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Olive oil and the Mediterranean diet: beyond the rhetoric

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Objective: The purpose of this study was to analyze the association of food, nutrient and energy intakes with olive oil consumption in Spain.
Design: Cross-sectional study by face-to-face interview.
Setting: Population-based random sample derived from the Catalan Nutrition Survey.
Subjects: In total, 1600 individuals between 18 and 60 y of age.
Intervention: Two 24-h recalls were administered to measure food and nutrient intakes. Food consumption and nutrient intakes were analyzed comparing the highest and lowest quartiles of olive oil consumption.
Results: Those with the highest consumption of olive oil (greater than 13.5% of total calories, fourth quartile) consumed less cereal, baked goods, whole milk, sausages, candy, fruit juice and soft drinks, but more fish, eggs, vegetables and added fats, as compared to those with the lowest olive oil consumption (less than 6.8% of total calories, first quartile). The group with the greatest olive oil consumption also demonstrated high total fat intake, although saturated fats showed a lower percentage of total energy intake. Vitamin intake was more adequate in those with the highest consumption of olive oil.
Conclusion: Olive oil is a key contributor to the healthy aspects attributed to the Mediterranean diet, and as such, nutritional objectives in Mediterranean countries should address reducing saturated fats, without modifying quantities of olive oil.
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Introduction

The Mediterranean diet is an eating pattern characterizing a lifestyle and culture that has been reported to contribute to better health and quality of life for those who adhere to it. Mediterranean foodways are sustained by three basic essentials: wheat, olives and grapes with characteristic foods including products such as wheat derivatives (bread, pasta, etc), olive oil, wine, fruits and vegetables, fish, meat (in small quantities), dairy products (yogurt and cheese), pulses and nuts. Given that within Mediterranean countries cultural and religious differences exist that bring about diversity in food patterns (in North Africa, for example, consumption of wine and pork is not allowed), nowadays the concept of Mediterranean diets is more commonly applied than that of merely one Mediterranean diet (Nestle, 1995).

Olive oil is the central element common to all these diets, and its health benefits have been considered only in the last few decades. The protective effects of olive oil against, among others, coronary heart disease, various cancers and age-related cognitive decline (Keys, 1995), are attributed to two fundamental components: *monounsaturated fatty acids* and *antioxidant* substances. Olive oil is rich in the monounsaturated oleic acid (comprising between 55 and 85% of fatty acid content), and in antioxidants such as vitamin E and a variety of phenolic compounds (Visioli & Galli, 2001).

Monounsaturated fatty acids exert important effects on lipid profiles: (1) reduction or modification of total and LDL cholesterol; (2) increased HDL cholesterol; and (3) LDL

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cholesterol levels more resistant to oxidation. The atherogenic process may also be reduced by various actions in arterial thrombus formation (such as decreased monocyte adhesion, increased fibrinolysis, decreased arterial pressure and insulin) (Lada & Rudel, 2003; Rivellese *et al*, 2003).

Moreover, olive oil contains antioxidant substances that include vitamin E and diverse phenolic compounds (simple: hydroxytyrosol and tyrosol; and complex: oleuropein and verbacosid, among others). Phenolic compounds are mainly found in extra virgin olive oil, and their concentration varies according to geographical location and processing methods (Visioli *et al*, 1998). The salient functions of phenols include: (1) inhibition of LDL-cholesterol oxidation; (2) protection against free radicals and their toxic effects; (3) inhibition of platelet aggregation and thromboxane generation; (4) stimulation of anti-inflammatory agents; and (5) increased nitric oxide production.

In the Mediterranean region, olive oil has traditionally been consumed in elevated quantities, which has led to high values of dietary lipids as a percentage of total calories, ranging from 25 to 40% or more, depending on the country. This fact has conflicted with nutritional objectives in Western countries that limit total fat intake to less than 30% or even 20% of calories. This goal would be completely unattainable in Mediterranean countries without a drastic reduction in olive oil consumption.

