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Identification of foods contributing to the dietary lipid profile of a Mediterranean population

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The identification of the target foods that most affect the fat content of a diet, independently whether or not they contain fat, can be a useful tool in the process of drawing up more effective dietary guidelines with nutritional education strategies more directed at the needs of each population. With this purpose, the contribution analysis designed by Block and colleagues and multiple linear regression models were applied to a representative sample of Catalonia. Olive oil was the food that provided the highest absolute and relative percentage of fat-derived energy intake and cheese the food that provided the highest percentage of saturated fat-derived energy intake. According to the results of the present work, during the last 10 years the consumption of fruits and vegetables in Catalonia has increased, more in women than men. The intake of white fish is significantly higher than the intake of blue fish, which should be increased in both men and women, and red meat is still the first meat source in this population. Special attention should be paid to the increasing sweet cereal consumption, which is a source of invisible fat to the diet.

Dietary lipid profile: Target foods: Plasma fatty acids

Obesity, hypertension, diabetes mellitus, dyslipidaemia and insulin resistance are increasing in frequency and becoming major causes of CVD[1]. The excess intake of energy and a sedentary lifestyle are major causes of these morbid conditions. Excess of SFA[1] and a relative deficiency in unsaturated fatty acids, especially n-3 PUFA, have been identified as contributing factors[2].

Total fat and SFA have been considered as common nutritional targets in public health[3]. Present nutritional goals aim to limit the consumption of total fat to 30 % of the daily energy intake – in the case of Mediterranean countries such as Spain, characterized by a large consumption of olive oil, a maximum of 35 % energy intake has been accepted[4] – and the consumption of SFA to less than 10 %[5].

Both nutrients, total fat and SFA, can be considered a useful tool to identify potential target foods in the diet of different populations in order to describe consumption patterns and future food-based dietary guidelines.

Therefore, the aim of the present work was to identify those food groups that had the greatest effect on the variation in the percentage of energy intake and contributed most to absolute intake supplied by total and saturated lipids in the consumption of a representative sample of the Mediterranean Catalan population.

Subjects and methods

Subjects

The subjects were a subgroup of a larger sample (1600 subjects) randomly recruited in Catalonia, a Mediterranean region in north-east Spain, for a cross-sectional nutritional survey[6]. The primary objective of the survey was to collect relevant information on the dietary habits of the Catalan population and assess their food consumption patterns. The sampling technique included stratification according to geographical area and municipality size, age and gender of inhabitants. The participation rate (65 %) in the present study can be regarded as representative of the adult population in Catalonia. A total of 550 participants agreed to have blood drawn and underwent physiological and anthropometric measurements in a clinical session after informed consent. There were no significant differences between the dietary intake of the subjects who did not complete the clinical assessment and those who did complete it (data not shown). From the former group, seventeen people under-reported their energy intake and were therefore not included for food consumption analysis. In the absence of direct measurement of BMR, estimates of BMR were calculated from standard equations for Europeans based on weight, height, age and gender[7]. Each identification

Abbreviations: SP, standard portion; VPA, vigorous physical activity.

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of under-reported food intake was made using Goldberg cut-off (energy intake/BMR ≥1·14 classified the individual as an under-reporter)[8]. Of the 533 Catalans, seventeen did not fast for >12 h before blood sampling and were therefore also excluded. The final sample consisted of 516 subjects, 203 men and 313 women. The study protocol was approved by the regional ethics committee, following the Declaration of Helsinki 1975 standards.

Anthropometric measurements

The anthropometric measures used in the present study were height (m), weight (kg), BMI (calculated as kg/m^2) and waist and hip circumferences. The anthropometric characteristics of the study participants are shown in Table 1, as well as the prevalence of vigorous physical activity (VPA).

Height was determined using a mobile anthropometer to the nearest mm. Body weight was determined to the nearest 100 g using a digital scale. Waist and hip circumferences were measured using a non-stretchable measuring tape. Hip circumference was measured at the tip of the hip bone in men and at the widest point between the hips and the buttocks in women. Cut-off limits for hip circumference determined by Aranceta-Bartrina and coworkers[9] were established for this study.

Physical activity data

The frequency of VPA was used to evaluate the physical activity of the participants. VPA refers to activities that caused sweating and hard breathing for at least 20 min on at least 3 of the 7 d preceding the survey. VPA include running/jogging (5 miles/h), bicycling (>10 miles/h), swimming (freestyle laps), aerobics, walking very fast (4 miles/h), heavy yard work, weight lifting, basketball (competitive)[10]. There were six categories of VPA frequency (daily; two to three per week; once per week; two to three per month; occasionally; disabled).

Nutrition data

Data on food intake were obtained with the use of a FFQ, which was previously validated[11] and applied to other studies and surveys over the Spanish population[12,13]. The FFQ, which asked the subject to recall average use over the past year, consisted of 118 items. The FFQ was arranged by food type and meal pattern. Frequency categories were based on the number of times that items were consumed per d, week or month. Consumption less than once per month was considered no consumption. Daily consumption (g) was determined by dividing the reported amount of the intake by the frequency (d). The relevant period of consumption of seasonal items was also taken into account. Edible fractions of foods were recorded in the database. Food values were converted into nutrient values by validated software developed by the Centre for Superior Studies in Nutrition and Dietetics, which is based on Spanish tables of food composition[14]. Foods were divided into the following groups: red meat; poultry and game; processed meat; eggs; white fish; blue fish; reduced-fat milk and yoghurt; whole-fat milk and yoghurt; cheese; sweet cereals (breakfast cereals, cakes, biscuits); savoury cereals (such as pasta and rice but not bread); bread; oils; butter; margarine; green vegetables; fruit; pulses; tubers; sugars; wine and spirits. The number of portions of each food group consumed by the population was calculated. The grams consumed of each food group were divided by the size of the standard portion (SP) for different age groups (Table 2). These SP have already been used in previous studies in the Spanish population[15].

