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Short Communication

Quantifying the contribution of foods with unfavourable nutrient profiles to nutritionally adequate diets

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Abstract

That 'all foods can fit' into a healthy diet is a long-standing principle of dietetic practice. The present study quantified the relative contributions of foods to encourage and foods to limit, using new techniques of individual diet optimisation and nutrient profiling. Individual foods from every food group were assigned to four nutrient profile classes based on the French SAIN,LIM system. Foods with the most favourable nutrient profiles were in class 1, and foods with the least favourable nutrient profiles were in class 4. An optimised diet that met the recommendations for thirty-two nutrients and that respected the existing eating habits was designed for each adult in the nationally representative 'Enquête Individuelle et Nationale sur les Consommations Alimentaires 1' dietary survey (*n* 1171). The relative proportions of the four nutrient profiling classes were assessed before and after the optimisation process. The contribution of fruits and vegetables, whole grains, milk and fish was significantly increased, whereas the contribution of refined grains, meats, mixed dishes, sugars and fats was decreased. The optimised diets derived more energy (30 *v.* 21 % in the observed diets) from class 1 foods and less energy (41 *v.* 56 %) from class 4 foods. They also derived a higher amount of class 1 foods (61 *v.* 51 %) and a lower amount of class 4 foods (22 *v.* 32 %). Thus, nutrient adequacy was compatible with the consumption of foods with an unfavourable nutrient profile (one-fifth the basket weight), provided that the diet also contained almost two-thirds of foods with the most favourable profile. Translating these results into concrete and quantified advice may have very tangible public health implications.

Key words: Standards: Classification: Linear models: Nutritive value: Foods

It is well established that healthful diets[1,2] ought to contain low-fat dairy products, fish and lean meats, beans and legumes, and plenty of vegetables and fruits[3–5]. However, much of dietary advice is still based on nutrients to avoid. Consumers are advised to limit the intake of SFA, sugar and Na[6–8] and to eat sparingly foods that contain those nutrients in excess[1,4]. Missing from nutrition education messages are many processed foods[9] and mixed foods belonging to more than one food group[10].

The 2005 Dietary Guidelines for Americans[11] identified nutrient density of foods as a novel strategy for nutrition education and positive dietary guidance. Consumers selecting nutrient-dense foods and beverages would be able to satisfy daily nutrient requirements without exceeding their daily energy needs[11]. Supplemental 'discretionary' energy, defined as the balance of energy remaining after satisfying nutrient needs, could then be consumed in proportion to energy allowance[11]. Nutrient-dense foods were described as those that provided relatively more nutrients than energy, whereas the amount of discretionary energy was set low[12].

The new science of nutrient profiling[13–15] can classify individual foods based on their overall nutritional quality. Nutrient profiling can help distinguish between nutrient-rich foods that provide more nutrients than energy and those foods that are energy-rich but are nutrient-poor[16]. Given that lower-scoring foods can be more enjoyable and may provide energy at a lower cost[17], calculating

Abbreviation: EAR, estimated average requirement.

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their relative proportion in a healthy diet is a question of both public health and consumer importance. Coupling the new techniques of nutrient profiling[14] and individual diet optimisation[18], the objective of the present study was to quantify the shift in food intakes from different nutrient profile classes needed to reach nutritional adequacy, while taking into account individual dietary patterns and preferences.

Methods

Dietary data

Data used in the present study were based on dietary data collected from 1171 adults (age >18 years) in the cross-sectional dietary survey 'Enquête Individuelle et Nationale sur les Consommations Alimentaires', conducted in 1999 by the French National Agency for Food Safety[19]. Habitual food intakes were estimated using a 7 d food diary recorded by all participants. Energy and nutrient intakes were calculated for each participant using the French food composition database, described previously[20].

The SAIN,LIM nutrient profiling system

The SAIN,LIM scoring system was applied to each food in the food database. After the exclusion of drinking-water, diet beverages, tea, coffee and fortified foods, the remaining 613 foods were aggregated in ten food groups. The French SAIN,LIM system has been described in detail elsewhere[14]. Briefly, it assigned each food to one of four classes, based on two independent subscores. The positive SAIN subscore was the mean percentage nutrient adequacy for five basic nutrients (proteins, fibre, vitamin C, Fe and Ca), calculated per 100 kcal (418·4 kJ) of food and a variable number of optional nutrients applied to different food groups in the database. Vitamin D, vitamin E, α-linolenic acid and MUFA were used as optional nutrients for nuts and for foods containing more than 97 % of their energy as lipids, while only vitamin D was used as an optional nutrient for all other foods. The negative LIM subscore was calculated as the mean percentage of maximal recommended values for three nutrients to limit, SFA, added sugar and Na, and it was expressed per 100 g.

