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The Fat-Sucrose Seesaw in Relation to Age and Dietary Variety of French Adults

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Abstract

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Guidelines for a healthy diet often recommend limiting dietary sugars and fats. Some researchers have called these aims mutually incompatible, suggesting that fat and sugar intakes, when expressed as percent dietary energy, are inversely linked. Others have argued that sugar, more specifically sucrose, acts as a vehicle for dietary fat and serves to suppress the overall quality of the diet. This study examined the relationship between age, sucrose and fat intakes, body mass index (BMI), and measures of dietary diversity and variety in a community-based sample of 837 French adults. Consistent with other studies, high consumption of added sucrose (in g/day or g/1000 kcal per day) was associated with higher consumption of energy and fat and lower consumption of vegetables and fruit. However, eating patterns were strongly influenced by age. High-sucrose consumers were significantly younger and had lower BMI values than did low-sucrose consumers, who were both older and had higher BMIs. High-sucrose diets had minimal effect on the diet diversity score and were associated with more varied diets, as evidenced by a higher dietary variety score.

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Introduction

The relationship between fat and sugar intakes and the degree of being overweight has been the focus of many clinical and epidemiological studies (5,7,12,17). Some investigators have reported an inverse relationship between added sugars and fats when the two were expressed as percent energy (7,12). This fat-sugar seesaw was reported for added or extrinsic sugars, that is, sucrose (12), as well as for total sugars (17), and held moreover, within and across populations. The reciprocal relationship between dietary sugar and fat was further said to be a causal one, such that any attempt to limit sucrose intakes would result in a corresponding increase in fat consumption (7,12). Accordingly, dietary guidelines to reduce the consumption of sugar as well as fat, still the most common strategy for weight control, were described by some investigators as being mutually incompatible (7).

The opposing view has been that added sucrose, far from limiting fat intake, serves as a vehicle for dietary fat by making fatty foods more palatable (5). In a study published in the United Kingdom (5), elevated consumption of added sucrose was associated with a higher consumption of fats in confectionery and sweets, lower consumption of fruit, and a static consumption of vegetables. Those researchers concluded that without sucrose in the diet, most of the fat would not have been eaten, and argued that increased sucrose consumption suppressed the overall quality of the diet. That study (5) sparked considerable controversy regarding the fat-sugar seesaw and the contribution of added sucrose to diet quality as well as the maintenance of bodyweight (6,10,18,24).

The proportion of sucrose in the diet changes with age. Most studies on the fat-sugar seesaw have not taken the age variable into account. Studies have either used overly broad age categories (17) or failed to stratify subjects by age altogether (5,7,12). Some studies cited in support of the fat-sugar seesaw were based on subjects aged 18 years to 85 years (13) or 19 years to 50 years (17), whereas the contrary report (5) was based on subjects aged from 25 years to 69 years, an extremely broad age range. Finer distinctions by age were not made, and fat and sugar consumption data across different age groups were not shown.

The consumption of added sugar, whether expressed in terms of total g/day or as percent daily energy, generally declines with age (3,8). In contrast, although the amount of fat consumed (in g/day) also declines with age, the percentage of fat energy remains approximately stable, at least as shown in U.S. data sets (19). Furthermore, younger people who consume substantially more energy, sugar, and fat than do older people generally have lower body mass index (BMI) values (20). Unless the data are stratified by age, it is quite possible to obtain significant inverse correlations between energy intakes and body mass, as reported by Hill and Prentice (12), or between sugar intakes and body mass, as reported by Gibney et al (7).

Some investigators (12) have argued that the inverse correlation between BMI and total energy intakes (19) is an artifact created by underreporting of food intake by subjects who are overweight. An alternative explanation is that the heavier subjects are also older and therefore eat less. To wit, NHANES II data (19,20) clearly show that 18-year-old to 24-year-old men had a median BMI of 23.0 and consumed a median of 2731 kcal/day. In contrast, men in the 55 to 64 age group had a median BMI of 25.8 and consumed a median of 1966 kcal/day. An inverse correlation exists between energy intakes and BMI that is modulated by activity levels. Although underreporting of intake may also play a role, the primary effect appears to be that of age.

