Higher nutritional quality at no additional cost among low-income households: insights from food purchases of "positive deviants"

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ABSTRACT

Background: It is unknown whether diet quality is correlated with actual food expenditure. According to the positive deviance theory, the study of actual food expenditure by people with limited economic resources could help identify beneficial food-purchasing behavior.
Objectives: The aims were to investigate the relation between actual expenditure on food and nutritional quality and to identify "positive deviants" among low-income households.
Design: Individuals in deprived social situations ($n = 91$) were recruited as part of the "Opticourses" nutrition intervention conducted in 2012–2014 in poor districts of Marseille, France. Opticourses participants collected food-purchase receipts for their household over a 1-mo period. "Actual diet costs" and "estimated diet costs" were calculated per 2000 kcal of food purchases by using actual expenditures and a standard food price database of food consumed by a representative sample of French adults, respectively. Mean adequacy ratio (MAR), mean excess ratio (MER), and energy density (ED) were used as nutritional quality indicators. "Positive deviants" were defined as having a higher MAR and a lower MER than the respective median values.
Results: Opticourses participants selected less-expensive food options than the average French population, both within a food group and for a given food item. Higher diet costs were associated with higher nutritional quality (higher MAR, lower ED), regardless of whether costs were calculated from actual expenditure or on the basis of standard food prices. Twenty-one positive deviants were identified. They made significantly healthier purchases than did other participants (MAR: +13%; MER: −90%. ED: −22%) at higher estimated diet costs. Yet, they did not spend more on food (having the same actual diet costs), which showed that they purchased food with a higher nutritional quality for their price.
Conclusion: In this low-income population, actual diet cost was positively correlated with nutritional quality, yet the results showed that higher diet quality is not necessarily more costly when foods with higher nutritional quality for their price are selected. The Opticourses intervention was registered at clinicaltrials.gov as NCT02383875. *Am J Clin Nutr* 2015;102:190–8.

Keywords: nutrition economics, food expenditure, nutritional quality, low income, positive deviance

INTRODUCTION

Cross-sectional epidemiologic studies have always shown a positive association between diet quality and diet cost, regardless of the country (1–5) or of a population's socioeconomic status (6, 7). Lower incomes are generally associated with lower diet costs and lower quality diets (4, 8, 9). The social gradient in diet quality may therefore be explained by the high cost of healthy diets (10), and so the higher cost of more nutritious diets may contribute to socioeconomic disparities in health (11).

In a precursory study, McAllister et al. (12) showed that healthier diets usually but not necessarily cost more. In self-selected diets they observed a positive association between diet quality and diet cost, but they also showed that healthy diets can be designed at a moderate cost and need not be more expensive (12). An overall positive relation between diet quality and diet cost was observed in the United States among women in the Nurses' Health Study, but large interindividual variability was found, with some women in the lowest quintile of daily diet cost having healthy diets (3). In the NHANES, US adults from some ethnic groups were shown to consume lower-cost yet higher-quality diets (4, 13). This is reminiscent of the positive deviance theory that emerged in the 1970s for community education (14). It is predicated on the observation that even in "at risk" situations, there are some individuals or households, called "positive deviants," with uncommon but beneficial behavior, leading to adequate food security, housing, or health (14). In the field of nutrition, dietary patterns of positive-deviant individuals could provide insights into how appropriate consumption can be achieved in an unfavorable context, such as with limited economic resources, cultural pressures, or low educational standards (15).

The variability in food choices and food expenditure is the key to identifying the best food pattern to reach nutritional recommendations under budget constraints. Unfortunately, the studies

on the link between diet costs and nutritional quality did not use actual food expenditures but instead used standard food price databases, computed from prices paid by a national panel (1, 2, 4) or from local supermarket retail prices (6, 8). Yet, a number of studies have shown the feasibility and accuracy of using cash register receipts to assess actual expenditure and food patterns of households (16–20).

Thus, in previous studies, the relation between diet costs and the nutritional quality of diets was always explored by using standard food prices (1–7), and when food expenditure was recorded, its association with indicators of diet quality was never explored (16–19). In the present study, we used food-purchase cash register receipts for a 1-mo period, collected as part of the baseline assessment of a nutrition intervention conducted in a low-income population, to test whether the positive relation observed between diet cost and nutritional quality is confirmed when diet cost is estimated from actual expenditure. In addition, the present study aimed at exploring the variability in food-purchasing behavior to identify "positive deviants" among low-income households.

METHODS

The Opticourses intervention

Data for the present study were collected as part of the baseline assessment of the Opticourses nutrition intervention (21), which aims to improve the nutritional quality of food purchases under budgetary constraints. The criteria for households to be included in the study were willingness to be involved in an intervention session, consisting of five 2-h workshops, and living in the northern districts of Marseille. These districts are socioeconomically deprived, with very low incomes, heavy financial dependence on social benefits, and overrepresentation of individuals covered by free social security. The workshops were based on the individuals' actual food purchases and, notably, on their cash register receipts. During the 5 worshops, the receipts were used as intervention tools: participants and research staff discussed the receipts brought in by all participants and exchanged ideas and experiences around food-purchasing behaviors. Over 2 y, between September 2012 and September 2014, 91 participants kept a detailed record of the quantities of food entering their household over 1 mo, including purchases, gifts, and from other sources. During 1 of the 5 workshops, each participant had a face-to-face interview to answer questions related to their household, particularly how they perceived their financial situation. All participants provided written informed consent to participate in the study and were compensated for collecting their food purchase receipts. No institutional review board approval was necessary for this research, as stated by the Comité de Protection des Personnes Sud-Méditerranée, which reviewed the protocol of the Opticourses education intervention. This trial was registered at clinicaltrials.gov as NCT02383875.