Nutritional objectives have been formulated from different positions: (1) for the appropriateness of reducing total dietary lipids in the more classic academic circles (James *et al*, 1989); or (2) for improving the quality of fat consumed, principally through the incorporation of olive or other oils rich in monounsaturated fatty acids. The latter approach is common in Mediterranean countries and in certain more innovative academic forums (Willett *et al*, 1995; Serra-Majem & Aranceta, 2001).

Recently, in a nonsystematic review, Ferro-Luzzi *et al* (2002a) challenged the importance of diets rich in olive oil (and thus in total fat) within the context of the Mediterranean diet as a healthy dietary model, focussing on the issue of obesity. Their propositions, counter-argued by Trichopoulos (Ferro-Luzzi *et al*, 2002b; Trichopoulos, 2002), demonstrate once again the difficulties involved with the international scientific community reaching consensus on key issues such as added dietary fats, in this case olive oil, which in the Mediterranean represents up to 20% of total calories consumed.

The purpose of this study was to conduct an in depth analysis of the Mediterranean diet in the Spanish adult population, evaluating food consumption patterns and energy and nutrient intakes with respect to the consumption of olive oil. Moreover, the association of relative olive oil and total dietary fat intake and the prevalence of obesity in this population was also evaluated.

Material and methods

The present analysis was conducted drawing from the database of the Catalan Nutritional Survey (1992–1993); the methodology of this survey has been described elsewhere (Serra-Majem *et al*, 1999) and will be summarized here. The random sample population consisted of inhabitants aged 6–75 y living in Catalan municipalities.

Dietary assessment consisted of combining two 24-h recalls and a food frequency questionnaire with 77 food items. The 24-h recall was carried out twice during the 1992 study period, the first in a warm season (May–July) and the second in a cold season (November–December). This was to avoid the influence of seasonal variations. The surveys were always carried out at the home of the subject being interviewed. There were 36 interviewers, assigned an average of 78 subjects each, which allowed the fieldwork to be completed within the 6 week timeframe anticipated for this phase of the project. The interviewers, all dietitians, underwent a rigorous training program, thus establishing a quality control mechanism that lasted throughout the entire dietary data collection period. In all, 20% of the sample was interviewed by phone in order to verify certain aspects of the dietary information previously gathered by personal interview. The coding of food data was carried out by the same interviewers, under the supervision of two dietitians.

In order to estimate volumes and portion sizes, the household measures found in the subjects' own homes were used. Volumes for these measures were also noted concurrently. On some occasions standard portions sizes were used. Diet histories for subjects with disabilities or memory defects were carried out via the primary caretaker. Conversion of food into nutrients was made utilizing the French 'Répertoire générale des aliments' which comprises 572 foods specifying 32 nutrients, energy and portion size (Feinberg *et al*, 1991). Adjustment for intraindividual variability was conducted by analysis of variance, using the method described by Beaton and Liu (Beaton *et al*, 1983).

For the present analysis, the population aged 18–60 y was distributed according to their quartile of olive oil consumption, using adjusted values for intraindividual variability. The consumption of principal food groups was compared between low and high consumers (first and fourth quartile) of olive oil. Comparisons also included the percentage of energy intake from fat, carbohydrate and protein and the intake of energy, vitamins and minerals. Averages were always standardized by age using the indirect method.

Out of a total of 4000 individuals included in the random sample, 2757 (68.9%) participated in the survey, and those participants aged 18–60 y (1600) were selected.