Statistical analyses

The 'contribution analysis' method developed by Block *et al.*[16] was applied to identify those top twenty-five foods or food groups that most contribute to the fat and saturated fat intake of the Catalan representative sample. Briefly, this

Table 1. Characteristics of the study sample of the Catalan population†
(Mean values and standard deviations)

	All (*n* 516)		Men (*n* 203)		Women (*n* 313)	
	Mean	SD	Mean	SD	Mean	SD
Age	41·5	14·3	42·1	14·4	41·3	14·1
Body weight (kg)	70·1	10·8	78·2**	10·2	64·3	11·1
BMI (kg/m^2)	25·4	4·8	26·3**	4·0	24·8	5·2
Hip circumference (cm)	101·5	9·7	101·8	7·4	101·5	9·7
WHR	0·8	0·1	0·9***	0·1	0·8	0·1
WHR > cut-off limits	11·2		12·8***		10·2	
Energy intake (kJ)	8482·2	2352·7	9403·2***	2875·2	8304·2	2273·9
VPA for at least 20 min (%)						
Daily	13·0		19·9***		11·4	
2–3 times per week	21·1		25·5***		20·1	
once per week	9·0		10·7		8·6	
2–3 times per month	9·6		9·3		10·0	
Occasionally	38·0		28·4***		43·5	
Disabled	6·3		6·2		6·4	

Mean values were significantly different from women: **$P<0·01$; *$P<0·001$ ($\chi 2$ test).
† For details of subjects and procedures, see Subjects and methods.
Cut-off limits: men's waist:hip ratio (WHR) >1, women's WHR >0·90.
VPA, Prevalence of vigorous physical activity.

Table 2. Size of standard portions per group of age and mean number of standard portion consumed per day and gender†

	Standard portions (g)		Number of standard portions					
	Age (years)		Men (*n* 203)			Women (*n* 313)		
Food group	18–59	≥60	P_{25}^{*}	P_{50}	P_{75}	P_{25}	P_{50}	P_{75}
Red meat	100	100	0·3	0·5	0·8	0·3	0·5	0·8
Poultry and game	100	100	0·3	0·4	0·6	0·3	0·4	0·6
Processed meat	50	50	0·2	0·3	0·6	0·1	0·2	0·4
Eggs	100	50	0·1	0·2	0·3	0·1	0·2	0·2
White fish	120	100	0·1	0·2	0·4	0·2	0·4	0·4
Blue fish	120	100	0·1	0·1	0·3	0·1	0·1	0·3
Reduced-fat milk and yoghurt	200	200	0·0	0·8	1·2	0·0	1·0	1·9
Whole-fat milk and yoghurt	200	200	0·0	0·2	1·0	0·0	0·1	1·0
Cheese	50	50	0·2	0·5	0·9	0·2	0·5	1·0
Sweet cereals	60	50	0·1	0·3	0·7	0·1	0·3	0·7
Savoury cereals	70	40	0·3	0·6	0·7	0·3	0·5	0·7
Bread	65	50	1·3	2·4	2·7	0·8	1·9	2·4
Oil	25	25	0·5	1·1	1·4	0·9	1·1	1·3
Butter	25	25	0·0	0·0	0·0	0·0	0·0	0·0
Margarine	25	25	0·0	0·0	0·0	0·0	0·0	0·1
Green vegetables	225	150	0·8	1·3	2·0	0·9	1·3	2·1
Fruit	130	130	1·0	2·1	3·7	1·5	2·4	3·4
Pulse	60	40	0·2	0·3	0·5	0·2	0·2	0·4
Tubers	350	200	0·1	0·2	0·3	0·1	0·2	0·3
Sugars	15	15	0·0	0·1	0·4	0·0	0·2	0·6
Wine	100	100	0·0	0·2	1·3	0·0	0·0	0·2
Spirits	50	50	0·0	0·0	0·1	0·0	0·0	0·0

P_{n}^{*}–*n*th percentile.
† For details of subjects and procedures, see Subjects and methods.

procedure selects informative foods based on their average percentage contribution to absolute nutrient intake in a target population. Food items out of a comprehensive item list are then ranked according to their mean contribution to nutrient intake in the study population.

Two models of multiple linear regressions developed by Cucó *et al.* were applied[15]. The first model was based on calculating the variation in the percentage of fat- and SFA-derived energy intake for a SP of food. This model predicts the change in percentage of fat- and SFA-derived energy intake when the consumption of a particular food group increases in a SP. The equation for the model is:

Predicted percentage of energy provided by the macronutrient = $\alpha + \beta_1$ red meat + β_2 poultry and game + β_3 processed meat + β_4 eggs + β_5 white fish + β_6 blue fish + β_7 reduced-fat milk and yoghurts + β_8 whole-fat milk and yoghurts + β_9 cheese + β_{10} sweet cereals + β_{11} savoury cereals + β_{12} bread + β_{13} oils + β butter$_{14}$ + β_{15} margarine + β_{16} vegetables + β_{17} fruit pulses + β_{18} tubers + β_{19} sugars + β_{20} wine + β_{21} spirits.

The second model was applied to determine the effect of an individual's average food consumption on the percentages of fat- and SFA-derived energy intake. Instead of using SP as the independent variable, as in the first model, the portion relative to the consumption of the population was used. This variable is the ratio between the number of SP of a food consumed by a subject and the average number of SP of that food consumed by the population.

All multiple regressions were applied in conditions that ensured a suitable fit. These conditions were explored using relevant residual analyses. The level of significance $P < 0.05$ for bilateral contrasts was used.

Data were analysed with the software SPSS 12.0 for Windows (SPSS Inc., Chicago, IL, USA). The χ^2 test was used to test differences between groups.

Results

Men showed a higher mean body weight, BMI, prevalence of risk values for waist:hip ratio as well as a higher daily VPA than women. No significant differences were observed in the reported energy intake according to gender (123·1 (SD 43·0) kJ/kg body weight for men *v.* 129·3 (SD 43·5) kJ/kg body weight for women) and after stratifying the sample for obesity.