Food-composition database and "standard food price database"

Food product nutrient composition was obtained from the national food database created by ANSES (French Agency for Food, Environmental and Occupational Health Safety), which includes 1343 food items declared as consumed by a represen-

tative sample of 2624 adults participating in the 2006–2007 national dietary survey Individuelle Nationale des Consommations Alimentaires (INCA2) (22). Drinking water was excluded from all analyses because it is not necessarily purchased. All remaining foods were aggregated into 9 groups and 29 categories. For instance, the "nuts," "vegetables," and "fruit" categories (including fruit juices) were combined into the "fruit and vegetables" group.

A "standard food price database" was obtained by estimating the standard price of each of the 1343 INCA2 food items from the 2006 Kantar-World Panel purchase database (23), which gives the annual expenditure and quantity purchased of food products registered through the use of bar codes by a representative sample of 12,000 French households. For each INCA2 food item, its standard price was calculated by dividing the annual expenditure by the quantities purchased of all of the food products available on the market corresponding to this item in the Kantar-World Panel purchase database. Because these were the prices paid by a representative panel of consumers, the standard prices reflected the most frequently purchased forms of each food. After adjustment for preparation and waste, food prices in the database were expressed in euros (€) per 100 g of edible portion.

Receipt protocol training and data collection

At the first workshop, the protocol for receipt collection and annotation was explained to the participants. They were asked to save all receipts for foods consumed at home during a 1-mo period. Foods consumed outside of home were not included. To facilitate data collection, participants were given a notebook of food purchases in which they could find step-by-step instructions, example receipts, and, on the last page, an envelope in which to collect the receipts. In case of incomplete or ambiguous printed information with regard to the name of the store, the name of a food, the quantities purchased, or the price paid for a food, participants were instructed to write it on the receipt. Expenditures without receipts (gifts or from other sources) were to be recorded in the notebook: we also use the term "receipt" to refer to these food items. The participants were also requested to ask other household members to keep their receipts. The second workshop, 2 wk later, provided the opportunity to discuss the receipt collection and to help participants encountering difficulties. At the third workshop, after another 2 wk, each participant handed over the notebook of food purchases; it was checked to verify whether there was any missing information, and the notebook was kept for analysis by dietitians. Food waste or meals consumed by visitors were not recorded because Nelson et al. (24) showed that adjustments to purchases for waste are negligible and foods consumed by visitors account for <0.5% of average family food energy purchased.

Data record protocol and creation of the "Opticourses food price database"

When collected, the annotated receipts were entered into a food-purchases database. For each food item, date of purchase, source, the most accurate INCA2 food name and corresponding INCA2 food code, quantity, and price were entered. Not all of the receipts contained the information about the purchased quantity.

In those instances, 3 methods were used to determine an appropriate estimate of quantity: *1)* commercial websites containing databases of foods with detailed quantity descriptions were searched; *2)* if the information was not available but the food item was purchased at least twice (with the receipt showing the weights) among all households, we calculated an observed mean food price per unit of weight and then, to estimate the quantity purchased, we divided the price paid for the food item by the corresponding observed mean price; *3)* if we did not have an observed mean food price, we used the corresponding standard food price in the same way.

We created the "Opticourses food price database," which contains observed mean food prices per unit of weight for foods purchased at least twice among all households with the receipt showing the weights. For cases in which the food consumed was gifted or came from food aid, we calculated a theoretical price using the observed mean food price. For each item, an edible portion was calculated to take into account the changes in weight associated with preparation and waste.

We use the term "diet" to refer to daily purchases per person or per 2000 kcal of purchases. We use "actual diet cost" to refer to the actual amount of money spent by households for their food purchases (i.e., as indicated by the receipts) per person or per 2000 kcal. We use the term "estimated diet cost" to indicate the cost of a diet calculated with the standard food price database per person or per 2000 kcal.

Data analysis

Price and type of food purchased

The price and type of food purchased by the households of Opticourses participants (also called "Opticourses households" below) were analyzed by comparing different ways of calculating the median energy cost (price per 100 kcal) of 7 food groups. First, the median energy cost was calculated by using the standard prices of all of the food items included in the standard food price database for each food group. Second, the median energy cost was calculated by using the standard prices but only for the food items actually purchased by Opticourses households. Opticourses participants did not purchase all of the food items included in the standard food prices database. Third, the median energy cost was calculated by using only the Opticourses food price database (i.e., by including only the food purchased by the Opticourses households and at the prices paid, on average, by this population).

Diet cost and nutritional quality

Daily food weight (in g/d per person), daily energy intake (in kcal/d per person), and daily nutrient intake (in g, mg, or μg/d per person) were estimated for each household by summing the edible weight and the energy or the nutrient content of all foods and beverages purchased and dividing by the number of days of data collection and the number of household members.