Results

Table 1 shows daily food group consumption with respect to the relative contribution of olive oil by gender. Individuals with relatively low olive oil consumption (lower quartile men $<6.6\%$ and women $<6.8\%$ of energy intake) were

Table 1 Mean daily food consumption (g/day) in Spanish men and women aged 18–60 y in the lowest (Q1) and highest (Q4) quartiles of olive oil intake as a percentage of energy

	Men=712					*Women=888*				
	Olive oil					*Olive oil*				
	Q1: <6.6% energy		*Q4: >13.5% energy*			*Q1: <6.8% energy*		*Q4: >14.3% energy*		
	Mean	*s.d.*	*Mean*	*s.d.*	P	*Mean*	*s.d.*	*Mean*	*s.d.*	P
Cereals	257.3	115.8	184.5	80.9	<0.001	155.4	81.0	120.0	72.1	<0.001
Wholemeal bread	6.3	37.5	4.3	17.3	0.721	5.7	17.4	4.6	15.0	0.922
Other bread	139.3	93.0	118.0	67.3	0.108	64.4	56.3	60.5	48.3	0.844
Pasta	16.8	26.9	11.1	22.1	0.057	9.6	16.2	7.7	14.5	0.142
Rice	5.3	15.7	5.3	14.0	0.953	6.6	15.5	6.5	14.9	0.722
Scones, pastries	54.8	61.5	21.5	29.7	<0.001	43.0	44.7	24.1	34.6	<0.001
Potatoes	87.3	83.0	81.8	64.7	0.982	59.1	68.7	69.2	62.6	0.028
Fried potatoes	48.3	70.4	27.6	41.6	0.009	20.4	40.9	19.0	36.1	0.526
Dairy products	275.2	185.3	184.4	135.7	<0.001	274.3	164.9	221.8	121.8	0.001
Full fat milk	168.3	159.0	95.2	103.9	<0.001	147.5	149.4	100.6	104.9	<0.001
Other milk	23.4	65.4	29.1	79.8	0.396	55.3	98.0	59.5	95.7	0.188
Yogurts	33.9	80.5	26.8	47.3	0.947	31.9	63.1	32.4	55.3	0.386
Cheese	24.2	30.8	15.7	23.1	0.017	21.9	30.0	16.3	23.2	0.060
Meat/fish/poultry/egg	324.0	130.1	320.9	117.1	0.703	230.9	96.2	260.0	88.2	0.001
Meat	109.8	79.5	92.7	73.6	0.044	75.7	67.1	78.1	65.1	0.600
Processed meat	53.6	47.2	36.5	36.5	<0.001	29.3	30.2	19.4	22.5	0.001
Poultry	70.9	88.9	47.4	65.9	0.043	51.2	69.1	46.9	62.2	0.549
Fish	64.3	83.4	94.8	103.6	0.002	55.3	69.8	76.1	77.1	0.003
Eggs	22.3	29.5	45.5	41.1	<0.001	16.3	20.7	35.9	36.6	<0.001
Fruit and vegetables	403.5	315.3	488.6	257.9	<0.001	439.5	256.0	579.0	273.9	<0.001
Total fruits	260.1	279.6	222.0	183.4	0.580	304.8	226.2	282.7	198.9	0.502
Citrus fruit	45.4	76.0	54.6	94.5	0.583	72.0	105.9	70.3	88.1	0.401
Other fruit	205.8	259.4	159.0	153.0	0.411	225.9	185.7	203.2	171.9	0.273
Fruit juices	36.8	87.3	12.9	56.4	0.001	18.9	60.0	18.6	55.5	0.782
Vegetables	143.4	109.0	266.6	143.9	<0.001	134.7	102.2	296.3	140.2	<0.001
Pulses (cooked)	24.0	49.5	18.8	40.7	0.159	19.9	41.0	16.3	42.4	0.086
Fats	21.1	12.3	50.9	18.3	<0.001	16.0	10.0	42.8	16.9	<0.001
MUFA (olive oil)	12.3	6.0	42.4	14.7	<0.001	8.6	4.5	36.0	14.0	<0.001
PUFA oils	5.1	7.6	6.7	5.9	<0.001	3.4	5.5	4.7	3.9	<0.001
Butter	3.2	5.5	1.8	3.7	0.073	3.5	5.2	1.5	3.2	<0.001
Confectionery	25.1	27.9	13.6	13.2	<0.001	19.4	22.0	14.3	17.7	0.013
Nuts	4.9	14.2	2.5	9.1	0.076	3.0	9.6	1.1	5.2	0.004
Drinks (ml)	1073.4	523.5	887.3	525.5	<0.001	886.0	473.3	754.7	459.5	0.001
Tea	5.2	30.5	1.3	17.0	0.033	8.2	41.1	7.8	38.8	0.847
Coffee	66.3	65.1	71.5	58.4	0.163	63.9	58.2	71.0	59.0	0.133
Drinking chocolate	11.8	50.7	2.1	14.1	0.037	5.0	32.2	3.8	25.9	0.792
Soft drinks	149.8	207.9	65.6	133.7	<0.001	78.3	143.2	32.5	81.6	<0.001