The top twenty-five contributors of dietary sources of fat and saturated fat are respectively shown in Table 3 and Table 4 according to the Block method procedure[16]. Olive oil was the largest single contributor of total fat with a mean contribution of 70 % total fat. Cheese was the second most important source, closely followed by red meat. The first five food groups explained 89 % of total fat contribution in men and 93 % of total fat contribution in women. Significant differences were found for the following food groups according to gender: eggs; processed meat; savoury cereals; poultry; ice cream; olive oil; white fish. The previous food groups were higher in men than women except for olive oil and white fish. According to Table 4, cheese was the main contributor to saturated fat in the Catalan diet, with a mean contribution of 40 % total fat. Red meat made a contribution close to 20 %, followed by whole-fat milk and yoghurts in

Table 3. Major contributors of total fat in the Catalan diet†

		Men (*n* 203)		Women (*n* 313)	
Rank	Food/food group	% total fat	Cumulative % fat	% total fat	Cumulative % fat
1	Oil	67·12**	67·12	73·52	73·52
2	Cheese	9·63	76·75	9·56	83·08
3	Red meat	6·38	83·13	5·87	88·96
4	Eggs	3·47**	86·60	2·25	91·21
5	Whole-fat milk and yoghurt	2·47	89·06	2·08	93·29
7	Processed meat	1·34**	90·40	0·85	94·14
8	Savoury cereals	1·32**	91·72	0·86	95·00
9	Blue fish	1·28	93·00	1·27	96·27
10	Poultry and game	0·84**	93·85	0·58	96·85
11	Green vegetables	0·61	94·46	0·66	97·50
12	Sweet cereals	0·48	94·94	0·37	97·87
13	French fries and salty snacks	0·41	95·35	0·36	98·24
14	Pulse	0·34	95·69	0·32	98·55
15	Reduced-fat milk and yoghurt	0·31	96·01	0·39	98·95
16	White fish	0·17**	96·18	0·36	99·31
17	Sugars	0·14	96·31	0·14	99·45
18	Soups	0·09	96·41	0·08	99·53
19	Tubers	0·08	96·49	0·09	99·62
20	Biscuits	0·06	96·55	0·05	99·67
21	Butter	0·03	96·59	0·02	99·69
22	Margarine	0·02	96·62	0·02	99·71
23	Ice cream	0·02**	96·64	0·01	99·72
24	Fruit	0·01	96·65	0·01	99·73
25	Bread	0·01	96·66	0·01	99·74

Values were significantly different from women: $^{**}P<0{\cdot}01$ (χ^2).
† For details of subjects and procedures. see Subjects and methods.

Table 4. Major contributors of total saturated fat in the Catalan diet†

		Men (*n* 203)		Women (*n* 313)	
Rank	Food/food groups	% total SFA	Cumulative % SFA	% total SFA	Cumulative % SFA
1	Cheese	39·51	39·51	43·83	43·83
2	Red meat	17·27	56·78	17·00	60·83
3	Whole-fat milk and yoghurt	11·56	68·34	11·19	72·02
4	Eggs	5·66	74·00	5·39	77·41
5	Sweet cereals	4·61	78·62	4·43	81·84
6	Oil	3·54**	83·95	0·61	84·47
7	Processed meat	2·42**	86·37	1·84	86·21
8	Sugars	1·50	87·87	1·66	87·87
9	French fries and salty snacks	1·31	89·18	1·39	89·26
10	Pulse	1·13	90·31	1·12	90·38
11	Ice cream	1·06	91·37	0·96	91·34
12	Chocolate	0·97	92·34	0·89	92·23
13	Tubers	0·86**	93·20	0·75	92·98
14	Biscuits	0·75	93·95	0·72	93·70
15	Soups	0·64	94·59	0·67	94·36
16	Butter	0·23	94·82	0·23	94·59
17	Margarine	0·20	95·02	0·18	94·77
18	Savoury cereals	0·15	95·17	0·14	94·91
19	Blue fish	0·09	95·26	0·08	94·99
20	Poultry and game	0·05	95·31	0·06	95·05
21	White fish	0·02	95·33	0·02	95·07
22	Green vegetables	0·01	95·34	0·01	95·08
23	Reduced-fat milk and yoghurt	0·01	95·35	0·01	95·09
24	Bread	0·01	95·36	0·01	95·10
25	Jams and marmalade	0·01	95·37	0·01	95·11

Values were significantly different from women: $^{**}P<0{\cdot}01$ (χ^2 test).
† For details of subjects and procedures, see Subjects and methods.

an order of 10 %. From rank number 5 (sweet cereals), all components in the list contributed to less than 5 % of saturated fat in the Catalan diet.

The variation of the relative percentage of fat-derived energy intake per SP of food consumed by gender is shown in Table 5, according to the first model by Cucó and colleagues[15]. Oil was the food that was associated with the greatest relative percentage of fat-derived energy intake per SP consumed, in both men and women. Margarine, butter, processed meat and red meat also related to high relative percentages of fat-derived energy intake. Conversely, poultry and game, bread, savoury cereals and reduced-fat milk and yoghurt provided a lower relative percentage of fat-derived energy intakes.

The consumption of a SP of butter provided the greatest relative percentage of SFA-derived energy intake in women and a SP of eggs in men (Table 6). A SP of white fish for women and a SP of poultry and game for men provided the lowest relative percentage of SFA-derived energy intake.

Fig. 1 shows how changes in the relative portion affected the percentage of fat-derived energy intake in the diet of the Catalan population after application of the second model developed by Cucó and colleagues[15]. Olive oil was the food group that was associated with the highest relative percentage of fat-derived energy intake for both genders. Bread was the food that contributed most to decrease the relative percentage of fat, followed by fruit.

Cheese and whole-fat milk, yoghurt and red meat were the food groups related to the greatest relative percentages of SFA-derived energy intake. It is interesting to note that oil did not contribute to increase the SFA-derived energy intake in either gender (Fig. 2). As occurred with the total fat-derived energy intake, bread and fruits also provided the lowest relative percentages of SFA-derived energy intake.

According to the second regression model, the total fat energy intake was 37·1 (SD 4·6) % for men and 38·3 (SD 4·5) % for women in the Catalan sample. In both cases, more than 25 % of participants presented total fat intakes lower than the recommended amount for the Spanish population[17]. The calculated SFA intake energy was 11·3 (SD 2·3) % for men and 12·1 (SD 2·4) % for women. The percentage of men with their SFA intakes within the recommended guidelines[5] was significantly higher than the percentage of women (30 % men *v.* 18 % women). More than half of the Catalan sample showed SFA intakes lower than 12 % (65 % men and 55 % women).