Actual diet cost and estimated diet cost

The actual diet cost (in €/d per person) was calculated for each household by summing receipt prices of all foods and beverages purchased and dividing by the number of days of data collection and the number of household members. The estimated diet cost (in €/d per person) was calculated with the standard food price database, by multiplying the edible weight of each food and beverage by its unit cost, summing over all foods and beverages purchased, and dividing by the number of days of data collection and the number of household members. The actual and estimated diet costs per 2000 kcal were also calculated.

Dietary energy density

High dietary energy density (ED)[3] is an indicator of poor nutritional quality (25, 26). ED (in kcal/100 g) was calculated by dividing the total energy provided by solid foods (including soups) by their total edible weight. As suggested by Ledikwe et al. (27), foods typically consumed as beverages (e.g., milk, juices, and soft drinks) were not included in the calculation of ED.

Mean adequacy ratio

The mean adequacy ratio (MAR) was used as an indicator of nutritional adequacy (28). It was calculated as proposed by Maillot et al. (29) as the mean percentage of the recommended intakes for 23 nutrients (proteins, fiber, linoleic acid, linolenic acid, DHA, vitamin A, thiamin, riboflavin, niacin, vitamin B-6, folates, vitamin B-12, ascorbic acid, vitamin E, vitamin D, calcium, potassium, iron, magnesium, zinc, copper, iodine, and selenium) as follows:

$$MAR = \frac{1}{23} \times \left(\sum_{n=1}^{23} \frac{Quantity_n}{RDA_n} \times 100 \right) \quad (1)$$

$Quantity_n$ is the quantity of each nutrient per 2000 kcal of purchases and RDA_n is the French Recommended Dietary Allowance (RDA) (30) for that nutrient (mean for men and women). Each ratio ($Quantity_n$:RDA_n) was limited to 1, so that a large quantity of 1 nutrient could not compensate for a small quantity of another (31).

Mean excess ratio

The mean excess ratio (MER) was used as an indicator of nutrients to be restricted (32). It was developed by Vieux et al. (32) by analogy with the MAR as the mean percentage of maximum recommended values (MRVs) for 3 harmful nutrients (hn), namely SFAs, sodium, and free sugars, as follows:

$$MER = \left[\frac{1}{3} \times \left(\sum_{hn=1}^{3} \frac{Quantity_{hn}}{MRV_{hn}} \times 100 \right) \right] - 100 \quad (2)$$

$Quantity_{hn}$ is the intake of each harmful nutrient per 2000 kcal of purchases. Free sugars include sugars naturally present in honey, syrups, and fruit juices and added sugars (33). The MRVs for SFAs and free sugars correspond to 10% of an energy intake of 2000 kcal (i.e. 22.2 and 50 g, respectively). The MRV for sodium was 3153 mg and corresponded to an intake of 8 g NaCl.

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[3] Abbreviations used: ED, energy density; INCA, Individuelle Nationale des Consommations Alimentaires; MAR, mean adequacy ratio; MER, mean excess ratio; MRV, maximum recommended value; RDA, Recommended Dietary Allowance.

Each ratio (Quantity$_{hn}$:MRV$_{hn}$) <1 was set to 1, so that a low intake of 1 harmful nutrient could not compensate for the high intake of another.

Identification of "positive deviants"

The method for classifying households on the basis of the nutritional quality of their purchases was inspired by Vieux et al. (32). MAR and MER per 2000 kcal of purchases were calculated for each household. Households were then ranked according to the value of these 2 indicators compared with their observed median. High-nutritional-quality purchases met with the 2 following criteria: MAR above the median and MER below the median. We refer to the households with such purchases as "positive deviants."

Statistical methods

Nonparametric statistics were used because diet variables were not normally distributed in this small sample of households. Wilcoxon's Matched-Pairs Signed Rank test and Spearman correlation were used for paired comparison and for correlations between variables, respectively. Wilcoxon two-sample test was used to compare quantitative variables of 2 independent groups and chi-square test was used to compare qualitative variables. An α level of 0.05 was chosen to determine statistical significance. Statistical analyses were performed by using SAS software version 9.4 (SAS Institute).

RESULTS

Opticourses households: descriptive characteristics

Seventy-six percent of the Opticourses participants were female. Opticourses households had 3 or 4 people on average [1.8 (range: 1–7) adults and 1.7 (range: 0–6) children], but 18% of participants lived alone (81% male and 19% female) and 25% of households comprised single women with children. The mean ($\pm$SD) age of Opticourses participants was 48.1 $\pm$ 10.1 y. Only 15% reported being in a stable financial situation, 48% were in a precarious financial situation, and 37% had severe financial difficulties. Ten households consisted of food aid recipients (i.e.,

11% of the studied sample); food aid represented, on average, 30% $\pm$ 25% of their energy intake (data not shown). On average, each household shopped at 5 different stores to buy food while collecting receipts.

We identified 21 positive-deviant households. **Table 1** shows that there was no difference in descriptive characteristics between positive deviants and other households. Household composition, the number of stores patronized, and the financial situation of the 2 groups were similar.