compared to those with high intakes (upper quartile men >13.5% and women >14.3% of energy intake).

Table 2 presents comparisons between high and low olive oil consumers and intakes of energy, fatty acids, proteins, carbohydrates, vitamins and minerals.

In Table 3, results showing body mass index and the prevalence of obesity with respect to olive oil consumption and total fat intake are described, according to age and sex.

Discussion

In the present analysis, the effect of olive oil intake in varying quantities in the Spanish diet on food and nutrient intakes was investigated via a cross-sectional study. It was conducted in a large representative sample of the Catalan population, whose methodological characteristics have previously been described (Serra Majem *et al*, 1999).

This study demonstrates that individuals consuming greater quantities of olive oil (upper quartile) have higher total fat intakes (around 42% of total calories) than those who consume less olive oil (36% of total calories from fat). However, the percentage of total calories derived from saturated fats is lower in those persons with higher olive oil consumption, especially in women (12.5 *vs* 13.5%).

In the low olive oil consumers, greater intakes of minerals were observed, but only for men (no significant differences for calcium and iron were found in women). This was also

Table 2 Mean daily energy and nutrient intakes in Spanish men and women aged 18–60 y in the lowest (Q1) and highest (Q4) quartiles of olive oil intake as a percentage of energy

	Men=712					*Women=888*				
	Olive oil					*Olive oil*				
	Q1: <6.6% energy		*Q4:>13.5% energy*			*Q1: <6.8% energy*		*Q4:>14.3% energy*		
	Mean	*s.d.*	*Mean*	*s.d.*	P	*Mean*	*s.d.*	*Mean*	*s.d.*	P
Energy (kJ with alcohol)	10829.4	3117.3	9312.3	2403.2	<0.001	7471.0	2259.5	7303.1	2100.8	0.516
Energy (kcal with alcohol)	2575.3	742.3	2218.7	574.5	<0.001	1774.7	538.3	1738.6	501.9	0.561
Proteins (g)	122.6	42.2	102.6	28.0	<0.001	87.5	26.2	86.5	23.3	0.912
Vegetable protein (g)	34.4	24.9	24.5	8.4	<0.001	20.5	8.6	18.7	7.3	0.014
Animal protein (g)	88.3	31.4	78.1	25.7	0.001	67.0	24.5	67.8	22.4	0.400
Carbohydrates (g)	272.1	93.4	201.3	63.2	<0.001	191.0	67.4	162.8	55.5	<0.001
Mono and disaccharides (g)	109.0	49.6	76.8	32.4	<0.001	95.0	40.9	80.7	32.1	<0.001
Polysaccharides (g)	163.1	66.9	124.5	47.1	<0.001	95.9	45.0	82.1	41.0	0.001
Fiber (g)	19.1	9.2	16.8	6.0	0.009	14.5	5.7	15.7	6.5	0.059