Discussion

The Block method[16] as well as two regression models designed by Cucó *et al.*[15] were used to identify the target foods that most contributed to the absolute and relative increase and decrease of the fat and SFA-content in the current diet of a representative sample of the Catalan population.

According to the outcomes from the Block method, olive, cheese and red meat are the three main food components contributing to the absolute total fat intake in the current

Table 5. Comparison of the change in the relative percentage of fat-derived energy intake per intake of one standard portion by gender†

	% fat-derived energy intake					
	Men (*n* 203)			Women (*n* 313)		
		95 % CI			95 % CI	
Food group	Regression coefficient	LL	UL	Regression coefficient	LL	UL
Red meat	2·1***	0·7	3·5	1·7	0·7	2·7
Poultry and game	−2·5***	−4·4	−0·5	−0·3	−1·8	−1·1
Processed meat	2·7***	1·0	4·5	1·9	0·6	3·1
Eggs	2·2***	1·4	5·8	0·5	4·2	3·2
White fish	−0·8***	−2·7	−1·2	−2·9	−4·5	−1·3
Blue fish	1·3***	1·4	4·0	−1·2	−3·0	−0·7
Reduced-fat milk and yoghurt	−1·1	−1·6	0·7	−1·0	−1·3	−0·6
Whole-fat milk and yoghurt	0·3	−0·2	0·8	0·3	−0·1	0·7
Cheese	1·0***	0·2	1·8	1·8	1·3	2·3
Sweet cereals	0·0**	−0·7	−0·6	−0·4	−1·2	−0·3
Savoury cereals	−1·8	−3·3	−0·2	−1·6	−2·7	−0·5
Bread	−2·0	−2·4	−1·5	−2·2	−2·6	−1·8
Oil	6·3	5·4	7·2	6·5	5·7	7·3
Butter	2·4***	1·9	10·8	2·9	0·9	6·6
Margarine	4·0	−2·4	10·3	4·1	0·3	7·8
Green vegetables	−0·1	−0·6	0·5	0·0	−0·5	0·4
Fruit	−0·8	−1·1	−0·5	−1·1	−1·4	−0·8
Pulse	−1·0***	−3·3	−4·3	−0·5	−2·6	−1·5
Tubers	2·2*	0·9	5·3	−0·9	−3·4	−1·5
Sugars	−0·1**	−1·2	−1·0	0·3	0·4	0·9
Wine	0·1	−0·3	0·5	0·2	−0·3	0·8
Spirits	−0·7	−2·1	0·7	−2·7	−5·9	0·5
Regression constant, α	36·2	34·1	38·2	38·6	37·0	40·2
$cR^2 \times 100$	73·2			70·1		

F of Snedecor from ANOVA of the multiple linear regression, in men/in women: ** $P<0·01$; *** $P<0·001$.
† For details of subjects and procedures, see Subjects and methods.
LL, lower limit; UL, upper limit; cR^2, corrected square of the multiple correlation coefficient.

Table 6. Comparison of the change in the relative percentage of SFA-derived energy intake per intake of one standard portion by gender†

	% SFA-derived energy intake					
	Men (*n* 203)			Women (*n* 313)		
		95 % CI			95 % CI	
Food group	Regression coefficient	LL	UL	Regression coefficient	LL	UL
Red meat	1·1	−0·5	1·7	1·2	−0·8	1·7
Poultry and game	−1·0***	−1·8	−0·2	−0·1	−0·7	−0·5
Processed meat	1·2**	0·5	2·0	0·8	0·3	1·3
Eggs	1·7	−0·2	3·2	1·5	−0·0	3·0
White fish	−0·5***	−1·3	−0·3	−1·6	−2·3	−1·0
Blue fish	−0·2***	−1·3	−0·9	−0·9	−1·7	−0·2
Reduced-fat milk and yoghurt	−0·1	−0·3	0·0	−0·0	−0·2	0·1
Whole-fat milk and yoghurt	1·0	−0·8	1·3	1·1	−0·9	1·3
Cheese	1·6	−1·3	2·0	1·7	−1·5	1·9
Sweet cereals	0·9	−0·6	1·2	0·8	−0·5	1·1
Savoury cereals	−0·7***	−1·4	−0·1	−0·3	−0·8	−0·2
Bread	−0·6	−0·8	0·3	−0·7	−0·9	0·6
Oil	0·1	−0·3	0·5	−0·2	− −0·5	0·1
Butter	1·5***	2·0	5·1	4·6	3·1	6·2
Margarine	−0·7***	−3·4	−2·0	0·3	1·2	1·8
Green vegetables	−0·1	−0·3	0·2	−0·2	−0·4	0·0
Fruit	−0·2	−0·4	0·1	−0·4	−0·5	0·3
Pulse	−0·2***	−1·2	−0·8	−0·6	−1·4	−0·3
Tubers	−0·1***	−1·4	−1·2	−1·1	−2·1	−0·2
Sugars	0·4**	0·1	0·8	0·7	0·4	0·9
Wine	0·0	0·2	0·2	0·0	−0·2	0·3
Spirits	−0·2	−0·8	0·4	−0·3	−1·6	1·0
Regression constant, α	11·2	10·3	12·0	12·8	12·1	13·4
$cR^2 \times 100$	76·1			79·6		

F of Snedecor from ANOVA of the multiple linear regression, in men/in women: ** $P < 0·01$; *** $P < 0·001$.
† For details of subjects and procedures, see Subjects and methods.
LL, lower limit; UL, upper limit; cR^2, corrected square of the multiple correlation coefficient.