Price and type of food purchased by Opticourses households

A total of 9742 food items were purchased by Opticourses households and included in the food-purchases Opticourses database. The mean ($\pm$SD) number of days between the first and last receipt provided by households was 28.4 $\pm$ 17.1 d. **Figure 1** shows that the median energy costs of the "fruit and vegetables" and the "meat, fish, and eggs" groups were significantly lower when they were calculated by considering only the food bought by the Opticourses households and not all of the food present in the standard food database. This means that Opticourses households chose the less-expensive options within those 2 specific food groups but not within the other food groups. Figure 1 also shows that, within each food group, the median energy costs were significantly lower with Opticourses prices than with standard prices, except for starchy foods, which showed that Opticourses households also selected less-expensive options of the same food item. Yet, we observed the same hierarchy of food groups in terms of energy costs. Indeed, fruit and vegetables remained the most expensive energy source, whereas fats remained the least expensive, no matter how the median energy cost was calculated.

Spearman correlations between standard energy costs and Opticourses energy costs were performed for all foods purchased by Opticourses households and within each food group. All correlations were significant (data not shown), showing the same ranking of food prices for both Opticourses and standard food prices.

TABLE 1
Sociodemographic characteristics of Opticourses households

	All ($n = 91$)		Positive deviants[1] ($n = 21$)		Others ($n = 70$)		
	Mean $\pm$ SD	Median (IQR)	Mean $\pm$ SD	Median (IQR)	Mean $\pm$ SD	Median (IQR)	P
Respondent age, y	48.1 $\pm$ 10.1	48 (42–55)	52.0 $\pm$ 11.2	52 (46–58)	46.8 $\pm$ 9.42	47.5 (41–53)	0.053[2]
Household members, n	3.41 $\pm$ 1.97	3 (2–5)	3.24 $\pm$ 2.00	3 (2–5)	3.46 $\pm$ 1.96	3 (2–5)	0.62[2]
Children, n	1.70 $\pm$ 1.68	2 (0–3)	1.75 $\pm$ 1.86	1 (0–3.5)	1.69 $\pm$ 1.63	2 (0–3)	0.94[2]
Stores, n	4.85 $\pm$ 3.22	4 (2.5–6.5)	5.42 $\pm$ 4.05	5 (2–8)	4.69 $\pm$ 2.95	4 (3–6)	0.71[2]
Female respondents, %	77		81		74		0.53[3]
Food aid recipients, %	11		14		10		0.58[3]
Financial situation, %							0.47[3]
Stable	15		20		14		
Precarious	48		40		51		
Severe difficulties	37		40		35		

[1]"Positive deviants" is defined as having a higher MAR and a lower MER than the respective median values. MAR, mean adequacy ratio per 2000 kcal; MER, mean excess ratio per 2000 kcal.
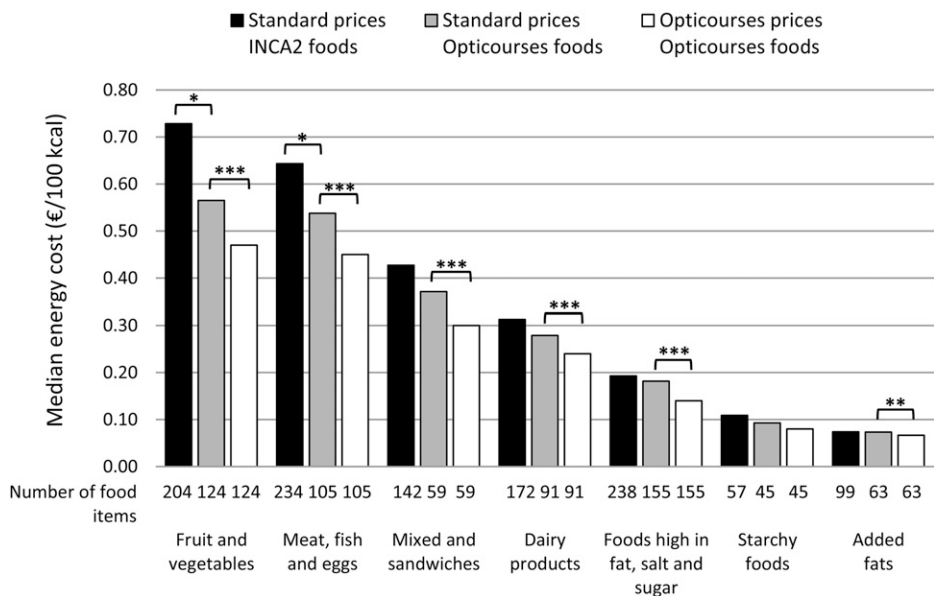[2]Wilcoxon two-sample test.
[3]Chi-square test.

FIGURE 1 Median energy costs (€/100 kcal) of ■ all foods in the national INCA2 food database using the standard food prices database; ▨ the foods purchased by Opticourses households using the standard food prices database; and ☐ the foods purchased by Opticourses households using Opticourses prices; by food group, ranked from the most expensive to the least expensive. Comparisons between median energy costs of INCA2 foods and Opticourses foods at standard prices were made with Wilcoxon two-sample test for each food group. Comparisons between median energy costs of Opticourses foods at standard prices and at Opticourses prices were made with Wilcoxon's Matched-Pairs Signed Rank test for each food group. $*P < 0.05$, $**P < 0.01$, $***P < 0.0001$. INCA, Individuelle Nationale des Consommations Alimentaires.

