Modifications in food-group consumption are related to long-term body-weight changes[1–3]

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ABSTRACT

Background: Dietary patterns play an important role in the control of body weight.

Objective: The aim of this study was to verify whether changes in some dietary patterns over a 6-y follow-up period would be associated with weight changes.

Design: A sample of 248 volunteers of the Québec Family Study were measured twice (visit 1: 1989–1994; visit 2: 1995–2000). Body weight, percentage body fat, subcutaneous skinfold thicknesses, and waist circumference measurements as well as 3-d dietary and physical activity records were obtained at each visit. At visit 2, all participants filled out a food-based questionnaire examining changes in the consumption of 10 food categories. To further investigate the relation between changes in food-group consumption and body-weight changes, a total of 51 food subcategories were identified from dietary records.

Results: A self-reported decrease in the consumption of food in the fat group or an increase in consumption in the fruit group from the food-based questionnaire predicted a lower increase in body weight and adiposity indicators over time. A more detailed examination of the change in food groups between diet records revealed that increases in the consumption of whole fruit as well as skimmed milk and partly skimmed milk were the 2 food patterns that negatively correlated with the changes of each body weight–related indicator.

Conclusions: These results show that changes in the consumption of some specific food groups are associated with body-weight changes. Such specific eating patterns could help to improve obesity treatment and prevention. *Am J Clin Nutr* 2004;80:29–37.

KEY WORDS Food groups, dietary patterns, food questionnaire, body-weight changes

INTRODUCTION

Weight control intervention typically recommends to decrease total energy and fat intakes. Adherence to such nutrient-based guidelines appears to be difficult because weight regain is seen in most reduced-obese individuals. Food-based recommendations could be more easily understood and could thus improve the efficacy of dietary intervention in the prevention and treatment of obesity. A review of literature showed that no consistent association could be identified between body mass index or obesity and food intake patterns in cross-sectional studies (1). The heterogeneity of the food patterns identified in these studies could explain in part this lack of consistency. Moreover, the cross-sectional nature of these studies does not permit identification of which pattern of food intake changes over time is more susceptible to affect body weight.

The influence of changes in food group consumption on subsequent body weight changes has not been extensively investigated. Most of the prospective studies that examined this issue assessed the effect of food group intakes at one time point (baseline or follow-up) (2–5), assessed mean effects of stable behavior over time (6), or investigated diet pattern (healthy, unhealthy, improved diet) (7) on body weight changes. Some studies showed an association between the consumption of food groups and body weight changes (2, 3, 5, 6), whereas others did not (4, 7). Only a few studies considered the effect of changes in specific food group consumption on body weight variations (3, 8, 9). French et al (8) reported that an increase in the consumption of french fries, dairy products, sweets, and meat in women and an increase in the consumption of sweets and eggs in men were positively related to weight gain over a 2-y period. However, that study included only 18 food items, which accounted for 60% of daily energy intake. In a second study, which included a more exhaustive evaluation of various food groups, the same group observed that an increase in the consumption of fruit and vegetables, the elimination of sweets in addition to energy reduction, and a decrease in the amount of food eaten were strategies when maintained over time that were associated with less body weight gain over the 4-y period (9). Similar changes in dietary patterns were also associated with a greater weight loss over time (3). It is important to note that most of these prospective studies were conducted in an intervention context in which changes in the consumption of food groups were suggested and therefore expected. Little is known about the effect of spontaneous changes in food group consumption over time on body weight changes.

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Received July 31, 2003.
Accepted for publication December 18, 2003.

The main aim of this study was to identify, with the use of a simple food-based questionnaire, which dietary pattern modifications are associated with body weight and adiposity changes over a follow-up period of 6 y. In addition, to examine which changes in a specific food group were associated with body weight changes, we studied the relations between changes in the consumption of more detailed food groups identified from dietary records and body weight variations over the same period.

SUBJECTS AND METHODS

Subject characteristics

Results used in the present analysis were obtained from subjects of the Québec Family Study. The analysis was conducted on parents and offspring (≥18 y old) who were tested twice in the Québec Family Study. The first visit was achieved between 1989 and 1994, and the second visit was performed between 1995 and 2000. Subjects who had completed the entire food-based questionnaire at the second visit included 248 participants (112 men and 136 women). All the subjects gave their written consent to participate in this study, which received the approval of the Laval University Ethics Committee.

Assessment of variables

Body weight and indicators of body weight

Body mass was taken with a standard beam scale with the participants wearing only a swimsuit. Waist circumference and skinfold-thickness measurements were performed according to the procedures of the Airlie Conference (10). Six subcutaneous fatfolds were measured on the left body side with use of a Harpenden caliper (Burgess Hill, United Kingdom): triceps, biceps, medial calf, subscapular, suprailiac, and abdominal. Body density was determined in 87% of the subjects by the underwater weighing technique. The Siri formula (11) was used to estimate the percentage body fat from body density.