Past studies on the fat-sugar seesaw have examined both U.S. and European data sets. Although the distinction between sucrose and total sugars was not always made clear, the U.S. sugars data base included total sugars from nutritive sweeteners such as sucrose, corn syrup, honey, and molasses (17). In contrast, the European data sets cited by previous researchers (7,12) typically referred to added or refined sugars, which consist chiefly of sucrose (5,6,10, 18,24).

Analyses of data from the U.S. 1977 to 1978 Nationwide Food Consumption Survey (17) showed that high consumers of added total sugars had a significantly lower percentage of dietary energy from fat than did moderate sugar consumers. Interestingly, it was noted that high-sugar consumers (g/kg) in the 19-year to 50-year age group tended to select more sweets and other sugar-rich foods but weighed significantly less than did moderate consumers (17). That observation is wholly consistent with the notion that high-sugar consumers were in fact younger and more active.

Another study, of 11,000 Scottish men and women, not stratified by age, showed a strong inverse relationship between intakes of added sucrose and the prevalence of obesity that was particularly marked for men (1). Other researchers (7,12) have also observed that high consumers of added sucrose tended to be thinner, thus contributing to the notion that sugar intake and obesity were inversely linked. Again, the issue of age was left unexplored.

Another argument touched on diet quality issues. In some studies, elevated energy intakes were associated with higher consumption of added sucrose and fat (in g/day) (18). Some researchers believe that this pattern simply reflects the fact that large and active people have higher energy needs and consume an energy-dense diet that includes a greater proportion of sucrose and fat (24). The counterargument (10) has been that people who eat more sucrose do not eat more of everything. Specifically, they tend to consume more foods containing fat and eat less complex carbohydrates, fiber, vegetables, and fruit (10). As a result, the quality of the diet is said to deteriorate as sucrose intakes rise (10), with potential consequences to overall health. However, diet quality, in relation to sucrose and fat intakes, was not actually measured in any of the studies cited.

This study addressed interrelationships between added sucrose and fat intakes, age, and BMI values in a large community-based sample of French adults. The study specifically examined the effect of age on the consumption of fat and added sucrose, expressed both in g/day and as a percentage of daily energy. The study also addressed the belief of many researchers that high-sucrose diets are automatically of poor quality (10) by using quantitative measures of dietary diversity and quality established in previous research (4). Finally, dietary intake assessments were based not on a single 24-hour food recall (19) or on a few days of self-administered diet records (17), but on an exhaustive diet history interview, widely regarded as the most reliable procedure in nutritional epidemiology (21).

Methods

Subjects were selected using a two-stage cluster-design sampling procedure. First, 12 of the 47 districts in the Val-de-Marne department (pop. 1,192,692) were selected by probability sampling, where the probability of selection was proportional to district size. In the second stage, 75 families per district were selected, again at random, from area telephone directories. The total response rate was 62%. The final sample was based on 361 men and 476 women, between 18 years old and 97 years old. Subject characteristics by sex, age, and selected demographic and socioeconomic variables are summarized in Table 1.

Dietary intakes were estimated using the interview-based dietary history method (21), adapted by the French National Institute for Science and Medical Research (INSERM) (2). The interviewer inquired about the type and the amount of foods habitually consumed at each meal or

Table 1. Characteristics of French subjects

Characteristic	All (n=837) n	All (n=837) %	Men (n=361) n	Men (n=361) %	Women (n=476) n	Women (n=476) %
Age (years)						
18 to 30	211	25.2	84	23.3	127	26.7
30 to 40	196	23.4	94	26.0	102	21.4
40 to 50	162	19.4	72	19.9	90	18.9
50 to 65	173	20.7	76	21.1	97	20.4
>65	95	11.4	35	9.7	60	12.6
Occupation						
Small business owners, craftsmen	24	2.9	16	4.4	8	1.7
Professional, technical workers	254	30.3	138	38.2	116	24.4
Clerical, sales, manual workers	404	48.3	181	50.1	223	46.8
Out of work force<60 years	133	15.9	26	7.2	107	22.5
Retired>60 years	22	2.6	0	0.0	22	4.6
Ethnic origin						
French	718	85.8	305	84.5	413	86.8
Immigrant	119	14.2	56	15.5	63	13.2
Tobacco use						
Nonsmokers	577	68.9	211	58.4	366	76.9
Smokers	260	31.1	150	41.6	110	23.1
Alcohol use						
Nondrinkers	384	45.9	163	45.2	221	46.4
Drinkers	453	54.1	198	54.8	255	53.6

snack and asked for the estimated frequency of consumption of each food for a period of up to 6 months. The estimated frequency of consumption and the average amount consumed at each eating occasion (in grams or in household measures) were thus obtained. Further questions addressed family grocery shopping patterns and seasonal adjustments in food intakes.