Relations between diet cost and nutritional quality

MAR and MER were mutually independent and, as expected, ED was negatively correlated with MAR and positively correlated with MER (**Table 2**). Regardless of whether diet cost was estimated from the standard food prices database (i.e., estimated diet cost) or on the basis of actual expenditure (i.e., actual diet cost), it was correlated in the same way with nutritional quality of diet: positively with MAR and negatively with ED. A more-expensive diet was nutrient rich and less energy dense, but there was no correlation with MER (Table 2).

Purchase characteristics

Diet cost and nutritional quality

The total mean energy purchased was 2450 kcal/d per person for a total mean edible weight of 1818 g/d per person (excluding drinking water), with wide variability due to the collection method. The nutritional quality indicators show, on average, an ED of 200 kcal/100 g, 74% of adequacy for the MAR, and 16% of excess for the MER (**Table 3**). Although actual and estimated diet costs were strongly correlated with one another (Spearman correlation: 0.84; Table 2), mean actual diet cost was significantly lower than mean estimated diet cost (3.65 vs. 4.77 €/d per person, respectively). The actual energy cost per 2000 kcal was 3.03 € and was significantly lower than the energy cost estimated with standard food prices (4.00 €/2000 kcal) (Table 3).

As expected, food purchases of positive deviants had a significantly higher MAR, lower MER, and consequently lower ED than food purchases of other Opticourses households. There was no significant difference in total energy purchased, total edible weight, or weight of solid foods. Actual daily cost and actual energy cost (per 2000 kcal) were similar for positive deviants and other households, but estimated energy cost (per 2000 kcal) was

significantly higher in purchases of positive deviants (Table 3). Compared with the rest of the population, the diets of positive deviants had higher amounts of 15 nutrients (of the 23 MAR nutrients) and lower contents of SFAs and free sugars but not sodium (**Supplemental Table 1**).

Food choices

Table 4 shows the mean amounts bought and expenditures for each food group and food category per 2000 kcal of purchases. Meat, fish, and eggs were the main contributors to food expenditure, at 0.85 € per 2000 kcal. Starchy foods, fruit and vegetables, and foods high in fat, salt, and sugar contributed to an equal proportion of the diet cost, ~0.50 € for each per 2000 kcal. Moreover, Table 4 compares food choices of positive deviants and the other households. The positive deviants purchased more fish and eggs, more starchy foods, especially more refined and unrefined grains, more fruit and vegetables, but less food high in fat, salt, and sugar, especially fewer sweets, soft drinks, and salty snacks, and fewer sandwiches and pizzas. The positive deviants purchased the same amount of dairy products, but

TABLE 2
Spearman correlations between estimated diet cost per 2000 kcal and actual diet cost per 2000 kcal and 3 indicators of nutritional quality—MAR, MER, and ED—in the Opticourses population[1]

	MER	ED	Estimated diet cost	Actual diet cost
MAR	0.11	−0.70***	0.61***	0.58***
MER		0.21*	0.17	0.15
ED			−0.46***	−0.41***
Estimated diet cost				0.84***

[1]$n = 91$. $*P < 0.05$, $***P < 0.0001$. ED, dietary energy density, in kcal per 100 g; MAR, mean adequacy ratio per 2000 kcal; MER, mean excess ratio per 2000 kcal.

TABLE 3
Purchasing characteristics of Opticourses households in terms of nutritional quality and cost[1]

	All (n = 91)		Positive deviants[2] (n = 21)		Others (n = 70)		
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	P[3]
Total energy, kcal/d per person	2450 ± 1572	2173 (1452–3060)	2090 ± 1030	1956 (1439–2327)	2557 ± 1693	2222 (1575–3060)	0.19
Total weight, g/d per person[4]	1818 ± 1551	1462 (904–2391)	1607 ± 748	1457 (1115–2215)	1881 ± 1720	1497 (839–2485)	0.49
Weight of solid food, g/d per person[4]	1188 ± 857	1012 (669–1461)	1241 ± 615	1021 (846–1582)	1173 ± 921	975 (654–1444)	0.16
ED, kcal/100 g	200 ± 47.0	187 (164–235)	160 ± 20.8	163 (143–172)	212 ± 46.3	207 (176–243)	<0.0001
MAR, % adequacy/2000 kcal	73.9 ± 9.37	75.0 (67.9–81.2)	81.2 ± 4.4	81.2 (77.5–84.0)	71.7 ± 9.4	71.4 (66.4–79.1)	<0.0001
MER, % excess/2000 kcal	15.8 ± 17.5	10.6 (1.05–26.4)	1.69 ± 2.18	0.90 (0.00–2.62)	20.0 ± 17.9	16.5 (5.85–30.9)	<0.0001
Daily cost, €/d per person							
Estimated diet cost	4.77 ± 3.21	4.06 (2.78–5.76)	4.47 ± 2.30	3.96 (2.86–5.40)	4.85 ± 3.45	4.15 (2.75–5.76)	0.48
Actual diet cost	3.65 ± 2.54	3.07 (2.11–4.43)***	3.34 ± 1.93	2.77 (2.11–4.23)	3.75 ± 2.70	3.23 (2.13–4.61)	0.35
Energy cost, €/2000 kcal							
Estimated diet cost	4.00 ± 1.23	3.71 (3.06–4.67)	4.40 ± 1.15	4.50 (3.26–5.29)	3.88 ± 1.24	3.57 (3.04–4.56)	0.03
Actual diet cost	3.03 ± 0.95	2.91 (2.27–3.70)***	3.17 ± 0.87	3.20 (2.57–3.70)	2.98 ± 0.97	2.86 (2.19–3.68)	0.18