Lipids (g)	101.3	35.6	101.3	31.5	0.980	71.4	27.5	80.9	30.6	0.001
SFA (g)	36.8	14.1	30.7	11.0	<0.001	26.9	12.0	24.6	11.0	0.036
MUFA (g)	43.6	16.5	49.0	15.9	0.003	29.5	11.9	38.8	15.1	<0.001
PUFA (g)	12.3	6.3	12.6	4.6	0.111	8.4	4.7	9.9	4.1	<0.001
Cholesterol (mg)	499.0	273.4	512.2	202.2	0.273	367.8	158.6	426.1	170.8	<0.001
Alcohol (g)	13.1	20.7	13.8	17.8	0.121	3.2	7.5	2.5	6.1	0.844
Proteins (% energy)	20.1	4.7	19.7	4.0	0.721	20.7	5.6	20.9	5.2	0.418
Lipids (% energy)	36.4	6.4	42.7	5.8	<0.001	36.1	6.8	41.6	6.5	<0.001
SFA (% energy)	13.2	3.0	12.9	2.8	0.275	13.5	3.8	12.5	3.3	0.006
MUFA (% energy)	15.6	3.3	20.6	3.4	<0.001	14.9	3.2	20.0	3.4	<0.001
PUFA (% energy)	4.4	1.9	5.3	1.4	<0.001	4.2	1.9	5.0	1.2	<0.001
Carbohydrates (% energy)	43.8	7.3	37.8	6.7	<0.001	43.4	7.6	37.8	6.8	<0.001
Sodium (mg)	3210.8	1717.3	2459.6	930.4	<0.001	1970.0	843.7	1732.9	766.6	0.002
Potasium (mg)	3423.6	1124.5	3152.6	905.5	0.029	2778.1	873.3	3027.4	742.3	<0.001
Magnesium (mg)	349.9	126.2	303.4	92.1	<0.001	259.0	81.6	259.3	72.7	0.817
Phosphorus (mg)	1596.3	478.4	1346.5	347.6	<0.001	1200.0	371.6	1170.5	291.4	0.639
Calcium (mg)	871.5	414.8	686.8	266.3	<0.001	771.0	390.8	688.5	240.0	0.072
Iron (mg)	15.7	7.1	13.3	4.1	<0.001	10.9	3.6	11.3	3.4	0.399
Retinol (μg)	430.3	631.9	397.6	912.3	0.020	698.0	3253.0	571.1	2217.9	0.007
Carotenoids (μg)	3221.4	2981.1	4838.2	3729.9	<0.001	3483.6	3303.8	5417.8	3797.4	<0.001
Thiamin (mg)	1.5	0.6	1.2	0.4	<0.001	1.1	0.4	1.0	0.3	0.981
Riboflavin (mg)	1.9	0.7	1.6	0.4	<0.001	1.6	0.7	1.5	0.6	0.490
Vitamin B_6 (mg)	2.1	0.9	1.9	0.5	0.008	1.6	0.5	1.6	0.5	0.194
Vitamin B_{12} (μg)	7.1	4.8	8.4	7.7	0.667	6.0	8.3	6.5	8.3	0.561
Vitamin C (mg)	97.2	74.8	105.5	68.9	0.061	97.1	68.2	120.9	65.1	<0.001
Vitamin D (μg)	4.4	6.8	4.7	8.0	0.705	2.8	4.0	3.0	5.8	0.225
Vitamin E (mg)	9.3	5.8	10.6	3.7	<0.001	7.5	4.8	9.5	3.3	<0.001
Niacin (mg)	25.6	17.0	20.1	6.3	<0.001	17.6	6.7	17.5	5.9	0.902
Pantothenic acid (mg)	6.4	3.0	5.5	1.5	0.002	5.0	2.0	4.9	1.6	0.913
Folic acid (μg)	305.6	178.6	335.3	152.8	0.006	267.4	144.3	333.0	138.5	<0.001

true for certain vitamins associated with cereal consumption (thiamin, riboflavin, vitamin B_6 and niacin), again only observed in men. Vitamins E, C, carotenes and folic acid intakes were greater in men and women with higher olive oil consumption. These differences in nutrient intakes, with potential consequences on health, are explained by those differences observed in the other foods consumed.