Dietary intake and daily energy expenditure

Dietary intake was assessed by a 3-d dietary record (12), which was completed during 2 weekdays and 1 weekend day. All subjects received guidelines from a nutritionist on the procedures to complete the dietary record and to measure food portions. Macronutrient and micronutrient intakes were estimated with a computerized version of the Canadian Nutrient File (13). Daily energy expenditure, physical activity level, or both were estimated by a physical activity diary (14) completed on the same days as the dietary record.

Changes in dietary patterns

At the second visit, all subjects completed a food-based questionnaire on the changes in the perceived consumption of different food categories over the past 5 y (**Appendix A**). Subjects were instructed to indicate whether they consumed more, as much, or less of 10 food categories: sugar and sweet foods, fat and fatty foods, salt and salty foods, milk and milk products, fruit, vegetables, meats, breads and cereals, soft drinks, and chocolate. Subjects could also indicate "I don't know" when it was impossible for them to estimate changes for a given food category.

Changes in the consumption of specific food groups

Food items from dietary records were grouped into 51 food subgroups (**Appendix B**) mainly on the basis of macronutrient composition. Percentage of energy for each food group at visits 1 and 2 was calculated, and changes in the consumption of the various food groups were evaluated from differences between follow-up and baseline values. Among these 51 food subgroups, 10 food groups were excluded from the analyses because they contained very few kilojoules or because they showed almost no changes in their consumption (SD < 1). Hence, a total of 41 food subgroups were included in the analyses. These 41 food subgroups represented a mean (visit 1 and 2) of 99.4 ± 1.3% of total daily energy intake.

Statistical analysis

All statistical analyses were performed in the entire sample of men and women. An analysis of covariance adjusted for age at visit 1 and for corresponding baseline anthropometric and adiposity characteristics was performed to detect morphologic differences between individuals having reported to consume more, as much, or less of each food category. When subjects responded "I don't know," they were excluded from the statistical analyses. An analysis of variance was performed for dietary intake differences between consumption of each food category (more, as much, or less). When the analysis of variance or the analysis of covariance was significant, a Tukey-Kramer test was used to detect which conditions were statistically different from each other. Stepwise multiple regression (with a probability to enter the model fixed at $P < 0.05$) was performed to determine intake changes of which specific food group could explain the variance observed in body weight and adiposity changes. This procedure was performed after adjustment for age at visit 1, corresponding baseline anthropometric and adiposity characteristics (model 1), and estimated total energy expenditure (model 2). All values are expressed as mean ± SEM, and differences were considered significant at $P < 0.05$. Statistical analyses were performed with use of SAS statistical software, version 8.2, and JUMP software, version 3.1.6.2 (SAS Institute Inc, Cary, NC).

RESULTS

Subject characteristics

The mean duration of the follow-up period was 5.9 ± 0.1 y. Age of participants ranged from 18 to 65 y ($\bar{x}$ ± SEM = 39.6 ± 0.9). At baseline, mean body mass index (in kg/m^2) was 25.3 ± 0.3 (range: 17.4–55.6). Body weight change over time was 3.1 ± 0.4 kg, corresponding to a range of weight change of −24.5 to 42.8 kg.

Eating pattern modifications associated with body-weight changes

Only 2 subjects for the breads and cereals category and 1 subject for the salt and salty foods category answered that they did not know if their consumption changed over the preceding 5 y and were excluded from the statistical analyses. Among all dietary pattern modifications, self-reported changes in the consumption of fat and fatty foods group and fruit group were the food patterns associated with changes in all anthropometric and