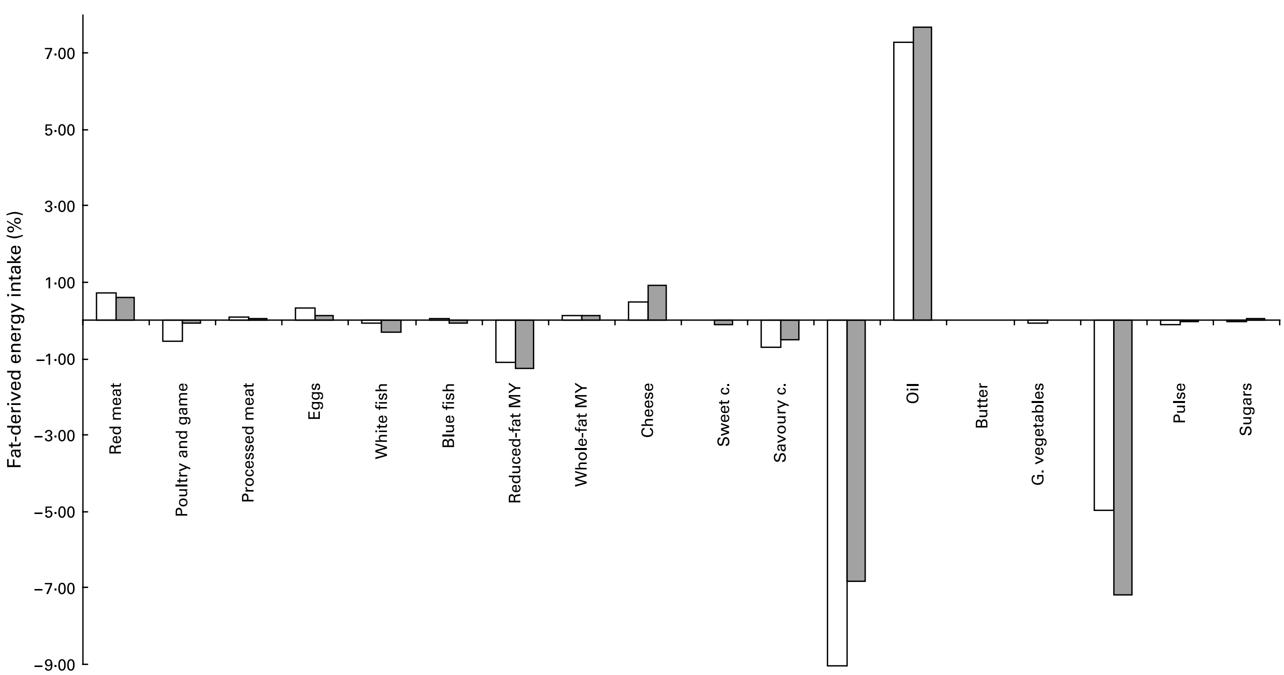

Fig. 1. Change in the percentage of fat-derived energy intake per relative portion of the population intake. Number of cases: men (□) 203; women (■) 313. Men: corrected R^2 0·752; constant of regression 36·1. Women: corrected R^2 0·701; constant of regression 38·7. Reduced-fat MY, reduced-fat milk and yoghurt; Whole-fat milk, whole-fat milk and yoghurt; Sweet c, sweet cereals; Savoury c, savoury cereals; G. vegetables, green vegetables. For details of subjects and procedures, see Subjects and methods.

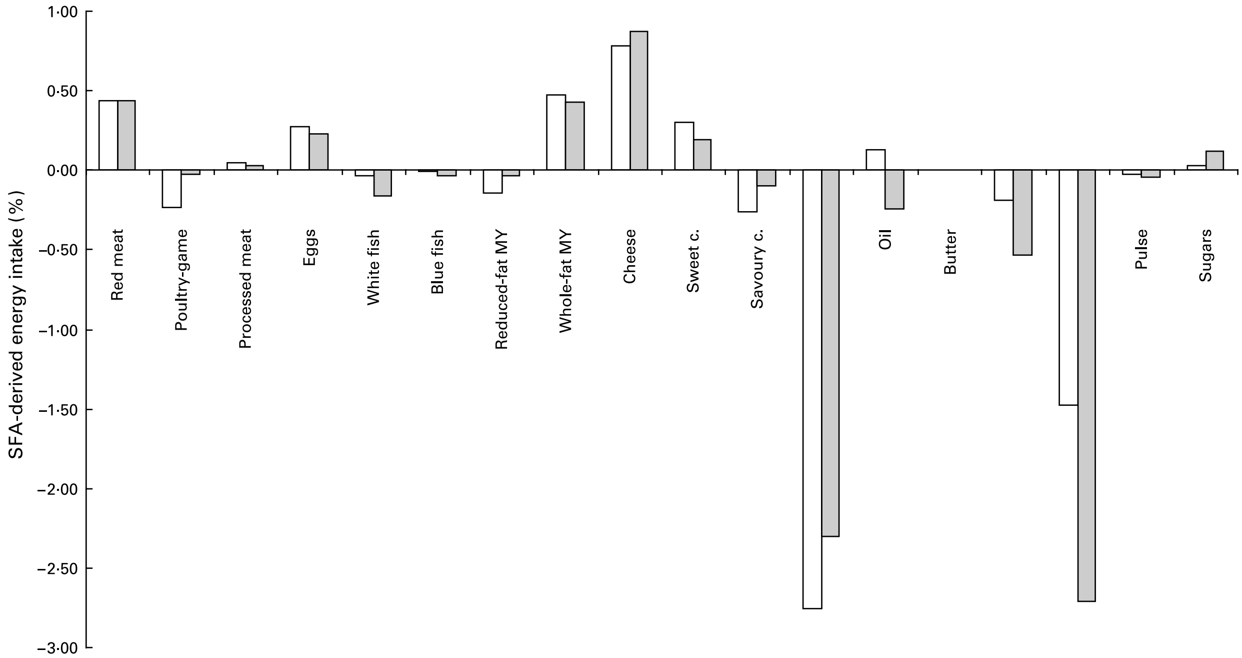

Fig. 2. Change in the percentage of SFA-derived energy intake per relative portion of the population intake. Number of cases: men (□) 203; women (■) 313. Men: corrected R^2 0·751; constant of regression 11·2. Women: corrected R^2 0·795; constant of regression 12·8. Reduced-fat MY, reduced-fat milk and yoghurt; Whole-fat milk, whole-fat milk and yoghurt; Sweet c, sweet cereals; Savoury c, savoury cereals; G. vegetables, green vegetables. For details of subjects and procedures, see Subjects and methods.