Individuals with diets higher in dietary fat and olive oil present in this study had significantly more favorable food profiles that are in keeping with Mediterranean diet patterns, such as greater consumption of fish, eggs and vegetables. In contrast, those with lower total dietary fat intakes and more restricted olive oil consumption had higher intakes of cereals, baked goods, full fat milk, sausages, candy, fruit juice and soft drinks. Therefore, a significant part of the differences in monounsaturated fatty acid intakes observed in high and low olive oil consumers is the substitution of olive oil for mono and disaccharides. Full fat dairy products and sausages in the group with low olive oil consumption account for the concomitant greater intakes of saturated fats.

The establishment of nutritional recommendations or objectives for a country or a region, such as the Mediterranean, should be carried out with full knowledge of the dietary patterns and nutritional status of the target popula-

Table 3 Body mass index and obesity in Spanish men and women according to the percentage of energy from olive oil in the diet and percentage of energy from total fat

			Olive oil as a % of energy					*Total fat as a % of energy*					
Gender	*Age (y)*	*Variable*	*≤5%*	*6–10%*	*11–15%*	*≥15%*	*P trend**	*<30%*	*30–34%*	*35–39%*	*40–44%*	*≥45%*	*P trend**
Men	18–39 y	BMI (kg/m^2) *x*	23.6	24.2	23.9	24.4	0.416	24.3	24.1	24.2	24.0	23.9	0.926
(*n*=695)	(*n*=420)	%BMI ≥ 30	5.9	1.8	6.1	5.6	0.588	3.8	6.5	5.1	2.1	5.4	0.599
		N	85	164	99	72		26	62	118	140	74	
	40–60 y	BMI *x*	27.4	25.8	26.3	26.6	0.110	27.0	26.7	26.2	26.3	26.1	0.538
	(*n*=275)	%BMI ≥ 30	10.8	10.1	10.6	15.6	0.388	9.5	7.8	11.4	13.9	13.5	0.317
		N	37	89	85	64		21	51	79	72	52	
Women	18–39 y	BMI *x*	22.9	22.2	22.7	23.0	0.070	23.3	22.5	22.4	22.7	22.7	0.487
(*n*=857)	(*n*=487)	%BMI ≥ 30	5.4	2.4	2.5	1.9	0.206	5.7	2.9	2.5	2.8	2.6	0.528
		N	92	170	122	103		35	70	122	145	115	
	40–60 y	BMI *x*	26.8	26.1	27.0	26.4	0.352	27.8	27.3	26.0	26.4	25.9	0.069
	(*n*=370)	%BMI ≥ 30	20.0	19.4	16.8	21.8	0.830	28.3	15.9	16.4	23.2	16.0	0.529
		n	60	108	101	101		46	63	116	95	50	
			n=274	*n*=531	*n*=407	*n*=340		*n*=128	*n*=246	*n*=435	*n*=452	*n*=291	

tion and as such, should acknowledge existing food idiosyncrasies and gastronomy of the region (Serra-Majem *et al*, 1997; WHO, 1998).

On the other hand, the substitution of olive oil for alternative MUFA-rich fats/oils may not have the beneficial effects associated with olive oil consumption. Olive oil is the oil of choice for its culinary use as a salad dressing and for frying fish and other foods, as indicated by the present study. Healthy food guides in the Mediterranean region incorporate the utilization of olive oil, as its inclusion in the diet favors the intake of beneficial vegetables. The reduction of SFA as well as moderate use of other types of added fats should also be taken into account, being applicable in the home as well as the food industry and food service settings.

In the present study, no significant differences in BMI and the prevalence of obesity in relation to olive oil intake were found. This has been also observed in other populations (Trichopoulou *et al*, 2002). This is important, since olive oil reduction has been advocated to halt increasing obesity in Mediterranean populations. This should not serve as a justification for rising fat intake in Mediterranean countries, as such an increase occurred in spite of decreased olive oil consumption since the 1960s. Epidemiological evidence supports the major role of sedentarism on higher rates of obesity in Mediterranean countries (Martínez-González *et al*, 2001).

Theoretical arguments should not take precedence over reasoning based on empirical evidence, particularly when it comes to establishing nutritional objectives and dietary guidelines for the population. This should always be accomplished by basing guidelines on food consumption data of the country or region (WHO, 1998).