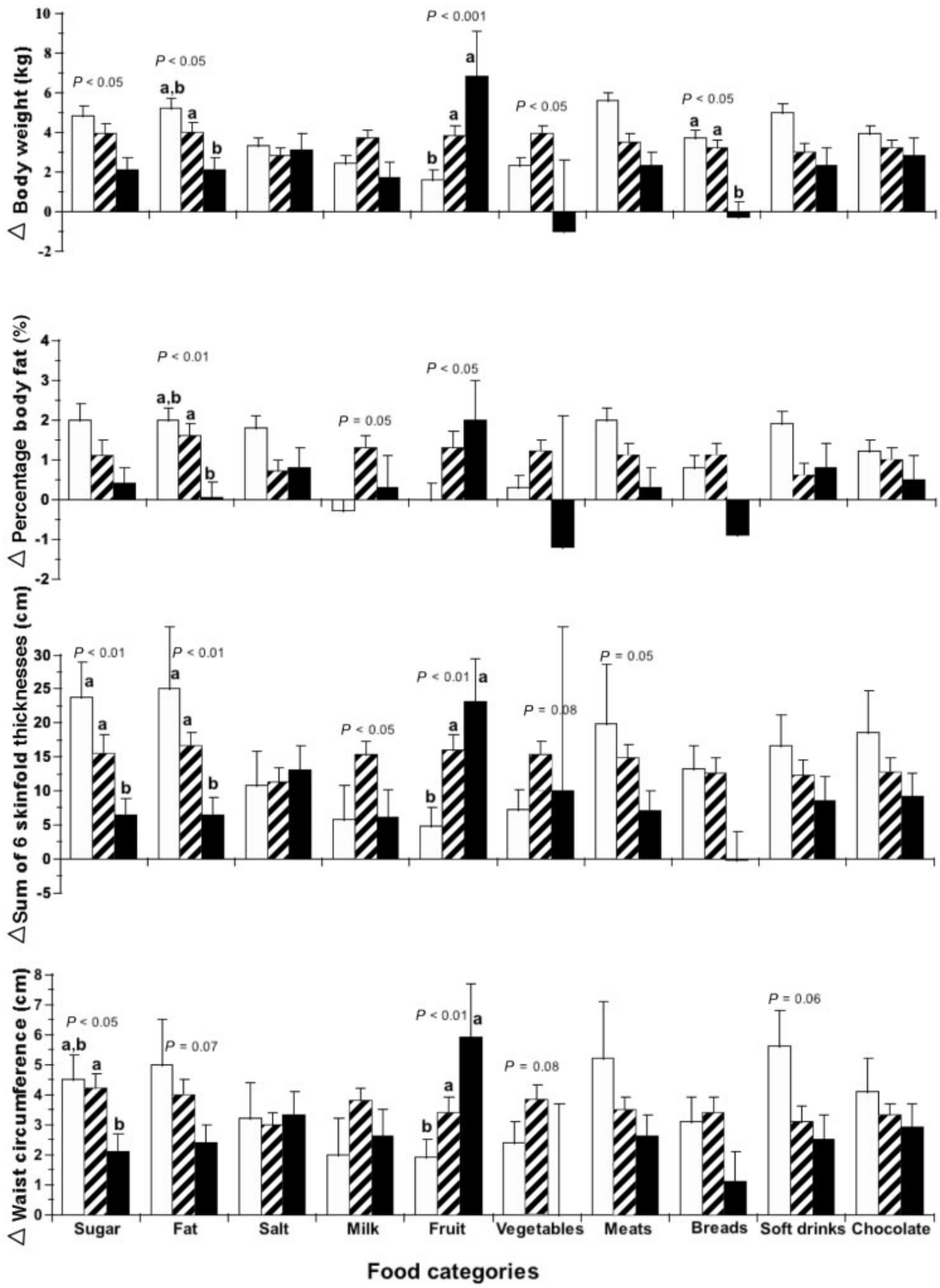

FIGURE 1. Mean (± SEM) 6-y changes in body weight, percentage body fat, sum of 6 skinfold thicknesses, and waist circumference between individuals who reported eating more (□), as much (▨), or less (■) of each food category. $n = 248$. *P* value indicates significant differences between each group of food category consumption tested with analysis of covariance. Values in the same category with different superscript letters are significantly different (Tukey-Kramer test). Some analyses of covariance show significant *P* values but no between-group differences (Tukey-Kramer test).

body fat indexes. Individuals who reported eating less fat and fatty foods showed a less pronounced increase in body weight, percentage body fat, and sum of 6 skinfold thicknesses compared with individuals who reported eating more fat. They also showeda tendency to have a lower increase in waist circumference in comparison to individuals who reported eating more fat and fatty foods (**Figure 1**). For the fruit consumption pattern, individuals who reported eating more fruit displayed a less pronounced increase in body weight, sum of 6 skinfold thicknesses, and waist circumference compared with individuals who reported eating less fruit. They also showed a tendency to have a lower increase in percentage body fat (Figure 1). We observed similar results with a small decrease in the level of significance after control for changes in physical activity level (data not shown).

Self-reported changes in the consumption of sugar and sweet foods also showed some associations with changes in anthropometric and adiposity indexes over time. Individuals who reported a decrease in the consumption of sugar and sweet foods were characterized by a lower increase in the sum of 6 skinfold thicknesses and a tendency to gain less body weight compared with individuals who reported eating more

TABLE 1
Food intake differences between individuals who reported consuming more, as much, or less fat and fatty foods now relative to 5 y ago ($n = 248$)[1]