[1]***Wilcoxon's Matched-Pairs Signed Rank test between estimated diet cost and actual expenditure medians, $P < 0.0001$. ED, energy density; MAR, mean adequacy ratio; MER, mean excess ratio.

[2]"Positive deviants" is defined as having a higher MAR and a lower MER than the respective median values.

[3]Wilcoxon two-sample test.

[4]Edible weight.

tended to buy less cheese. They bought the same amount of added fats. Table 4 also compares expenditures of positive deviants and others. The difference between positive deviants and others was comparable to the difference between food expenditure and food weights, which suggests that positive deviants and the other households purchased their food at the same price. To confirm our findings, we calculated actual mean prices per food group for positive deviants and for other households. Wilcoxon's matched-pairs comparison did not show any difference (data not shown).

DISCUSSION

This is the first study, to our knowledge, to assess the relation between the actual cost of diets and their nutritional quality. Based on household food purchases, the results confirm that the known positive association between diet nutritional quality and diet costs (1–5) exists even within a low-income population (6) and they show that this relation persists when using actual food expenditure. However, much variability in food-purchasing behavior was observed, so it was possible to identify positive deviants who purchased higher-quality diets at no additional cost and to characterize their food choices.

One strength of this study was the use of real food expenditure. Opticourses households actually spent 3.65 €/d per person on food consumed at home, which is remarkably close to the mean national expenditure for food at home for households in the lowest quintile of socioeconomic conditions, as calculated by the French National Institute of Statistics and Economic Studies from the last French National Budget Survey (i.e., 3.85 €/d per person in 2005) (34). Compared with expenditure on food consumed at home in the general French population (i.e., 5.25 €/d per person), the Opticourses population spent rather little on food. The use of standard food prices instead of prices actually paid by this population would overestimate their real expenditure on food by ~1 €/d per person (4.77 vs. 3.65 €). Previous studies also found relatively weak agreement between diet cost estimated with standard food prices and with prices actually paid

by individuals (35–37). This important difference in daily diet costs can be explained by different food choices, as suggested by the comparison of the Opticourses food price database with the standard food price database. We highlighted 2 distinct strategies implemented by Opticourses households to economize their food budget: they selected the less-expensive food items within a food group and they purchased the cheapest options for a given food item. Indeed, in France, branded products were found to cost, on average, 2.5 times more than the cheapest version of the same product (38), which is why low-income households increasingly shop at discount food stores and to a larger extent than do affluent people (34). Yet, although food budgets in low-income households are low, it represents a high proportion of their total budget, as predicted by Engel's law (39).

A positive correlation between diet nutritional quality and cost was observed regardless of whether energy cost was estimated from standard food prices or cash register receipts. Opticourses participants purchased less-expensive food, but the ranking of energy costs among food groups remained the same as in the standard food price database. As previously observed, low-energy-dense and nutrient-rich foods, such as fruit and vegetables or meat products, were the most expensive sources of calories, whereas energy-dense and nutrient-poor foods, such as foods high in fat, salt, and sugar; starchy foods; or added fats were the cheapest sources of calories (40, 41). This relation between food prices and nutritional quality among food products forms the basis of the positive association between food expenditure and nutritional quality. Because Opticourses participants had a small amount of money to spend on food, the higher energy costs of healthy food groups were likely to be a barrier to healthy eating. Incidentally, their food purchases showed less-favorable nutritional quality indicators (more energy dense and less nutrient rich) than the average French diet (32).

The selection process of positive deviants led to the identification of 21 participants who purchased higher-quality diets (+13% of MAR, −90% of MER, and −22% of ED compared with the other households). In accordance with the positive

TABLE 4

Opticourses-household purchases: mean amounts (g/2000 kcal) and expenditures (€/2000 kcal), by food group and food category, in descending order of expenditure[1]