Catalan diet. It is interesting to note that some of the more classical sources of fat, such as butter and ice cream, are far down in the list of main contributors to total fat, with low contributions among Catalans. A few items, such as green vegetables and pulses, made a contribution to total fat intake chiefly by virtue of additives, such as dressings, which are mainly composed of olive oil or other oils, not tabulated separately.

Not surprisingly, the ranking of foods was in general similar to that seen for total fat, although the high contribution of cheese to the total saturated fat in the range of 40 % was unexpected. It is interesting to highlight that olive oil, which was the main contributor of total fat, occupied the ranks 6 and 15 in the list of saturated fat contributors for men and women respectively. This fact is related to the healthy composition in MUFA but not in saturated fat in olive oil, which is the characteristic main lipid source in the Mediterranean regions.

On the other hand, the suitability of both models designed by Cucó was confirmed by the high values obtained for the respective corrected square of the multiple regression coefficients (in the range of 0·7–0·8) for the sample under study.

The first model described the effect that consuming one SP from each food group would have on the dietary fat profile of the subjects' diet. This model was useful to identify the food groups that most contribute to the relative percentage of fat and SFA. However, the diets of the subjects contained foods that, as can be expected, were consumed at a very different frequency than one portion per d. This is why the second model was applied to determine the effect of an individual's average food consumption on the relative percentages of fat and SFA-derived energy intake.

As expected for a Mediterranean region such as Catalonia, and as was previously found with the Block method, olive oil was the food that provided the highest relative percentage of fat-derived energy intake in the current Catalan diet. The same outcome was found in the Catalan diet in the 1990s[15]. The present results therefore confirm that during the last decade the Catalan population has still maintained one of the fundamental characteristics of the traditional Mediterranean diet. The health benefits derived from a regular consumption of olive oil have been widely reported[18,19].

Butter and margarine are fat sources widely used in Western societies[20] but their contribution to the total fat and SFA-derived energy intake was not relevant in the Catalan diet due to the low consumption of both items.

The second food group in importance for the fat-derived energy intake was dairy products. In Western populations with high intakes of dairy products, the consumption of these foods affects both the fat and SFA-derived energy intake[21,22]. However, in the Catalan diet, this effect was observed only for the consumption of cheese. Other dairy products, such as whole-fat milk and yoghurts, increased the relative SFA-derived energy intake but did not significantly increase relative fat-derived energy intake, since the subjects who usually consume more milk and yoghurts do not consume other food that is even richer in fats.

The consumption of meat has been generally related to a greater total intake of fat in many populations[15,23]. In the present work, red meat and processed meat led to notable higher relative percentages of fat-derived energy intake, while the consumption of poultry and game had the contrary effect. However, according to the second regression model, the contribution of processed meat in the SFA-derived energy intake was not of importance in comparison with the calculation for red meat. On the other hand, the positive contribution of poultry and game to decrease the SFA-derived energy intake was significantly higher for men than for women. This is probably due to the high consumption of poultry and game by men than by women. Red meat was the third food that contributed to increase the relative fat and SFA-derived energy intake in the Catalan sample. However, this contribution was lower than that calculated for the Catalan diet in the 1990s[15], reflecting a current trend to balance the consumption of red meat with that of poultry and game.

Cereals were the foods related to lower relative percentages of fat-derived energy intake in the Catalan sample. No significant differences were observed in the effect of consuming a SP of bread and a SP of savoury cereals on the relative percentage of fat-derived energy intake. This was mainly due to the fact that bread included not only white bread, which is the most consumed by the Spanish population, but also brown and cereal-enriched bread. As bread was consumed more than the savoury cereals, the effect of a relative portion of bread was significantly greater. Interesting to note is the consumption of invisible fat implied by the relative percentage of SFA-derived energy intake from the sweet cereals. Sweet cereal is a target group to have in mind in nutritional recommendations, mainly in children. The consumption of invisible fat has become an increasing problem in developed Western populations[24,25] and, with the increasing incidence of overweight and obese people in European countries[26,27], industrial food with considerable amounts of invisible fat should be restricted in the diet of the new generations. According to the present study data, an increase in the consumption of savoury cereals, such as rice and pasta, should be recommended in the Catalan population.

The second food group in importance to decrease the relative fat and SFA-derived energy intake was fruit. The average intake of fruits among the Catalan sample agreed with the nutritional recommendations of consuming two to three portions of fruit per d. This fact was not accomplished in the last decade in Catalonia[15].

The consumption of vegetables in the Catalan diet helped to decrease the relative percentage of SFA-derived energy intake, but had no contribution to decrease the total fat. This could be explained by the fact that in the Spanish population a greater consumption of vegetables usually leads to a greater intake of added fats. These added fats mainly consist of olive oil itself or as the main ingredient in salad dressings. The high monounsaturated and low saturated fat content in the olive oil would indirectly be responsible for the decreasing effect of SFA-derived energy intake by the vegetables group. According to the present data, men should be recommended to increase their consumption of fruits and vegetables, at least to the levels shown by women.

The present work also confirmed the need to encourage the Catalan population to increase their fish consumption. Both men and women preferred white fish over blue fish. The average of consumption was not even a portion of blue fish per week for both genders. However, the average intake of white fish was almost three portions per week for women, double that observed for men. The reduction in the relative SFA-derived energy intake of a 0·5 % per relative portion observed in women, together with the reported healthy properties[28,29] due to a regular consumption of fish, mainly oily fish, should be taken into account in order to promote the consumption of fish among the Catalan population.

Some limitations of the present study must however be noted. Although a FFQ is considered one of the major dietary data collection instruments and the primary instrument in epidemiology[30], no dietary method can measure dietary intake without error and it is important to be aware of the strengths and limitations of the FFQ application to the present data. The FFQ by Martin-Moreno *et al.* used in this study[11] was developed taking into account the cultural Mediterranean background of Spain and the existing geographical differences of diet in this country. To assess the appropriateness and relevance of the food items contained in an initial extensive food list including 290 foods, two different approaches of the 24-h recall strategy were implemented (in-person interviews and interviews by telephone, both in each of the four seasons). To identify the most important food sources of specific nutrients, all reported foods were initially ranked in terms of their contribution to total nutrient intake by all individuals and they were finally reduced to a final form of the FFQ based on 118 food items. The number of food items on a questionnaire tends to vary widely, in the range from five to 350, seventy-nine being the median number[31]. The non excessively high number of food items in our FFQ did not contribute to rapidly decrease marginal gain in information, which has been reported with increasing detailed questionnaires[32].