Specific thresholds were derived for each subscore so that foods were assigned to four broad classes: high SAIN and a low LIM (class 1: most favourable); low SAIN and low LIM (class 2); high SAIN and high LIM (class 3); low SAIN and high LIM (class 4: least favourable).

According to the SAIN,LIM system, most fruits and vegetables, eggs, milk, low-fat dairy products, fish and shellfish, potatoes, legumes and whole grains were in class 1 (Table 1). Most refined cereals, including white bread, together with some cereal-based products containing low amounts of SFA, sugar and salt were in class 2. Many cheeses salted and/or smoked fatty fish, meats with an intermediate fat content and most nuts and vegetable oils were in class 3. Virtually all sweets and desserts, animal fats, sweetened beverages, a high proportion of salted snacks and mixed dishes, most deli meats and fatty meats, high-fat dairy products and sweetened cereals were in class 4.

Diet optimisation

We designed a set of 1171 individual-specific nutritionally adequate diets using a recently developed individual diet modelling approach[18]. For each individual, a model started from his/her observed diet (i.e. food intakes and nutrient intakes) to design an isoenergetic optimised diet respecting his/her food selections and a set of nutrient goals. Nutritional adequacy was ensured by having each

Table 1. Number of foods from each food group in each SAIN,LIM class and average contribution of each food group to total diet weight among observed and optimised diets

(Mean values with their standard errors)

	Number of foods in each SAIN,LIM class				Contribution to total wt (%)			
					Observed		Optimised	
	Class 1	Class 2	Class 3	Class 4	Mean	SE	Mean	SE
Fruits and vegetables†	87	11	7	1	23·1	11·4	33·6*	7·4
Unrefined starches	13	5	0	2	5·4	3·6	7·9*	3·8
Refined starches	0	6	0	5	12·6	6·6	13·7*	4·7
Milk‡ and yogurt	15	1	6	13	13·2	9·8	15·6*	7·1
Cheese	0	0	35	17	3·0	2·3	1·4*	1·1
Meats	34	1	26	40	11·9	5·5	7·9*	3·0
Fish	45	5	13	1	2·5	2·5	4·1*	1·9
Mixed dishes and salted snacks	18	11	18	46	13·9	9·2	5·5*	4·7
Added fats	9	0	18	11	2·4	1·3	1·3*	0·8
Sweets§	1	5	4	83	11·9	8·6	9·1*	5·1

* Mean value was significantly different from that of the observed diets.
† Contribution to the total weight of fruit juice was 3 and 2·5 % in the observed and modelled diets, respectively.
‡ Contribution to the total weight of milk was 8·1 and 8·4 % in the observed and modelled diets, respectively.
§ Contribution to the total weight of soft drinks was 2·5 and 1·4 % in the observed and modelled diets, respectively.

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diet meet a set of constraints based on the French recommendations for thirty-two nutrients: proteins, fibres, total carbohydrates, total lipids, essential fatty acids, eleven vitamins (including vitamin D) and nine minerals, and nutrients to limit. As described previously[18], the minimum levels imposed for nutrients in the optimised diets were at least the estimated average requirements (EAR) when the observed intake was lower than the EAR; at least the RDA when the observed intake was greater than the RDA; equal to the observed intake level when it was between the EAR and the RDA. This was done to improve the nutrient intakes of each individual in order to reach at least the EAR level for each nutrient, while ensuring that the optimisation process did not deteriorate any nutritional component of the observed diets. This is consistent with the current consensus for diet planning of minimising the percentage of individuals with dietary intakes below the EAR[21].

For the energy contribution of macronutrients and for essential fatty acids (including linolenic acid, linoleic acid, DHA and EPA), the constraint levels were identical for all individuals, but for fibres and micronutrients, the lower constraint bounds depended on sex, age and the individual's observed intake of these nutrients, as described previously[18]. The nutrients to limit were Na (maximum 2759 and 2365 mg/d for men and women, respectively), free sugars (maximum 10 % energy), SFA (maximum 10 % energy) and cholesterol. For cholesterol, the maximal constraint bound was either 300 mg/d when the observed intake was below 300 mg/d or the observed intake when it was above 300 mg/d. Safe upper limits for niacin, folate, ascorbic acid, vitamins A, B_6, E and D, Zn and Se were also included in each optimisation model.