Changes in variables (visit 2 − visit 1)	Changes in fat and fatty food consumption over the past 5 y: More ($n = 16$)	As much ($n = 102$)	Less ($n = 130$)	P^2
Energy intake (kcal/d)	597 ± 158^a	65 ± 63^b	87 ± 56^b	0.007
Protein intake (g/d)	20.9 ± 6.8	4.6 ± 2.7	7.0 ± 2.4	0.09
Protein intake (% kcal)	0.1 ± 0.9	0.3 ± 0.4	0.7 ± 0.3	0.67
Lipid intake (g/d)	23.9 ± 9.0^a	$2.2 \pm 3.6^{a,b}$	0.01 ± 3.2^b	0.05
Lipid intake (% kcal)	0.5 ± 1.8	-0.1 ± 0.7	-1.7 ± 0.6	0.16
Saturated fatty acids (g/1000 kcal)	-1.0 ± 1.0	0.1 ± 0.4	-0.6 ± 0.4	0.30
Monounsaturated fatty acids (g/1000 kcal)	-0.5 ± 1.1	0.6 ± 0.4	0.0 ± 0.4	0.40
Polyunsaturated fatty acids (g/1000 kcal)	0.0 ± 0.6	0.5 ± 0.3	1.0 ± 0.2	0.19
Cholesterol (g/1000 kcal)	5.1 ± 6.9	-3.6 ± 6.7	-14.0 ± 6.8	0.36
Carbohydrate intake				
(g/d)	58.8 ± 20.5^a	1.0 ± 8.1^b	$15.4 \pm 7.2^{a,b}$	0.03
(%/kcal)	$-2.2 \pm 1.8^{a,b}$	-1.3 ± 0.7^a	1.0 ± 0.7^b	0.03
Fiber intake (g/1000 kcal)	$-0.2 \pm 0.8^{a,b}$	0.7 ± 0.3^a	1.8 ± 0.3^b	0.008
Vitamin C (mg/1000 kcal)	-2.9 ± 4.7^a	-42.4 ± 11.8^b	-2.9 ± 4.7^b	0.007

[1] All values are $\bar{x} \pm$ SEM. Values on the same line with different superscript letters are significantly different (Tukey-Kramer test).
[2] P value for the dietary intake differences between each group of food category consumption tested with ANOVA.

sugar (Figure 1). Similar associations were observed after adjustments for changes in activity level (data not shown). For the remaining food groups, we observed no consistent significant associations between individuals' reported consumption and body weight or adiposity changes over time.

We also compared the dietary pattern changes with changes in macronutrient and micronutrient intakes obtained from dietary records. This comparison was done only for food patterns that were associated with body weight–related indicators (fat and fatty food, fruit, and sugar and sweet food categories). Individuals who reported a decrease in the consumption of fatty foods also showed a better profile of macronutrient and micronutrient intakes. For instance, individuals who reported eating less fat and fatty foods had a less pronounced increase in energy and total lipid intakes, a less marked decrease in vitamin C intake, and a tendency to increase dietary fiber intake (**Table 1**). We also observed a slight increase in the proportion of energy as carbohydrate in this group. For fruit consumption, we observed that individuals who reported eating more fruit compared with 5 y ago had a significantly lower increase in energy intake over the 6-y follow-up. This difference was accompanied by a lower increase in protein intake and by a decrease in total and saturated lipid intakes. In addition, these individuals showed an increase in percentage energy as carbohydrate, an increase in dietary fiber intake, a tendency to increased folate consumption, and a maintenance of vitamin C intake compared with individuals who had decreased their fruit consumption over the follow-up period (**Table 2**). Finally, individuals who reported eating less sugar and sweet foods compared with 5 y ago had a more pronounced increase in intake of calcium and a tendency to increased dietary fiber and phosphorus consumption compared with individuals who reported consuming more of those foods (**Table 3**).

Changes in specific food group consumption associated with body-weight changes

Changes in consumption of specific food groups were established from dietary records completed at baseline and at 6-y follow-up. Stepwise linear multiple regression analysis revealed that changes in the consumption of whole fruit as well as skimmed milk and partly skimmed milk were changes that consistently accounted for a significant fraction of the variance in changes of all body weight and adiposity indexes (**Table 4**). After further adjustment for the change in daily physical activity, we observed that skimmed milk and partly skimmed milk were no longer independent factors explaining the variation in body weight and adiposity indices (Table 4). In contrast, the change in whole fruit consumption remained associated with variations in all body weight and fatness variables.

DISCUSSION

The main aim of this study was to test whether changes in some dietary patterns would be associated with long-term body-weight and adiposity changes. Results from the short food-based questionnaire showed that a self-reported decrease in the consumption of fat and fatty foods and an increase in the intake of the fruit group represented the 2 changes in dietary patterns that provided the smallest body-weight gain over time. A self-reported decrease in the consumption of sugar and sweet foods was also associated with a less pronounced increase in some body-weight and adiposity indicators over time. A more detailed evaluation of changes in food group consumption from dietary recalls revealed that changes in whole fruit, skimmed milk, and partly skimmed milk were associated with variations in all body-weight and adiposity indicators over the 6-y follow-up period.