However, the fact that our FFQ was self-administered could have contributed to a lack of information due to incomplete answers, because some respondents tend to complete the FFQ for items that they usually eat. We are aware that FFQ *per se* are hampered by the inability of individuals to accurately report their food intake retrospectively over a long period of time. Furthermore, correlation coefficients (interviewer *v.* self-administered) between FFQ and reference measures are generally higher for interviewer-administered FFQ than for self-administered FFQ for fat (0·55 *v.* 0·50) and energy (0·55 *v.* 0·46)[31]. When the conversion of frequency estimates of food intake to nutrient values was computed for the present population sample, cross-check questions were used to correct for misreporting of certain food groups (mainly fruits and vegetables, which often tend to be over-reported). Although the introduction of this methodology was effective for foods from plant origin, its application to fat was not significantly important, as has been previously reported[33].

On the other hand, validation of the FFQ method is essential[34]. The validation of the FFQ by Martin-Moreno was designed following the methods used by Willet *et al.*[35] in a sample of the Spanish population (*n* 180) during a period of 1 year. The reproducibility of the FFQ nutrients was in the range from *r* 0·35 to *r* 0·90 with an average *r* 0·50 (values expressed as Pearson correlation coefficients), values within the common range obtained in other studies[36,37]. The nutrients on which the present study was focused, total fat and saturated fat presented reproducibility values of *r* 0·59 and *r* 0·51 respectively, contributing to the bias derived from the use of the questionnaire to assess the Catalan dietary intake. In addition, the fact that there were no significant differences in the reported dietary intake of the participants after stratificating by obesity could imply a possible limitation of the present study to detect under-reporting of overweight and obese subjects. The present results are nevertheless in agreement with previous studies in other Mediterranean populations, in which this tendency of dietary intake under-reporting by obese participants has also been observed[38]. Despite their limitations, the scientific evidence derived from the nutritional studies, in which this FFQ and other similar FFQ have been used, confirm that it is not time to abandon this tool in nutritional studies[39].

An additional limitation of the present study could also be the lack of data concerning socio-economic status as well as ethnical characteristics of the sample. It has been previously reported that the stratification of the population by socio-economic factors can significantly influence the diet quality[40]. Furthermore, Catalonia is one of the Spanish regions where the percentage of immigration is higher than 10, and, therefore, changes in eating patterns and food consumption introduced by the increasing multicultural population could affect the Mediterranean dietary patterns in the near future. Future surveys in the Catalan population should take this statement into account when recruiting study participants.

As Cucó *et al.*[15] suggested, more feasible strategies of food consumption by identifying and quantifying the foods that most affect the variation of the fat and the SFA intake in the diet of populations are needed. Bearing in mind that the characteristics of populations are nowadays in constant change, due to different factors such as immigration or ageing of population in some developed countries, the change in eating habits and food consumption should be periodically verified. According to the present study, olive oil is still the main fat source in this Mediterranean region. Furthermore, during the last decade some healthy improvements have been detected in the Catalan diet, such as the increase in the average intake of fruits, vegetables, poultry and game. A new trend in the consumption of dairy products has also been observed, the intake of cheese being responsible for the highest SFA-derived energy intake.