The foods consumed were grouped into 73 separate foods and food groups. The 73 food items were drawn from several categories, including meat and fish (10 items), milk and cheese (15 items), fats and oils (6 items), grains (10 items), fruits and vegetables (15 items), sweets and sugars (8 items), alcohol (5 items), and other beverages, including water and mineral water (4 items). Energy intakes, macronutrient content of the diet, and added sucrose consumption were estimated using modified nutrient composition tables developed by INSERM. The methodology and the principal results of the Val-de-Marne study, including a detailed description of sampling and interview techniques, have been published previously (4,11,25).

Composite measures of diet quality, the Dietary Diversity Score (DDS) and the Dietary Variety Score (DVS), have been described in previous research (4). The DDS counted the number of food groups in the habitual diet, awarding 1 point for foods in each of the five major food groups, dairy, meat, grain, fruit, and vegetable, for a maximum score of 5. In past studies conducted in the United States by the U.S. Department of Agriculture (16) and by other researchers (15), sugars and sweets, fats and oils, and alcohol were summarily dropped from all analyses and did not contribute to the overall measure of diet quality. In accordance with previously established procedures (16), foods consumed in less than minimum amounts per day (15 g to 30 g depending on food group) did not contribute to the total score. The DVS was defined as the number of different foods in all food categories (out of a possible total of 73) that were consumed on a habitual basis and so defined the individual's food repertoire (4).

Separate analyses of data for men and women showed similar trends, and the two groups were pooled. Statistical analyses of body mass and dietary intake data used SPSS for Windows (version 6.0) one-way analyses of variance with post hoc contrasts between means established using least significant difference tests. Correlation analyses were conducted to examine the relationship between age (years) BMI, and selected dietary variables. Stepwise multiple regression was used to test whether age was a predictor variable in determining sucrose consumption.

Results

Subjects were first divided into five nonoverlapping age groups. Mean BMI values and selected dietary intake data by age group are summarized in Table 2. Also shown are F ratios for one-way analyses of variance together with p values. The effects of age were highly significant. Consistent with most other epidemiological data sets including NHANES II (19), BMI values rose, whereas energy intakes declined, as a function of age. Fat and sucrose intakes, expressed in absolute terms (g/day), also declined with age, consistent with previous results (3,8,19). Sucrose intakes, expressed as percent energy, declined, as did the percentage of energy from fat. Correlations between age and intakes of energy, sucrose, and fat were all negative and significant at the $p<0.001$ level. Consistent with previous reports (18), there was a positive relationship between sucrose and fat intakes when expressed in absolute terms ($r=0.51$; $p<0.001$). In contrast, there was no evidence for a reciprocal relationship between fat and sucrose intakes when expressed as percent energy ($r=-0.01$; not significant [ns]).

The data showed further that consumption of confectionery and sweets, the major sources of sucrose in the French diet, declined sharply after the age of 30 years, whereas consumption of alcohol, on the contrary, increased. The consumption of fruit was static, but the consumption of vegetables increased with age. The last finding is wholly consistent with NHANES II data showing that vegetable consumption was highest among older people (22).

Sucrose is the principal added sugar in the French diet. The consumption of sucrose in France is considerably lower than that in many other European countries (7), accounting for no more than 6.5% of daily energy. Mean consumption of added sucrose was estimated at 41.8 g/day for men (range, 23 g to 230 g) and 30.3 g/day for women (range, 34 g to 277 g). In contrast, mean intake of nonlactose added sugars in the United States has been estimated at 53 g/day, accounting for 11% of daily energy (13). This includes both sucrose and fructose, the latter chiefly consumed in carbonated soft drinks (8).