| | Quantities, g/2000 kcal | | | | Expenditure, €/2000 kcal | | | |
| | Positive deviants[2] | | | | Positive deviants | | | |
	All (n = 91)	(n = 21)	Others (n = 70)	P[3]	All (n = 91)	(n = 21)	Others (n = 70)	P[3]
Meat, fish, and eggs	132 ± 84.2	147 ± 53.1	124 ± 88.4	0.01	0.85 ± 0.60	0.95 ± 0.55	0.80 ± 0.59	0.06
Red meat	51.0 ± 65.6	44.9 ± 33.4	51.2 ± 70.1	0.22	0.39 ± 0.47	0.39 ± 0.44	0.37 ± 0.45	0.28
Poultry	28.9 ± 44.1	28.5 ± 39.6	28.4 ± 45.0	0.42	0.17 ± 0.26	0.19 ± 0.34	0.16 ± 0.22	0.49
Fish and shellfish	18.9 ± 27.6	32.6 ± 39.4	14.3 ± 21.1	0.02	0.17 ± 0.20	0.24 ± 0.23	0.14 ± 0.18	0.03
Deli meat	11.6 ± 16.6	9.28 ± 11.9	12.0 ± 17.4	0.38	0.07 ± 0.12	0.05 ± 0.06	0.08 ± 0.13	0.25
Eggs	20.5 ± 25.4	30.0 ± 30.8	17.2 ± 22.2	0.04	0.05 ± 0.06	0.08 ± 0.08	0.04 ± 0.04	0.05
Offal	1.06 ± 3.86	2.04 ± 6.10	0.75 ± 2.84	0.27	0.01 ± 0.02	0.01 ± 0.03	0.01 ± 0.02	0.28
Starchy foods	386 ± 183	500 ± 171	344 ± 168	0.0002	0.52 ± 0.29	0.62 ± 0.24	0.48 ± 0.30	0.008
Refined grains	287 ± 172	365 ± 168	258 ± 163	0.003	0.42 ± 0.28	0.50 ± 0.23	0.39 ± 0.29	0.02
Potatoes	72.4 ± 76.4	91.5 ± 103	65.4 ± 65.1	0.27	0.07 ± 0.07	0.09 ± 0.09	0.06 ± 0.05	0.12
Legumes	21.2 ± 48.1	27.9 ± 59.9	18.7 ± 43.6	0.26	0.02 ± 0.07	0.02 ± 0.03	0.02 ± 0.07	0.26
Unrefined grains	5.29 ± 21.5	15.6 ± 40.3	1.98 ± 5.01	0.08	0.01 ± 0.02	0.02 ± 0.03	0.01 ± 0.02	0.09
Fruit and vegetables	272 ± 151	389 ± 160	232 ± 123	<0.0001	0.50 ± 0.31	0.69 ± 0.29	0.43 ± 0.28	0.0001
Vegetables	136 ± 93.2	193 ± 94.6	117 ± 84.1	0.0007	0.26 ± 0.21	0.35 ± 0.19	0.23 ± 0.21	0.001
Fruit	135 ± 107	195 ± 148	113 ± 75.5	0.001	0.22 ± 0.16	0.34 ± 0.21	0.19 ± 0.11	0.0007
Nuts	1.65 ± 6.18	0.31 ± 1.29	1.99 ± 6.75	0.07	0.01 ± 0.05	0.004 ± 0.01	0.02 ± 0.06	0.08
HFSS	199 ± 140	89.7 ± 64.9	228 ± 139	<0.0001	0.48 ± 0.33	0.27 ± 0.14	0.54 ± 0.33	<0.0001
Sweets	50.6 ± 33.7	28.8 ± 19.6	56.2 ± 34.0	0.0001	0.22 ± 0.15	0.13 ± 0.10	0.24 ± 0.16	0.0003
Desserts	32.7 ± 51.1	21.4 ± 18.9	35.1 ± 54.8	0.24	0.12 ± 0.20	0.09 ± 0.08	0.12 ± 0.20	0.38
Soft drinks	105 ± 118	33.9 ± 51.4	124 ± 123	0.0001	0.09 ± 0.13	0.02 ± 0.04	0.11 ± 0.13	<0.0001
Salty snacks	6.1 ± 9.4	2.60 ± 4.81	7.08 ± 10.1	0.01	0.04 ± 0.06	0.01 ± 0.02	0.04 ± 0.07	0.01
Breakfast cereals	4.75 ± 8.11	2.96 ± 6.34	5.22 ± 8.45	0.17	0.02 ± 0.03	0.01 ± 0.02	0.02 ± 0.03	0.15
Dairy products	185 ± 135	215 ± 177	172 ± 117	0.30	0.30 ± 0.19	0.31 ± 0.22	0.29 ± 0.19	0.40
Cheese	23.4 ± 18.5	19.1 ± 19.0	24.1 ± 17.8	0.07	0.16 ± 0.14	0.14 ± 0.15	0.16 ± 0.13	0.13
Milk	121 ± 120	158 ± 162	108 ± 101	0.29	0.08 ± 0.08	0.11 ± 0.11	0.07 ± 0.07	0.16
Yogurt	40.1 ± 35.2	38.5 ± 41.3	39.8 ± 33.0	0.32	0.06 ± 0.06	0.06 ± 0.07	0.06 ± 0.05	0.37
Mixed	33.5 ± 57.8	19.7 ± 52.8	36.5 ± 55.9	0.004	0.16 ± 0.29	0.09 ± 0.21	0.18 ± 0.29	0.01
Sandwiches, pizza	17.1 ± 27.9	10.1 ± 27.5	18.7 ± 26.6	0.01	0.10 ± 0.17	0.06 ± 0.11	0.11 ± 0.18	0.02
Mixed dishes	16.3 ± 41.9	9.57 ± 26.3	17.8 ± 43.6	0.11	0.06 ± 0.18	0.04 ± 0.12	0.07 ± 0.18	0.07
Other drinks	230 ± 529	167 ± 314	249 ± 579	0.26	0.11 ± 0.18	0.08 ± 0.11	0.12 ± 0.20	0.27
Hot drinks	211 ± 520	154 ± 318	228 ± 568	0.33	0.06 ± 0.13	0.05 ± 0.09	0.07 ± 0.14	0.39
Alcoholic drinks	14.9 ± 43.8	12.3 ± 36.2	15.7 ± 46.1	0.41	0.04 ± 0.11	0.03 ± 0.06	0.05 ± 0.12	0.36
Diet drinks	3.79 ± 12.7	1.03 ± 4.70	4.61 ± 14.1	0.12	0.004 ± 0.01	0.0004 ± 0.002	0.01 ± 0.02	0.11
Added fats	36.8 ± 26.4	29.9 ± 19.4	38.9 ± 27.9	0.08	0.09 ± 0.07	0.09 ± 0.07	0.09 ± 0.07	0.26
Oil and margarine	24.9 ± 22.3	21.6 ± 19.0	25.9 ± 23.2	0.28	0.06 ± 0.06	0.06 ± 0.06	0.06 ± 0.05	0.36
Butter and cream	8.40 ± 10.8	5.81 ± 6.97	9.18 ± 11.7	0.16	0.03 ± 0.04	0.02 ± 0.03	0.03 ± 0.04	0.30
High-fat sauces	3.57 ± 6.64	2.48 ± 4.04	3.90 ± 7.23	0.23	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.22
Condiments	14.5 ± 22.1	22.0 ± 40.1	12.3 ± 12.2	0.37	0.05 ± 0.07	0.08 ± 0.13	0.04 ± 0.04	0.26