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References

1. Haffner S & Taegtmeyer H (2003) Epidemic obesity and the metabolic syndrome. *Circulation* **108**, 1541–1545.
2. Wolfram G (2003) Dietary fatty acids and coronary heart disease. *Eur J Med Res* **20**, 321–324.
3. Tur JA, Romaguera D & Pons A (2005) Does the diet of the Balearic population, a Mediterranean-type diet, ensure compliance with nutritional objectives for the Spanish population? *Public Health Nutr* **8**, 275–283.
4. Serra-Majem L, Ngo de la Cruz J, Ribas L & Salleras L (2004) Mediterranean diet and health: Is all the secret in olive oil? *Pathophysiol Haemos Thromb* **33**, 461–465.
5. World Health Organization Regional Office for Europe (2003) *Food-based Dietary Guidelines in the WHO European Region*. Report No. EUR/03/5045414. Geneva: WHO.
6. Junca S, Guillen M, Aragay JM, Brugulat P, Castell C, Seculi E, *et al.* (2003) Methodological aspects in the evaluation of health and risk-reduction objectives of Health Plan for Catalonia for the year 2000. *Med Clin* (Barc) **121**, Suppl. 1, 10–19.
7. Commission of the European Communities (1993) *Scientific Committee for Food of the European Community: Nutrients and Energy Intakes for the European Community. Reports of the Scientific Committee for Food*. 31st series. Luxemburg: Commission of the European Communities.
8. Goldberg GM, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, *et al.* (1991) Critical evaluation of energy physiology. Derivation of cut-off limits to identify underrecording. *Eur J Clin Nutr* **45**, 569–581.
9. Aranceta-Bartrina J, Serra-Majem L, Foz-Sala M & Moreno-Esteban BGrupo Colaborativo SEEDO (2005) Prevalence of obesity in Spain (in Spanish). *Med Clin* (Barc) **125**, 460–466.
10. Macera CA, Ham SA, Yore MM, Jones DA, Ainsworth BE, Kimsey CD, *et al.* (2005) Prevalence of physical activity in the United States: Behavioral Risk Factor Surveillance System 2001. *Prev Chronic Dis* **2**, 1–10.
11. Martin-Moreno JM, Boyle P, Gorgojo L, Maisonneuve P, Fernandez-Rodriguez JC, Salvini S, *et al.* (1993) Development and validation of a food frequency questionnaire in Spain. *Int J Epidemiol* **22**, 512–519.
12. Serra-Majem L, Morales D, Domingo C, Caubet E, Ribas L & Nogués RM (1994) Comparison of two dietary methods: 24-hour recall and semiquantitative food frequency questionnaire (in Spanish). *Med Clin* (Barc) **103**, 652–656.
13. Tur JA, Romaguera D & Pons A (2004) Adherence to the Mediterranean dietary pattern among the population of the Balearic Islands. *Br J Nutr* **92**, 341–346.
14. Cervera P (2006) *Food Composition Tables of CESNID (The Centre for Superior Studies in Nutrition and Dietetics) (in Spanish)*. Barcelona, Spain: McGraw-Hill.
15. Cuco G, Fernandez-Ballart J, Marti-Henneberg C & Arija V (2002) The contribution of foods to the dietary lipid profile of a Spanish population. *Public Health Nutr* **5**, 747–755.
16. Block G, Dresser CM, Hartman AM & Carroll MD (1985) Nutrient sources in the American diet: Quantitative data from the Nhanes II Survey. Macronutrients and fats. *Am J Epidemiol* **122**, 27–40.
17. Aranceta J & Serra-Majem L & Working Party for the Development of Food-Based Dietary Guidelines for the Spanish Population (2001) Dietary guidelines for the Spanish population. *Public Health Nutr* **4**(6A), 1403–1408.
18. Perona JS, Cabello-Moruno R & Ruiz-Gutierrez V (2006) The role of virgin olive oil components in the modulation of endothelial function. *J Nutr Biochem* **17**, 429–445.
19. Bes-Rastrollo M, Sanchez-Villegas A, de la Fuente C, de Irala J, Martinez JA & Martinez-Gonzalez MA (2006) Olive oil consumption and weight change: the SUN prospective cohort study. *Lipids* **41**, 249–256.
20. Osler M, Heitmann BL, Gerdes LU, Jorgensen LM & Schroll M (2001) Dietary patterns and mortality in Danish men and women: a prospective observational study. *Br J Nutr* **85**, 219–225.
21. Burke SJ, Gibney MJ, O'Dwyer NA & McCarthy SN (2005) The influence of cereal and dairy consumption on the Irish diet: implications for developing food-based dietary guidelines. *Public Health Nutr* **8**, 227–237.
22. Haraldsdottir J (1999) Dietary guidelines and patterns of intake in Denmark. *Br J Nutr* **81**, Suppl. 2, S43–S48.
23. Bamia C, Orfanos P, Ferrari P, Overvad K, Hundborg HH, Tjonneland A, *et al.* (2005) Dietary patterns among older Europeans: the EPIC-Elderly study. *Br J Nutr* **94**, 100–113.

24. Nielsen SJ, Siega-Riz AM & Popkin BM (2002) Trends in food locations and sources among adolescents and young adults. *Prev Med* **35**, 107–113.
25. Popkin BM, Siega-Riz AM, Haines PS & Jahns L (2001) Where's the fat? Trends in US diets 1965–1996. *Prev Med* **32**, 245–254.
26. Aranceta-Bartrina J, Serra-Majem L, Foz-Sala M & Moreno-Esteban BGrupo Colaborativo SEEDO (2005) Prevalence of obesity in Spain. *Med Clin* (Barc) **125**, 460–466.
27. Bes-Rastrollo M, Sanchez-Villegas A, Gomez-Gracia E, Martinez JA, Pajares RM & Martinez-Gonzalez MA (2006) Predictors of weight gain in a Mediterranean cohort: the Seguimiento Universidad de Navarra Study 1. *Am J Clin Nutr* **83**, 362–370.
28. Williams CM & Burdge G (2006) Long-chain n-3 PUFA: plant v. marine sources. *Proc Nutr Soc* **65**, 42–50.
29. Harris WS (2005) Extending the cardiovascular benefits of omega-3 fatty acids. *Curr Atheroscler Rep* **7**, 375–380.
30. Dood KW, Guenther PM, Freedman LS, Subar A, Kipnis V, Midthune D, *et al.* (2006) Statistical methods for estimating usual intake of nutrients and foods: A review of the theory. *J Am Diet Assoc* **106**, 1640–1650.
31. Cade J, Thompson R, Burley V & Warm D (2002) Development, validation and utilisation of food-frequency questionnaires – a review. *Public Health Nutr* **5**, 567–587.
32. Pietinen P, Hartman AM, Haapa E, Rasanen L, Haapakoski J & Palmgren J (1988) Reproducibility and validity of dietary assessment instruments. A qualitative food frequency questionnaire. *Am J Epidemiol* **128**, 667–676.
33. Wolk A, Ljung H, Vessby B, Hunter D & Willet WC (1998) Effect of additional questions about fat on the validity of fat estimates from a food frequency questionnaire. *Eur J Clin Nutr* **52**, 186–192.
34. Nelson GJ, Schmidt PC, Bartolini G, Kelley DS & Kyle D (1997) The effect of dietary arachidonic acid on platelet function, platelet fatty acid composition, and blood coagulation in humans. *Lipids* **32**, 421–425.
35. Willet W, Sampson L, Stampfer MJ, *et al.* (1985) Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol* **122**, 51–65.
36. Engle A, Lynn L, Kouri K, *et al.* (1990) Reproducibility and comparability of a computerized, self-administered food frequency questionnaire. *Nutr Cancer* **20**, 906–912.
37. Overvad K, Tjonneland A, Haraldsdottir J, *et al.* (1991) Development of a semiquantitative food frequency questionnaire to assess food, energy and nutrient intake in Denmark. *Int J Epidemiol* **20**, 900–905.
38. Panagiotakos DB, Chrysohoou C, Pitsavos C & Stefanadis C (2006) Association between the prevalence of obesity and adherence to the Mediterranean diet: the ATTICA study. *Nutrition* **22**, 449–456.
39. Willett WC & Hu FB (2006) Not the time to abandon the food frequency questionnaire: point. *Cancer Epidemiol Biomarkers Prev* **15**, 1757–1758.
40. Hann CS, Rock CL, King I & Drewnowski A (2001) Validation of the Healthy Eating Index with use of plasma biomarkers in a clinical sample. *Am J Clin Nutr* **74**, 479–486.