Subjects were then divided by deciles of added sucrose consumption, corrected for energy and expressed as g/1000 kcal per day. These data are summarized in Table 3. For all variables listed, the main effect of sucrose consumption was significant at the $p<0.0001$ level. High sucrose consumption was associated with high consumption of energy (in kcal) and fat (in g), high consumption of confectionery and sweets, reduced consumption of vegetables, and unchanged consumption of fruit, exactly as described in previous reports (5,17). High consumers of added sucrose also tended to consume less alcohol than did low consumers. The proportion of fat in the diet, expressed as percent energy, was not affected by sucrose consumption ($p<0.07$; ns). This pattern of results was obtained whether or not sucrose con-

Table 2. Subject characteristics, daily energy and macronutrient intakes, and selected intake data by age groups

	Age group (years)						
Characteristic	**18 to 30 (n=205)**	**30 to 40 (n=196)**	**40 to 50 (n=162)**	**50 to 65 (n=173)**	**Over 65 (n=98)**	$F[4,836]$ =	p **Value**
Age (years)	24.0 ± 0.2	34.6 ± 0.2	44.0 ± 0.2	56.2 ± 0.3	74.0 ± 0.8	3090.0	<0.0001
BMI (kg/m^2)	21.5 ± 0.2	22.7 ± 0.2	24.0 ± 0.3	25.2 ± 0.3	24.5 ± 0.4	33.1	<0.0001
Energy (kcal)	2,238 ± 62	2,069 ± 50	1,963 ± 48	2,012 ± 53	1,750 ± 58	8.33	<0.0001
Sucrose (g)	55.6 ± 3	36.0 ± 2	26.2 ± 1.9	22.9 ± 1.6	26.6 ± 2.6	34.4	<0.0001
Fat (g)	92.4 ± 3	85.7 ± 2	81.6 ± 2.4	79.3 ± 2.4	69.0 ± 3.4	8.89	<0.0001
Sucrose (%)	9 ± 0	7 ± 0	5 ± 0	5 ± 0	6 ± 0	31.6	<0.0001
Fat (%)	37 ± 0	38 ± 0	38 ± 0	36 ± 1	35 ± 1	5.05	<0.0001
Alcohol (g)	2.8 ± 0.6	11.9 ± 1.5	14.5 ± 1.7	17.3 ± 2.3	11.2 ± 2.1	13.5	<0.0001
Confectionery (g)	168.5 ± 16	75.6 ± 7.6	46.9 ± 7.4	60.5 ± 7.9	55.3 ± 11.6	22.1	<0.0001
Cake (g)	55 ± 4	37.4 ± 2.9	26.1 ± 2.5	31.6 ± 3.0	35.4 ± 4.5	11.4	<0.0001
Fruit (g)	263 ± 17	244 ± 14	227 ± 12	288 ± 16	252 ± 14	2.31	ns
Vegetables (g)	315 ± 11	358 ± 11	377 ± 13	394 ± 14	401 ± 17	7.67	<0.0001
DDS	4.8 ± 0.0	4.8 ± 0.0	4.9 ± 0.0	4.9 ± 0.0	4.9 ± 0.0	1.54	ns
DVS	27.3 ± 0.3	28.2 ± 0.3	27.2 ± 0.4	26.7 ± 0.4	25.9 ± 0.4	4.41	<0.0001

Data are means ± SE.

Table 3. Subject characteristics, daily energy and macronutrient intakes, and selected intake data by deciles of added sucrose consumption (expressed in g/1000 kcal per day)