References

Beaton GH, Miller J, McGuire V, Feather TE & Little JA (1983): Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. Carbohydrate sources, vitamins and minerals. *Am. J. Clin. Nutr.* **37**, 986–995.

Feinberg M, Favier JC & Ireland-Ripert J (1991): *Répertoire général des aliments*. Paris: Tec & Doc Lavoisier.

Ferro-Luzzi A, James WPT & Kafatós A (2002a): The high-fat Greek diet: a recipe for all? *Eur. J. Clin. Nutr.* **56**, 796–809.

Ferro-Luzzi A, James WPT & Kafatos A (2002b): Response to the letter submitted by D Trichopoulos entitled 'In defense of the Mediterranean diet'. *Eur. J. Clin. Nutr.* 2000; **56**, 928–929, 930–931.

James WPT, Duthie GG & Wahle KWJ. (1989): The Mediterranean diet: protective or simply non-toxic?. *Eur. J. Clin. Nutr.* **43** Suppl 2, 31–42.

Keys A (1995): Mediterranean diet and public health: personal reflections. *Am. J. Clin. Nutr.* **61** (Suppl), 1321S–1323S.

Lada AT & Rudel LL (2003): Dietary monounsaturated versus polyunsaturated fatty acids: which is really better for protection from coronary heart disease? *Curr. Opin. Lipidol.* **14**, 41–46.

Martínez-González MA, Varo JJ, Santos JL, De Irala J, Gibney M, Kearney J & Martínez JA (2001): Prevalence of physical activity during leisure time in the European Union. *Med. Sci. Sports Exerc.* **33**, 1142–1146.

Nestle M (1995): Mediterranean diets: historical and research overview. *Am. J. Clin. Nutr.* **61** (Suppl), 1313S–1320S.

Rivellese AA, Maffettone A, Vessby B, Uusitupa M, Hermansen K, Berglund L, Louheranta A, Meyer BJ & Riccardi G (2003): Effects of dietary saturated, monounsaturated and n-3 fatty acids on fasting lipoproteins, LDL size and post-prandial lipid metabolism in healthy subjects. *Atherosclerosis* **167**, 149–158.

Serra-Majem L & Aranceta J (2001): Nutritional objectives for the Spanish population. Consensus from the Spanish Society for Community Nutrition. *Public Health Nutr.* **4** (6A), 1409–1413.

Serra-Majem L, Ferro-Luzzi A, Bellizzi MC & Salleras L (1997): Nutrition policies in Mediterranean Europe. *Nutr. Rev.* **55** (Suppl II), S39–S54.

Serra-Majem L, Ribas L & Ramon JM (1999): Compliance with dietary guidelines in the Spanish population. Results from the Catalan Nutrition Survey. *Br. J. Nutr.* **81** (Suppl), S105–S112.

Trichopoulos D (2002): In defense of the Mediterranean Diet: a letter to the editor. *Eur. J. Clin. Nutr.* **56**, 928–929.

Trichopoulou A, Gnardellis C, Benetou V, Lagiou A, Bamia C & Trichopoulos D (2002): Lipid, protein and carbohydrate intake in relation to body mass index. *Eur. J. Clin. Nutr.* **56**, 37–43.

Visioli F, Bellosta S & Galli C (1998): Free radical-scavenging properties of olive oil poly phenols. *Biochem. Biophys. Res. Commun.* **247**, 60–64.

Visioli F & Galli C (2001): The role of antioxidants in the Mediterranean diet. *Lipids* **36** (Suppl), S49–S52.

Willett WC, Sacks F, Trichopoulou A, Drescher G, Ferro-Luzzi A, Helsing E & Trichopoulos D (1995): Mediterranean diet pyramid: a cultural model for healthy eating. *Am. J. Clin. Nutr.* **61** (Suppl), 1402S–1406S.

World Health Organization (1998): Preparation and use of food-based dietary guidelines: report of a joint FAO/WHO consultation. Technical Report Series no 880. Geneva: WHO.