Consumption constraints ensured that each optimised diet corresponded as much as possible to the dietary pattern and food preferences of each individual. An upper limit was placed on the quantity of each food and each food-group, calculated as the 95th percentile amount of the consumer distribution (except when the observed intakes exceeded the 95th percentile).

Each optimised diet created by individual modelling came as close as possible to the corresponding observed diet while simultaneously respecting multiple individual-specific constraints. For each person, the optimisation algorithm (1) preferentially chose foods that the person habitually consumed, (2) maintained quantities consumed as far as possible and (3) if necessary to reach nutritional adequacy, introduced novel foods but in the lowest amount possible and by preferentially selecting foods with a high percentage of consumers in the French population (i.e. the most popular ones). The energy content of the optimised diets was the same as in the observed diets, and the weight of foods could not exceed 115 % of the observed weight. Population-based consumption constraints on foods and food groups were added to ensure social acceptability to the optimised diets.

Statistical analysis

The relative average contributions of each nutrient profiling class to the total weight and energy of the optimised diets were calculated for each diet and tested between the observed and optimised diets using a paired Student's t test. The relative contributions of the ten food groups to total weight were similarly assessed and tested. Statistical Analysis Systems version 9.2 was used for diet modelling and statistical analysis, using a 5 % α level for significance.

Results

The mean weight of the optimised diets was 1598 g/d as compared with 1425 g/d for the observed diets. The mean energy density of the optimised diets was accordingly reduced from 623 kJ/100 g (149 kcal/100 g) to 552 kJ/100 g (132 kcal/100 g). Table 1 shows the average contribution of each food group to the total weight of the observed and optimised diets. The total amount of fruits and vegetables increased from 23·1 to 33·6 %. The amount of unrefined starches increased from 5·4 to 7·9 %, and that of refined cereals increased from 12·6 to 13·7 %. The amount of fresh dairy products such as yogurt and milk increased from 13·2 to 15·6 %, whereas the amount of fish increased from 2·5 to 4·1 %. The optimisation process reduced the amounts of meat, cheese, added fats and sweets, with the greatest drop being observed for mixed dishes and salted snacks (from 13·9 to 5·5 %). When a given food group was increased, foods that had an augmentation mainly came from the SAIN,LIM class 1

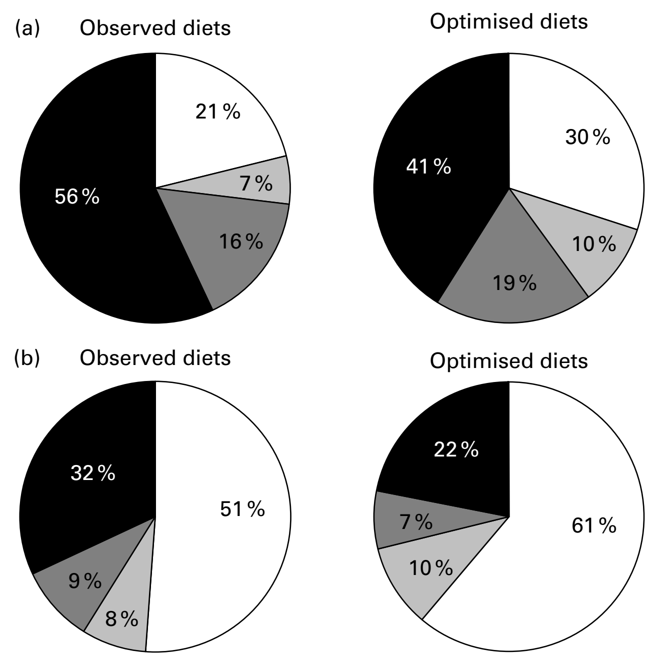

Fig. 1. Relative contributions of each nutrient profiling class to (a) total diet energy and (b) total diet weight among the observed and optimised diets. □, Class 1; ▒, class 2; ▓, class 3; ■, class 4.

(results not shown). When a given food group was decreased, foods that had a diminution mainly came from the SAIN,LIM classes 3 and 4 (results not shown).