These results support the evidence suggesting that consuming a healthy diet (ie, low in fat and sugar, high in fruit and vegetables) can decrease body weight or prevent body-weight gain over time (2, 3, 5, 6). Moreover, these findings are in accordance with findings of other similar studies that focused on dietary pattern changes over time. Retrospective and prospective observational studies in England and Germany showed that cutting back on fats is one of the least fattening patterns of eating over ≥1–2 y in addition to not consuming energy-rich drinks between meals (15). Our data confirm that, in a free-living context, a decrease in

TABLE 2
Food intake differences between individuals who reported consuming more, as much, or less fruit now relative to 5 y ago ($n = 248$)[1]

Changes in variables (visit 2 − visit 1)	Changes in fruit consumption over the past 5 y			
	More ($n = 101$)	As much ($n = 131$)	Less ($n = 16$)	P^2
Energy intake (kcal/d)	92 ± 63^b	68 ± 55^b	579 ± 158^a	0.01
Protein intake (g/d)	6.1 ± 2.7^b	5.2 ± 2.4^b	25.4 ± 6.8^a	0.02
Protein intake (% kcal)	0.4 ± 0.4	0.5 ± 0.3	1.0 ± 0.9	0.82
Lipid intake (g/d)	-1.8 ± 3.6^b	2.3 ± 3.1^b	30.2 ± 8.9^a	0.005
Lipid intake (% kcal)	-2.0 ± 0.7^b	$-0.5 \pm 0.6^{a,b}$	3.1 ± 1.7^a	0.02
Saturated fatty acids (g/1000 kcal)	-0.9 ± 0.4^b	$-0.2 \pm 0.4^{a,b}$	1.9 ± 1.0^a	0.04
Monounsaturated fatty acids (g/1000 kcal)	-0.6 ± 0.4	0.7 ± 0.4	1.7 ± 1.1	0.03
Polyunsaturated fatty acids (g/1000 kcal)	0.5 ± 0.3	0.9 ± 0.2	0.9 ± 0.7	0.41
Cholesterol (g/1000 kcal)	-16.4 ± 6.7	-3.7 ± 5.9	1.9 ± 17.0	0.31
Carbohydrate intake				
(g/d)	21.1 ± 8.2	1.7 ± 7.1	43.2 ± 20.6	0.06
(% kcal)	1.6 ± 0.7^a	-0.9 ± 0.6^b	-4.7 ± 1.8^b	0.001
Fiber intake (g/1000 kcal)	1.8 ± 0.3^a	$0.9 \pm 0.3^{a,b}$	-0.5 ± 0.8^b	0.01
Vitamin C (mg/1000 kcal)	-0.6 ± 4.7^a	$-7.1 \pm 4.1^{a,b}$	-32.6 ± 11.9^b	0.04
Folate (μg/1000 kcal)	20.0 ± 4.4	10.0 ± 3.8	-7.3 ± 11.0	0.04

[1] All values are $\bar{x} \pm$ SEM. Values on the same line with different superscript letters are significantly different (Tukey-Kramer test).

[2] *P* value for the dietary intake differences between each group of food category consumption tested with ANOVA. Some ANOVAs show significant *P* values but no between-group differences (Tukey-Kramer test).

consumption of fat and fatty foods attenuates the weight gain normally observed over time. Choosing low-fat milk products, such as skimmed milk and partly skimmed milk, seems to be a valid strategy to decrease consumption of fatty foods. We also observed that cutting back on fatty foods helps individuals to control total energy and fat intakes. This observation is in agreement with studies that showed a beneficial effect of ad libitum low-fat diets on body-weight control (16).

In our study, a reported increase in fruit consumption was also associated with a better body-weight control, whereas consumption of vegetables was not. It is largely assumed that an increase consumption of fruit and vegetables could displace more energy-dense foods from the diet, leading to a lower-fat intake, ultimately resulting in weight loss. However, increasing consumption of fruit and vegetables has generated mixed results in long-term interventions concerning its effect on body weight (3, 9, 17–19). Some studies showed that an increase in consumption of fruit and vegetables over time was associated with a decrease in body weight (3, 9, 17), whereas others did not (18, 19). Beside differences in methods (different populations, intervention strategies, and follow-up period), the context in which individuals increased their consumption of fruit and vegetables could also be

TABLE 3
Food intake differences between individuals who reported consuming more, as much, or less sugar and sweet foods now relative to 5 y ago ($n = 248$)[1]

