> =148	16.3 (8.8, 23.8) <i>n</i> =144	16.0 (7.9, 24.1) <i>n</i> =332	8.2 (-9.9, 26.4) <i>n</i> =266
Added sugar (%)	9.1 (8.5, 21.2) <i>n</i> =102	7.6 (-7.7, 22.8) <i>n</i> =124	10.0 (4.0, 16.1) <i>n</i> =115	5.8 (-1.5, 13.0) <i>n</i> =123	8.9 (3.1, 14.6) <i>n</i> =148	8.8 (1.8, 15.8) <i>n</i> =144	21.5 (13.9, 29.0) <i>n</i> =332	4.1 ± 8.7 <i>n</i> =266
Weekdays								
Added sugar intake (g/day)	13.5 (9.7, 17.4) <i>n</i> =66	12.1 (8.6, 15.6) <i>n</i> =51	11.5 (7.9, 15.2) <i>n</i> =66	9.2 (5.6, 12.7) <i>n</i> =55	13.3 (10.1, 16.5) <i>n</i> =90	10.0 (6.7, 13.3) <i>n</i> =66	12.4 (10.0, 14.8) <i>n</i> =166	8.3 (5.6, 10.9) ¹ <i>n</i> =109
Added sugar (%)	15.0 (11.4, 18.5) <i>n</i> =66	15.1 (11.8, 18.4) <i>n</i> =51	9.1 (5.7, 12.4) <i>n</i> =66	7.4 (4.1, 10.6) <i>n</i> =55	7.2 (4.2, 10.2) <i>n</i> =90	6.8 (3.8, 9.8) <i>n</i> =66	21.7 (17.3, 23.2) <i>n</i> =166	17.9 (15.4, 20.4) <i>n</i> =109
Weekend days								
Added sugar intake (g/day)	13.9 (9.2, 18.5) <i>n</i> =66	17.0 (11.8, 22.2) <i>n</i> =51	16.7 (12.1, 21.3) <i>n</i> =66	7.0 (1.9, 12.0) ¹ <i>n</i> =55	15.2 (11.3, 19.2) <i>n</i> =90	13.0 (8.3, 17.6) <i>n</i> =66	18.2 (15.1, 21.3) ³ <i>n</i> =166	9.5 (5.8, 13.3) ¹ <i>n</i> =109
Added sugar (%)	14.4 (10.1, 18.8) <i>n</i> =66	16.7 (12.1, 21.8) <i>n</i> =51	7.6 (3.3, 11.8) <i>n</i> =66	5.1 (0.5, 9.9) <i>n</i> =55	7.2 (3.5, 10.9) <i>n</i> =90	7.8 (3.6, 12.2) <i>n</i> =66	20.3 (17.3, 23.2) <i>n</i> =166	21.7 (18.1, 25.3) <i>n</i> =109

All values are means (95% CI). Added sugar intakes per meal and added sugars as a percentage of total energy by meal were estimated by LSMEANS of PROC MIXED model in SAS. One gram of added sugars=3.87 calories.

n: The average number of times during the three 24HR given at the study point that participants ate the corresponding meal at the given location/day.

“At home”----meals were eaten at home; “Away from home”----meals were eaten at work, school, friend’s home, party, or reception; “Restaurant/fast food”----meals were eaten at a restaurant, cafeteria, fast food chains, take-out, or store.

¹ *P*<0.05 and *P* values compared differences between baseline and one year.

² *P*<0.05 and *P* values compared differences to breakfast at one year.

³ *P*<0.05 and *P* values compared differences to weekdays.

⁴ *P*<0.05 and *P* values compared differences between restaurant/fast food and eaten at home at the same time-point.