[1] Values are means ± SDs. HFSS, foods high in fat, salt, and sugar; MAR, mean adequacy ratio; MER, mean excess ratio.
[2] "Positive deviants" is defined as having a higher MAR and a lower MER than the respective median values.
[3] Wilcoxon two-sample test.

deviance theory (14), the 21 positive deviants did not differ significantly from the other Opticourses participants in their household composition or their financial situation. Yet, they purchased more fish, eggs, fruit, vegetables, and starchy foods and fewer products high in fat, salt, and sugar than did the rest of the Opticourses population. Moreover, they purchased less cheese and fewer animal fats (butter and cream), although not significantly so. These food choices could contribute to an increase in energy costs (e.g., due to the higher cost of fruit, vegetables, and fish), but they actually did not. Indeed, for the positive deviants, we found an increase in energy costs estimated from standard food prices but not in actual energy costs. This showed that the use of the standard food price database

would have failed to identify nutritionally favorable purchasing behavior with no increase in food budget. Positive deviants purchased higher-quality diets at no additional cost, either per day or per 2000 kcal, suggesting that they selected foods with good nutritional quality for their price, as defined by Maillot et al. (42). Compared with the rest of the Opticourses population, they did not buy more cheaply, but they made different choices. Although their choices did not completely adhere to all nutritional recommendations (MAR <100%), these households managed to have a healthier diet than the general adult population in France, with an equivalent MAR and DE and lower MER (32), showing that it is possible to improve one's diet on a limited budget.

Opticourses participants were not asked to make an inventory of their food stocks at the beginning and end of the receipts collection to take changes into account (43). We assumed that there was no change in the average amounts of food stocks within all households, although some households certainly acquired more than they consumed and others less, using stocks to adjust their actual food intake, which is why we did not exclude any outlier on the basis of incomplete records and why dietary indicators, such as diet costs, MAR, and MER were expressed for each household per 2000 kcal of purchases for statistical analysis. Indeed, there was a wide variability in the energy purchased per day and per person according to the receipts collected, and because these indicators are dependent on total energy they needed to be energy-adjusted to reflect diet quality.

This study has several limitations. First, a generic food-composition database was used, although actual food purchases were recorded. We assumed that there was no difference in nutrient composition between foods of a particular type (e.g., corn flakes), because results from several studies have shown that there is no systematic association between sale price and nutritional quality for food products of a particular type (38, 44, 45). Second, foods bought and consumed away from home were not recorded. Although eating out represents 53% of food expenditure in the United States (46), it is far less common in France, and represents only 15% of food expenditure among the lowest-income decile (34). A third limitation was that food purchases from small shops and markets were difficult to record because receipts are often not given and it is more difficult for participants to remember exactly what they purchased and to write it down at home. This may apply particularly to fresh foods, such as fruit and vegetables. Hence, we may have underestimated the actual purchases of fruit and vegetables of Opticourses participants. Last, participants were recruited for an intensive nutrition education intervention. Thus, they were persons in financial difficulty but who were trying to overcome this and may have been more aware of nutritional concerns than the rest of the population of the northern districts of Marseille. In addition, collecting and noting receipts for 4 wk is a highly demanding task, requiring participants to be motivated and involved over the long term. However, this limitation can be viewed as a strength because such a recruitment bias likely increased the probability of identifying positive deviants.

This study confirms that higher-quality diets are usually more expensive than lower-quality diets; however, households purchasing low-cost diets without sacrificing nutrition were identified. The healthy purchasing behavior of positive deviants confirms the relevance of interventions aimed at making foods with good nutritional quality for their price visible, available, and attractive to make the best nutritional use for those on a limited food budget.

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