	Changes in sugar and sugar foods consumption over the past 5 y			
	More (n = 22)	As much (n = 106)	Less (n = 120)	P^2
Energy intake (kcal/d)	361 ± 137	120 ± 62	57 ± 58	0.12
Protein intake (g/d)	8.9 ± 7.3	6.0 ± 2.7	7.3 ± 2.5	0.88
Protein intake (% kcal)	-0.7 ± 0.7	0.2 ± 0.3	1.0 ± 0.3	0.05
Lipid intake (g/d)	16.6 ± 7.7	2.9 ± 3.5	-0.5 ± 3.3	0.13
Lipid intake (% kcal)	0.1 ± 1.5	-0.8 ± 0.7	-1.2 ± 0.7	0.07
Saturated fatty acids (g/1000 kcal)	1.0 ± 0.9	-0.5 ± 0.4	-0.5 ± 0.4	0.30
Monounsaturated fatty acids (g/1000 kcal)	1.9 ± 0.9	0.3 ± 0.4	-0.1 ± 0.4	0.12
Polyunsaturated fatty acids (g/1000 kcal)	1.1 ± 0.6	0.4 ± 0.3	1.0 ± 0.2	0.21
Cholesterol (g/1000 kcal)	-16.8 ± 14.5	-4.0 ± 6.6	-11.0 ± 6.2	0.62
Carbohydrate intake				
(g/d)	38.9 ± 17.7	13.7 ± 8.0	6.1 ± 7.6	0.23
(% kcal)	-0.4 ± 1.6	0.0 ± 0.7	-0.2 ± 0.7	0.97
Fiber intake (g/1000 kcal)	0.2 ± 0.7	0.8 ± 0.3	1.8 ± 0.3	0.02
Calcium (mg/1000 kcal)	-80.1 ± 31.4^b	-28.6 ± 14.3^b	19.1 ± 13.4^a	0.004
Phosphorus (mg/1000 kcal)	$-21.5 \pm 34.8^{a,b}$	-20.1 ± 15.8^b	46.9 ± 14.9^a	0.006

[1] All values are $\bar{x} \pm$ SEM. Values in the same row with different superscript letters are significantly different (Tukey-Kramer test).

[2] *P* value for the dietary intake differences between each group of food category consumption tested with ANOVA. Some ANOVAs show significant *P* values but no between-group differences (Tukey-Kramer test).

TABLE 4
Changes in food-group consumption established from dietary records at baseline and at 6 y that explained a significant fraction of the variance of body-weight and adiposity indicators over 6 y[1]

	$\beta \pm$ SE	*P*	Model R^2
Model 1[2]			
Changes in body weight			
Whole fruit	−0.23 ± 0.09	0.02	0.06
Mixed meals	−0.08 ± 0.04	0.04	
Skimmed and partly skimmed milk	−0.20 ± 0.09	0.06	
Changes in percentage body fat			
Whole fruit	−0.18 ± 0.06	0.004	0.06
Skimmed and partly skimmed milk	−0.14 ± 0.06	0.02	
Changes in waist circumference			
Whole fruit	−0.23 ± 0.09	0.02	0.12
Yogurt with <2% fat	0.42 ± 0.19	0.02	
Skimmed and partly skimmed milk	−0.23 ± 0.09	0.02	
Sweet foods	0.16 ± 0.07	0.03	
Mixed meals	−0.09 ± 0.03	0.03	
Low-fat processed meats	−0.32 ± 0.16	0.04	
Changes in the sum of 6 skinfold thicknesses			
Whole fruit	−1.18 ± 0.40	0.002	0.06
Skimmed and partly skimmed milk	−1.01 ± 0.40	0.01	
Model 2[3]			
Changes in body weight			
Mixed meals	−0.08 ± 0.04	0.02	0.04
Whole fruit	−0.18 ± 0.09	0.03	
Changes in percentage body fat			
Whole fruit	−0.16 ± 0.06	0.01	0.06
Cream	−0.47 ± 0.22	0.03	
Changes in waist circumference			
Yogurt with <2% fat	0.54 ± 0.18	0.003	0.09
Cereals and flours	−0.17 ± 0.08	0.04	
Whole fruit	−0.19 ± 0.08	0.03	
Mixed meals	−0.07 ± 0.03	0.04	
Changes in the sum of 6 skinfold thicknesses			
Whole fruit	−1.05 ± 0.38	0.01	0.05
Sugar	1.62 ± 0.76	0.03	

[1] Stepwise linear multiple regression equations. Some ANOVAs show significant *P* values, but no between-group differences (Tukey-Kramer test).
[2] Model 1: all variables are adjusted for initial age and baseline body-weight indicators.
[3] Model 2: all variables are adjusted for initial age, baseline body-weight, or adiposity indicators and changes in daily physical activity level.

a factor to explain these mixed results. Fruit can be more easily eaten alone as snacks or desserts, whereas vegetables are often combined with extra kilojoules such as butter, cheese, sauce or gravy, and pastry with a main dish. Our study also suggests that whole fruit is likely to play a greater role in body-weight changes than are fruit juices. This suggestion is not surprising because whole fruit contains dietary fiber that could have a satiety effect (20, 21).