	Sucrose Deciles				
Characteristic	**1st (n=83)**	**2nd (n=84)**	**3rd (n=84)**	**4th (n=84)**	**5th (n=84)**
Age (y)	48.0 ± 1.5	48.7 ± 1.5	47.1 ± 1.5	45.9 ± 1.6	44.9 ± 1.8
BMI (kg/m^2)	25.3 ± 0.5	24.2 ± 0.4	23.9 ± 0.3	24.1 ± 0.4	24.2 ± 0.4
Energy (kcal)	1694 ± 87	1880 ± 68	2022 ± 70	2003 ± 65	2018 ± 87
Sucrose (g)	1.8 ± 0.2	7.6 ± 0.3	14.9 ± 0.6	20.5 ± 0.7	25.8 ± 1.2
Fat (g)	65.5 ± 3.0	74.6 ± 3.4	82 ± 3.4	84.7 ± 3.2	82.3 ± 4.3
Sucrose (% kcal)	0	2 ± 0	3 ± 0	4 ± 0	5 ± 0
Fat (% kcal)	36 ± 1	36 ± 1	36 ± 1	38 ± 1	37 ± 1
Alcohol (g)	14.7 ± 3.1	23.5 ± 3.8	14.7 ± 2.5	12.8 ± 2.1	12.3 ± 2.2
Confectionery (g)	18.7 ± 5.2	38.3 ± 9.4	45.7 ± 8.1	50.7 ± 10	63.0 ± 12
Cake (g)	6.2 ± 1.3	13.9 ± 1.6	24.2 ± 2.2	36.6 ± 3.4	33.5 ± 3.8
Fruit (g)	304 ± 25	254 ± 20	281 ± 21	254 ± 16	254 ± 27
Vegetables (g)	434 ± 21	404 ± 17	391 ± 18	391 ± 20	344 ± 16
DDS	4.9 ± 0.4	4.9 ± 0.4	4.9 ± 0.3	4.9 ± 0.3	4.8 ± 0.5
DVS	24.0 ± 0.5	26.2 ± 0.5	27.5 ± 0.5	27.0 ± 0.5	27.1 ± 0.6
	Sucrose Deciles				
Characteristic	**6th (n=83)**	**7th (n=84)**	**8th (n=84)**	**9th (n=84)**	**10th (n=83)**
Age (y)	40.4 ± 1.7	39.0 ± 1.7	41.7 ± 2.1	36.5 ± 1.9	34.9 ± 1.9
BMI (kg/m^2)	22.7 ± 0.4	22.4 ± 0.3	22.6 ± 0.3	21.8 ± 0.4	22.5 ± 0.5
Energy (kcal)	2015 ± 62	2172 ± 69	2010 ± 74	2165 ± 92	2455 ± 101
Sucrose (g)	31.4 ± 1.0	40.5 ± 1.4	45.9 ± 1.7	61.0 ± 2.7	104 ± 4.9
Fat (g)	83.4 ± 3.1	94.3 ± 4.5	82.3 ± 3.3	86.0 ± 4.1	98.7 ± 4.3
Sucrose (% kcal)	6 ± 0	7 ± 0	9 ± 0	11 ± 0	17 ± 0
Fat (% kcal)	37 ± 1	38 ± 1	37 ± 1	36 ± 1	36 ± 1
Alcohol (g)	8.2 ± 1.7	10.1 ± 1.7	4.5 ± 1.0	7.1 ± 1.8	3.4 ± 0.9
Confectionery (g)	79.4 ± 12	87.4 ± 11	109 ± 23	124 ± 16	265 ± 29
Cake (g)	44.5 ± 5.1	42.8 ± 4.9	44.1 ± 5.2	62.9 ± 6.4	72.6 ± 6.9
Fruit (g)	277 ± 20	214 ± 16	229 ± 23	253 ± 21	234 ± 27
Vegetables (g)	364 ± 18	355 ± 17	347 ± 15	325 ± 17	274 ± 17
DDS	4.9 ± 0.3	4.9 ± 0.4	4.9 ± 0.4	4.9 ± 0.4	4.7 ± 0.6
DVS	28.4 ± 0.5	28.7 ± 0.5	28.0 ± 0.5	27.4 ± 0.6	27.8 ± 0.5

Data are means ± SE.

sumption was expressed in g/day or was corrected for energy (g/1000 kcal).

Consistent with previous reports (17), high sucrose consumers had lower BMI values (p<0.0001). However, as is clearly shown in Tables 2 and 3, they were also younger (p<0.0001). A comparison of the bottom and top deciles by sucrose consumption (expressed in g/1000 kcal) showed that the highest sucrose consumers were 34.8 years old, consumed 2455 kcal/day, and derived 17% of energy from sucrose and 36% of energy from fat. Their mean BMI was 22.5. In contrast, the lowest sucrose consumers were 48.0 years old, consumed 1693 kcal/day, and had mean a BMI of 25.3. That group derived 0% energy from added sucrose and 36% of energy from fat. Age and sucrose consumption effectively covaried, as younger people with higher energy needs derived a large part of the extra energy from sucrose as opposed to fats. The proportion of fat in the diet did not vary as a function of either age or body mass in this population sample.