Both the observed and optimised diets were composed of foods from all four SAIN,LIM classes (Fig. 1). Following the optimisation process, the energy contribution of class 1 foods increased from 21 to 30 %, and that of class 4 foods decreased from 56 to 41 % (Fig. 1(a)). Following the optimisation process, the weight contribution of class 1 and class 2 foods increased and that of class 3 and class 4 foods decreased (Fig. 1(b)). The relative weight contribution of class 1 foods increased from 51 to 61 %, and that of class 4 foods decreased from 32 to 22 %.

Discussion

Foods from all nutrient profile classes can be part of nutritionally adequate diets. The present results show that foods with the least favourable nutrient profiles can still contribute as much as 41 % of energy to a nutritionally adequate food pattern, provided that nutrient-dense foods with the most favourable nutrient profile account for the majority of food weight (61 %). The present data used new techniques to quantify the relative contribution of different types of foods to a nutritionally adequate food pattern that, moreover, respected individual food choices. Early fears that nutrient profiling would perpetuate the dichotomy between 'good' and 'bad' foods are not borne out by our use of profiling methods and diet optimisation techniques.

Nutrient profile systems can help quantify the relative amounts of foods that need to be reduced or increased in order to achieve a healthy diet[14,22]. Moreover, they show that foods with an unfavourable nutrient profile need not be avoided altogether. Indeed, only a partial replacement of class 4 (and class 3) foods by class 1 (and class 2) foods was needed to design a nutritionally adequate diet for each person from the present study sample of French adults.

The present study has some limitations. First, the results of diet optimisation depend on the design of a particular model, including the constraints used to define nutritional adequacy[23]. However, in an earlier linear programming study, we used three different official sets of nutritional recommendations, and this did not change the present conclusions about the foods and nutrients limiting the design of optimal diets for young children in a developing country[24]. Moreover, in the present study, the use of individual diet modelling is likely to limit the risk of drawing conclusions that are too specific to the model applied. Indeed, the present conclusions were based on the results obtained from 1171 individual-specific models, each of them being unique in terms of objective function and constraints[18].

A second limitation is that the nutrient profiling approach may fail to correctly classify some key foods[25,26]. Nevertheless, the present results were fully consistent with studies from the UK[22], showing that foods deemed as least healthy using the UK Food Standard Agency nutrient profile contributed as much as 39 % of energy to the most healthy diets (based on the Diet Quality Index), an estimate in close agreement with the present estimate of 41 %. Given that the two studies, conducted in the UK and France respectively, differed in methodology (observational and modelling studies, respectively), such correspondence suggests that the amount of 'discretionary' energy can be higher than that previously envisaged. According to MyPyramid, most discretionary energy allowances are very small, between 418·4 and 1255·2 kJ (100 and 300 kcal), i.e. between 5 and 15 % of daily energy intakes[3]. Limiting so much the amount of discretionary energy could be more restrictive than effectively needed to reach nutritional adequacy.

Nutritionally adequate diets were in accordance with habitual dietary advice as they had a low energy density and contained plenty of foods of plant origin and reasonable amounts of animal products. The current debate on nutrient profiling leaves the consumer and the health professional alike with the impression that only the most nutrient-rich foods have a place in a healthy diet. Based on sophisticated mathematical techniques, the present study showed, to the contrary, that foods from all SAIN,LIM classes could be a part of individually tailored nutritionally adequate food diets. In this population of French adults, current nutrient recommendations were compatible with the consumption of one-fifth of energy-dense foods that were nutrient-poor (class 4), provided that the diets also contained almost two-thirds of nutrient-dense foods (class 1).

In many countries, consumers already receive information about the nutrient profile of individual foods, and this is considered as a possible way of favourably influencing food choices. For instance, in Sweden, the 'Green Keyhole' symbol has been in use since 1989, to help consumers identify low-fat and high-fibre alternatives[27], and in France, the ministry of health is currently considering the introduction of a healthy food label based on nutrient profiling[28]. Thus, translating the results of the present study into concrete and quantified advice to increase the consumption of food with a favourable nutrient profile (to at least two-thirds the basket weight) at the expense of foods with an unfavourable nutrient profile (to a maximum of one-fifth the basket weight) may have very tangible public health implications.

All too often dietary advice is either vague or solely based around avoiding or severely restricting a specific nutrient or food. Nutrient profiling models that accurately capture the nutrient density of foods can be an effective platform for nutrition education.

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