The associations observed between sugar and sweet food intakes and some body weight and adiposity indicators are interesting, because sugar consumption is not often associated with obesity (22). We speculate that this association is due to the combined increase in fat and sweet intake, because sweet foods are often rich in fat. Thus, we observed with dietary records that individuals who reported an increase in sweets intake also showed an increase in total energy and lipid intakes. Moreover, low-fat sweet products can be energy dense and thus also promote higher energy intake (23). This finding is consistent with studies that found that the elimination of or a decrease in the consumption of sweets represented one of the eating patterns associated with less body-weight gain (9) or a greater weight loss (3). Other studies observed a relation between high intake or an increase in consumption of food items rich in sugar and weight gain (2, 8, 24). Recently, a 10-wk experimental study showed that a daily supplement rich in sucrose (mostly as beverages) produces a significant increase in body weight, whereas artificial sweeteners did not (25). Interestingly, in our study, we also observed a trend for a more pronounced increase in all body-weight and adiposity indicators among individuals who reported an increase in soft drink consumption (Figure 1). It seems that this negative effect of sugar on body weight is more likely observed when sugar is added to the habitual diet rather than when it is added to a low-fat diet. This finding is supported by the results of a long-term randomized controlled trial, which showed that the concomitant increase in either simple or complex carbohydrates on a low-fat diet did not produce significant different body-weight changes (26).

Changes in physical activity behaviors could also be implicated in these previous relations found between food patterns and body-weight changes, because physical activity has been identified to be the most frequent weight-control strategy used by adults (9). In our study, the effect of physical activity could be observed after the adjustment for changes in physical activity level that produced a small decrease in the level of significance for the relations between changes in eating patterns and body weight.

The food-based questionnaire used in this study represents a simple tool to rapidly assess general changes in food patterns over time. Unlike quantitative questionnaires, this qualitative evaluation of food pattern changes was easily completed by most individuals. Only 3 participants indicated that they did not know if they changed their consumption of one food category over the past 5 y. Given the differences in findings that compared more finely divided food groups such as low-fat milk, it would certainly be relevant to extend some food groups of the food-based questionnaire in future studies. For example, milk and the milk product group could be divided into regular and low-fat milk products.

The increase in micronutrient and macronutrient intakes observed in individuals who adopted a least-fattening dietary pattern as defined by the food-based questionnaire is an interesting observation: data suggest that variations in micronutrient (calcium, magnesium, folic acid) intakes could be implicated in body-weight changes over time (27–30). This finding is consistent with the results from the Multiple Risk Factor Intervention Trial, which showed that weight loss was associated with a diet lower in energy but higher in several micronutrient intakes (3).

The use of the stepwise regression to explore the effect of more specific food patterns on body weight over time is perceived as a strength of this study. For instance, most studies investigating this issue have looked at the effect of macronutrients or different general diet patterns (Western compared with healthy diets) on body weight changes without considering the possibility that other components in foods could have an effect on body weight. We are aware that the use of this statistical analysis in this context must respect some conditions. Indeed, tests for collinearity and stability showed that most of our multiple food groups had low level of collinearity, whereas backward and forward stepwise procedures did not produce high level of stability for body weight and the sum of 6 skinfold thickness models. These observations did not affect our confidence in results for 2 main reasons. First, whole fruit and skimmed milk or partly skimmed milk were found to be the only 2 food patterns consistently associated with all body-weight indicators in the forward stepwise procedure. Second, the associations found with the stepwise procedure were in accordance with the main outcome of the food-based questionnaire, which revealed that a self-reported decrease in the consumption of fat and fatty foods and an increase in intake of the fruit group prevented body-weight gain over time. The use of the stepwise procedure in this context allowed us to explore the effect of more detailed food patterns on body weight and ultimately to provide more meaningful nutritional recommendations in a clinical context.

Some limitations of our study have to be acknowledged. First, the food pattern modifications evaluated with the food-based questionnaire can be subject to social desirability biases. The small number of subjects found in some dietary pattern modification groups, as assessed by the food-based questionnaire, suggests the presence of such a bias. A second limitation comes from the evaluation of changes in the more detailed food groups. These food patterns were obtained at 2 time points only, without consideration of intermediate changes in food group consumption or body weight and adiposity. This evaluation could have decreased the magnitude of the association of some food groups with body weight changes as reflected by the small r^2. However, the small r^2 found in the stepwise models is not surprising, considering the dietary record limitations and the multifactorial aspect of body-weight gain. Third, it should also be mentioned that subjects included in the present study were volunteers involved in a longitudinal study, and thus they could represent a group of health-conscious individuals. We have to be conscious of this possibility in extrapolating our results to the general population. Finally, the present study does not provide evidence for a causal link between the dietary pattern modifications identified and body-weight and adiposity changes.

In summary, this study suggests that some dietary pattern modifications, identified with the use of a simple food-based questionnaire, could help to prevent or at least limit body-weight and adiposity gain over time. An increase in whole fruit as well as skimmed and partly skimmed milk also appeared to be the specific food-pattern modification consistently associated with better body-weight control over time in this population. Such least-fattening food patterns could be helpful in developing dietary recommendations based on foods, which are easier to understand than recommendations based on nutrients. Consequently, this information could potentially be advantageous in obesity treatment and prevention strategies.