Stepwise regression analyses were conducted to determine the chief predictors of added sucrose consumption (corrected for energy) for this group of subjects. The independent variables entered were age, BMI, total energy, and percent energy from fat. The choice of variables was determined by our hypothesis that age, and not calories or percent energy from fat, was the key predictor variable. The first variable entered into the regression was age (multiple $R = 0.26$; $p<0.00$), followed by BMI, and then calories. As expected from the data in Table 3, both age and BMI were negative predictors of added sucrose intake, whereas energy was a positive predictor. In contrast, percent fat in the diet was not a significant predictor of added sucrose intake and did not enter into the regression equation ($p>0.10$). These data do not provide support for the existence of a fat-sucrose seesaw, when sucrose and fat intakes are expressed as percent energy.

The question of whether heavy consumers of extrinsic sugars are characterized by poor quality diets is also addressed in Table 3. The DDS, a measure of habitual consumption of the five major food groups, was close to the ceiling value of 5 across most sucrose consumption deciles, showing that both high- and low-sucrose consumers incorporated foods from the five major food groups into their diets. The DVS, defined as the total number of different foods consumed, actually increased with increasing sucrose consumption. The DVS data show that high-sucrose consumers incorporated the greatest number of different foods in their diet. According to the 1995 Dietary Guidelines for Americans (16), dietary variety is the most important criterion for a healthy diet.

Discussion

These data, obtained with a large community-based sample of French adults, clearly show that age has a major effect on intakes of added sucrose and fat. Consistent with previous findings (3,19), younger people consumed more energy, more added sucrose, and more fat. High sucrose intakes, corrected for energy (g/1000 kcal per day), were associated with elevated consumption of confectionery and cakes and with lower consumption of vegetables. Sucrose consumption, whether expressed in g/day or as percent energy, declined sharply as a function of age (8). The percentage of energy from fat also declined with age but to a lesser extent. Consistent with other reports (3,8,22), older people consumed less energy and less sucrose and sweets, but more vegetables. Fruit consumption was not influenced by age.

Not surprisingly, given the major influence of age on BMI, high sucrose consumers in the sample presented here had lower BMIs, exactly as reported previously (17). The inverse relationship between added sugar intakes and BMI, previously noted by other researchers (7,12,17), may be explained by striking differences in age between high- and low-sucrose consumers. Similar differences in sucrose consumption by age may also have been present in other studies, although no such analyses were reported. Of course, age is also associated with differences in activity level. The latter factor, known to influence both intakes and energy needs, was not assessed in this or in previous studies.

Alcohol consumption is also known to vary with age. Gibney (6) noted that those British subjects who had low sucrose and fat intakes, and so met the dietary sugar and fat guidelines, also consumed 330% more alcohol. Therefore, their diets were not necessarily better overall. Gibney et al. (7) had previously noted a negative association between alcohol and fat intakes when both were expressed as percent energy. Other researchers have observed a negative association between total sugar intakes and body mass (17). Again, these observations, confirmed in the data presented here, can be explained by differences in age. Although alcohol intakes and BMI values increased with age, sucrose intakes, on the contrary, declined (see Table 1).

Consistent with previous data (18) was a positive association between sucrose and fat intakes when the variables were expressed in grams per day. However, no significant relationship, i.e., no fat-sucrose seesaw, was observed when sucrose and fat intakes were expressed as percent energy. Macdiarmid et al. (18) used the United Kingdom National Diet and Nutrition Survey 1986 to 1987 (9) to show a positive relationship between extrinsic sugar and fat intakes, expressed in grams per day, but revealed an inverse relationship when the two variables were expressed as percentages of energy. Evidently, the fat-sugar seesaw, when observed, only held for data expressed as energy percentages. Another explanation for the absence of a fat-sucrose seesaw in the results presented here may be that added sucrose contributes much less energy to the French diet than it does to diets in England or in the United States (7,9).