The contributions of the authors were as follows: VD reviewed the literature, performed the statistical analyses, interpreted the data, and drafted the manuscript; LA and GF were involved in the conduction of the study and the data collection; CL contributed to the statistical analyses; J-PD, CB, and AT were involved in the study design and data collection. All the authors revised the manuscript and contributed to the global issue of changes in the consumption of food groups. None of the authors had a personal or professional conflict of interest.

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APPENDIX A

Food pattern modifications questionnaire: Compared to 5 y ago, do you eat more, as much, or less of these food categories?

Food categories	More	As much	Less	I don't know
Sugar and sweet foods	__	__	__	__
Fat and fat foods	__	__	__	__
Salt and salty foods	__	__	__	__
Milk and milk products	__	__	__	__
Fruit	__	__	__	__
Vegetables	__	__	__	__
Meats	__	__	__	__
Breads and cereals	__	__	__	__
Soft drinks	__	__	__	__
Chocolate	__	__	__	__

APPENDIX B
Specific food groups obtained from dietary records food items

Food groups	Foods in this group
Sugar	White and brown sugar, syrup, honey, etc
Sweet foods	Candies, pudding, granola bars, sweet cookies, sherbet
Sweet and fat foods	Other cookies, donuts, buns, pies, muffins, ice cream
Fruit beverage	Sugar-added beverage, cocktail juice
Saturated fats	Butter, lard, shortening, hydrogenated oils and margarines
Fatty and fried foods	French fries or onions, fried fish, flaky pastry, etc
Unsaturated fats	Oils and nonhydrogenated margarines
Salt and salty foods	Salt, chips, salty snacks, crackers with $>$100 mg sodium
Sauces	White and brown sauces
Broth[1]	Chicken, beef or vegetable broth, stock
Soups	Vegetable soup, chicken soup, noodle soup, etc
Cream soups	Chicken cream, mushroom cream, etc
Low-fat milk	Skimmed and partly skimmed milk
Regular milk	Whole milk
Low-fat yogurt	All yogurt with $<$2% fat
Regular yogurt	All yogurt with $>$2% fat
Low-fat cheeses	All cheeses with $<$20% fat
Regular cheeses	All cheeses with $>$20% fat
Cream	Cream and sour cream
Whole fruit	Fresh, frozen, or cooked apple, banana, orange, etc
Fruit juice	Nonsweet fruit juice: orange, apple, pineapple
High-fat fruit	Olives and avocadoes
Whole vegetables	Fresh, frozen, or cooked carrots, broccoli, sprouts, etc
Vegetable juice[1]	Vegetable, tomato, carrot juices
Low-salt marinades[1]	Marinades with $<$100 mg sodium
Potatoes	Mashed, boiled, roasted potatoes
Prepared salads	Salads with regular dressing
Legumes	Lentils, beans, peas
Regular meats	Regular beef, pork, chicken with skin, etc
Lean meats	Lean beef and pork, chicken or turkey breast without skin, etc
Giblets[1]	Giblets (chicken, turkey), offal (beef, pork)
Fish	All kinds of fish: salmon, tuna, trout, etc
Seafood	All kinds of seafood: shrimp, lobster, mussels, etc
Regular processed meats	Bologna, salami, pepperoni, etc
Low-fat processed meats	Low-fat ham, chicken, or turkey breast slices; pastrami; etc
Eggs	Fresh, boiled, fried eggs
Bread, pasta, rice, crackers	All kinds of breads, pastas, rice, and low-sodium crackers
Cereals and flours	Ready-to-eat cereals, oatmeal, and all kinds of flours
Regular sodas	Pepsi, 7-Up, Coke, Sprite, etc
Diet sodas[1]	Diet Pepsi, diet 7-Up, diet Coke, diet Sprite
Chocolate	All kinds of chocolate
Alcoholic beverages	Wine, beer, liquor, aperitifs, spirits
Nonalcoholic beverages[1]	Beer and wine without alcohol
Fast food	McDonalds, Burger King, etc
Nuts and seeds	Almonds, pistachios, cashews, peanuts, etc, and all kinds of seeds
Mixed meals	All kinds of sandwiches, meat loaf, meat pie, spaghetti with sauce, all kinds of frozen meals, quiches, ragout
Pizza	Ready-to eat pizza
Meal substitutes[1]	Slim-Fast shake or bar, Ensure, Nutribar
Hot beverage[1]	Coffee, tea, cocoa
Condiments[1]	Vinegar, mustard
Others[1]	Seasoning (basil, parsley, etc), essence extract, decaffeinated coffee

[1] Not included in the analyses (SD $<$ 1).