The contribution of added sucrose to diet quality deserves further discussion. The argument that, without sucrose in the diet, dietary fat would have been replaced by vegetables and other healthy foods (5) makes untenable assumptions about human eating habits. Replacing one source of energy in the human diet with another is a complex task, especially when dealing with populations with varied energy needs. As shown in Table 3, energy intakes of highest vs. lowest sucrose consumers differed by as much as 750 kcal. An even larger difference in energy intakes between high and low tertiles by sugar intake in g/kg was reported in the 1978 to 1979 NFCS data (1483 vs. 2362 kcal). It is unlikely that these energy differences can be made up simply by vegetables and fruit. Although essential to a healthy diet (14,27), vegetables and fruit are calorically dilute foods that must be consumed in massive quantities to provide sufficient energy. Replacing 750 kcal of dietary sugar (4 kcal/g) or fat (9 kcal/g) by equicaloric amounts of vegetables would require daily consumption of roughly 3 lb of boiled potatoes (0.6 kcal/g), 5 lbs of boiled broccoli (0.3 kcal/g), or 7 lb of spinach (0.2 kcal/g). Such high levels of intake would most likely result in gastrointestinal discomfort. In practice, high energy needs of younger people cannot be satisfied without at least some high-energy foods, and diets high in sucrose should not be automatically assumed to be unhealthy.

Some researchers have argued (5,17), in the absence of formal measures of diet quality, that diet quality deteriorates as sugar intakes rise. The assumption has been that a higher proportion of vegetables and fruit results in a better quality diet. However, diet quality is a multivariate concept that is not captured merely by the amount of fiber consumed. The best diet for a given individual is not necessarily the one that is highest in vegetables, but the one that is best suited to his or her age, health, and energy needs.

The question is whether the consumption of any high-energy foods, including sucrose, is detrimental to diet quality. Recent studies in nutritional epidemiology have began to focus on novel measures of the quality of the "total" diet. Such measures include the DDS, the DVS, the Diet Quality Index, and the Healthy Eating Index (4,16,23). For the most part, such indices provide qualitative measures of dietary adequacy, moderation, and variety and provide an overall diet quality score. Whereas some studies have used grams of fat or fiber as proxy measures of diet quality, the fact is that diet quality cannot be measured in terms of individual nutrients or diet components. There is ample evidence from clinical studies that diets that are low in fat are not necessarily the most healthy and can be detrimental when practiced by women of childbearing age (26). Statements regarding diet quality should be supported by quantitative *measures* of diet quality, a relatively new area of epidemiological research.

This study examined sucrose consumption with respect to two such measures. As shown in Table 2, high-sucrose consumers that had stable DDS had the highest DVS. In contrast, the diets of older persons, although lower in sugars and fats, were also the least varied. Both the 1992 USDA Food Guide Pyramid and the 1995 USDA dietary guidelines recommend increasing the variety of food choices. This is a distinct concept from modifying nutrient intakes, because choosing a greater variety of foods will not necessarily result in an eating pattern that is lower in fat, saturated fat, sugar, or salt. In France at least, higher sucrose consumption appears to be associated not only with younger age but also with the consumption of a more varied diet.

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References

1. **Bolton-Smith C, Woodward M.** The prevalence of overweight and obesity in different fat and sugar consumption groups (abstr). *Proc Nutr Soc.* 1993;52:383A.
2. **Cubeau J, Pequinot G.** La technique du questionnaire alimentaire quantitatif utilisé par la section Nutrition de l'INSERM. *Rev Epidemiol Santé Publ.* 1980;28:367–372.
3. **Drewnowski A.** Sensory preferences for fat and sugar in adolescence and in adult life. *Ann NY Acad Sci.* 1989;561: 243–250.
4. **Drewnowski A, Henderson SA, Shore AB, Fischler C, Preziosi P, Hercberg S.** Diet quality and diversity in France: Implications for the French paradox. *J Am Diet Assoc.* 1996; 96:663–669.
5. **Emmett PM, Heaton KW.** Is extrinsic sugar a vehicle for dietary fat? *Lancet.* 1995;345:1537–1540.
6. **Gibney M.** Extrinsic sugar as vehicle for dietary fat (letter). *Lancet.* 1995;346:695–696.
7. **Gibney M, Sigman-Grant M, Stanton JL, Keast DR.** Consumption of sugars. *Am J Clin Nutr.* 1995;62(Suppl):178S–194S.
8. **Glinsman WH, Irausquin H, Park YK.** Evaluation of health aspects of sugars contained in carbohydrate sweeteners. *J Nutr.* 1986;116(11S);S1–S216.
9. **Gregory J, Foster K, Tyler H, Wiseman M.** *The Dietary and Nutritional Survey of British Adults.* London: HM Stationery Office; 1990.
10. **Heaton KW, Emmett PM.** Extrinsic sugar as vehicle for dietary fat (letter). *Lancet.* 1995;346:697–698.
11. **Hercberg S, Preziosi P, Galan P, Deheeger M, Dupin H.** Apports nutritionels d'un echantillon representatif de la population du Val-de-Marne: II. Les apports en macronutriments. *Rev Epidemiol Santé Publ.* 1991;39:233–244.
12. **Hill JO, Prentice AM.** Sugar and body weight regulation. *Am J Clin Nutr.* 1995;62(Suppl):264S–274S.
13. **Hulshof KFAM, Wedel M, Lowik HRH, et al.** Clustering of dietary variables and other lifestyle factors: Dutch National Surveillance System. *J Epidemiol Commun Health.* 1992;46: 417–424.
14. **Human Nutrition Information Service.** *United States Department of Agriculture's Food Guide Pyramid.* Home and Garden Bulletin No 249. Washington, DC: United States Departments of Agriculture and Health and Human Services; 1992.
15. **Kant AK, Block G, Schatzkin A, Ziegler RG, Nestle M.** Dietary diversity in the US population, NHANES II, 1976–1980. *J Am Diet Assoc.* 1991;91:1526–1531.
16. **Kennedy ET, Ohls J, Carlson S, Fleming K.** The Healthy Eating Index: Design and applications. *J Am Diet Assoc.* 1995; 95:1103–1108.
17. **Lewis CJ, Park YK, Dexter PB, Yetley EA.** Nutrient intakes and body weights of persons consuming high and moderate levels of added sugars. *J Am Diet Assoc.* 1992;92:708–713.

18. **Macdiarmid JI, Cade JE, Blundell JE.** Extrinsic sugar as vehicle for dietary fat (letter). *Lancet.* 1995;346:696.
19. **National Center for Health Statistics, Carroll MD, Abraham S, Dresser CM.** *Dietary intake Source Data, United States 1976–80.* Vital and Health Statistics, series 11, no 231. DHHS Publ no (PHS) 83-1681, PHS. Washington, DC: U.S. Government Printing Office; 1983.
20. **National Center for Health Statistics, Najjar MF, Rowland M.** *Anthropometric Reference Data and the Prevalence of Overweight, United States 1976–80.* Vital and Health Statistics, series 11, no 238. DHHS Publ no (PHS) 87-1688, PHS. Washington, DC: U.S. Government Printing Office; 1987.
21. **Pao EM, Cypel YS.** Estimation of dietary intake. In: Brown ML, ed. *Present Knowledge in Nutrition.* 6th ed. Washington, DC: International Life Sciences Institute-Nutrition Foundation; 1990;399–406.
22. **Patterson BH, Block G.** Food choices and the cancer guidelines. *Am J Publ Health.* 1988;78:282–286.
23. **Patterson RE, Haines PS, Popkin BM.** Diet Quality Index: Capturing a multidimensional behavior. *J Am Diet Assoc.* 1994;94:57–64.
24. **Prentice AM, Jebb SA, Black AE.** Extrinsic sugar as vehicle for dietary fat (letter). *Lancet.* 1995;346:695.
25. **Preziosi P, Galan P, Granveau C, Deheeger M, Papoz L, Hercberg S.** Consommation alimentaire d'un echantillon representatif de la population du Val-de-Marne: I. Contribution des aliments a l'apport energetique. *Rev Epidemiol Santé Publ.* 1991;39:221–231.
26. **Rock CL, Gorenflo DW, Drewnowski A, Demitrack MA.** Nutritional characteristics, eating pathology, and hormonal status in young women. *Am J Clin Nutr.* 1996;64:566–571.
27. **United States Departments of Agriculture and Health and Human Services.** *Nutrition and Your Health: Dietary Guidelines for Americans.* Home and Garden Bulletin No 232. Washington, DC: 1995.