

## ORIGINAL COMMUNICATION

# The high-fat Greek diet: a recipe for all?

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**Objective:** To examine critically the published results of dietary surveys on the fat content of the Greek diet, and to assess its evolution and its relationship to the health of the Greeks. To consider the implications of these findings for current views on the nature and health implications of the traditional Mediterranean diet and how best to define it for use in modern policy making.

**Design:** A systematic review of the literature on food consumption in Greece.

**Setting:** Greece.

**Results:** The first fully published data on the fat content of the Greek diet—the Seven Countries Survey—relates only to a small number of adult males in Crete and Corfu; the legitimacy of extrapolating these results to the rest of Greece is questioned. Earlier studies and chemical validation of intakes point to a lower fat content of the traditional diet than that inferred for Crete. Nearly all later surveys relate only to urban groups in Athens (mostly case–control hospital-based samples) and a variety of non-representative Cretan groups. Only two studies are larger and more representative, but one uses FAO food balance-sheets to reflect the national diet, and the other surveyed school-age children in three out of the 52 Greek counties. Unfortunately recent dietary studies have proved unreliable, given the continuing lack of national food composition tables with survey methods which proved inaccurate for dietary fat content. A progressive upward trend in total and saturated fat intake appears to have occurred with all health indicators in relation to fat indicating remarkable increases in adult and childhood obesity with attendant progressive deterioration in cardiovascular mortality and its risk factors, ie hypertension and diabetes. These data emphasise the need to alter current nutritional advice in Greece, particularly when it focuses on the promotion of olive oil and a high-fat diet.

**Conclusions:** The findings reaffirm low–moderate fat policies for optimum health, within which olive oil can be an important component of the diet.

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**Keywords:** Mediterranean diet; Greece; dietary fat; nutritional goals

### Introduction

Since the early 1960s, when the first results of the Seven Countries Study established that diet was an important risk factor for ischaemic heart disease (IHD), it also became clear that it was the type and not the total amount of fat that determined IHD. Japanese and Cretans had the lowest saturated fatty acid (SFA) intake—between 3% (Japan) and 8%

(Crete) total energy—and had the lowest IHD mortality rates (Keys, 1970); Finland had the highest SFA intake, 20%, as well as the highest IHD mortality (Roine *et al*, 1964). On the other hand, the variation in total fat intake ranged from the lowest value of 9% total dietary energy in Japan to perhaps 40% in Crete. On this basis and the wealth of experimental and clinical trials it was accepted that, as long as olive oil, ie a MUFA-rich oil, remained the main source of the fat in the Mediterranean diet, the actual level of fat did not represent a risk factor either for IHD or for obesity. This view is now being reiterated (Trichopoulou, 2000; Will-ett, 1994), often with the implication that a high-fat diet is appropriate for general good health (Supreme Scientific Health Council, 1999). In this paper, we explore the validity of the claim that the Greek data reinforce this view. Given the widespread assumption that the so-called Mediterranean diet is the basis for sound, evidence-based advice on healthy

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dietary habits one needs to be sure of the appropriate dietary and nutrient constituents of this Mediterranean diet.

This analysis is particularly appropriate now that a review of dietary factors in relation to health has been produced for the European Union (EURODIET, 2001a). This review was systematically scrutinised and discussed before finally emerging. Their recognition as the first set of EU dietary guidelines by the French Presidency (Société Française de Santé Publique, 2000) was obstructed by some member states because of the proposed total fat level. The objection turned on the view that the high-fat Greek diet should provide the basis for nutrient goals and dietary guidelines for Europe. The EU proposal (EURODIET, 2001b) in practice conformed with recent nutritional international consensus reports (FAO/WHO, 1997; WHO, 1998a; Fodor *et al*, 1999; International Task Force for Prevention of Coronary Heart Disease, 1998; Wood *et al*, 1998; WCRF & AICR, 2000). Therefore the proposition needs to be assessed to see if the Greek evidence is so robust that it overwhelms the data from other Mediterranean countries (WHO, 1998b).

In this paper we review first the information provided by the Seven Countries Study on the diets consumed in Crete and Corfu in the 1950s–1960s and comment on the plausibility of extrapolating these dietary styles to the entire Greek population. We then set out the evidence on the evolution of these earlier dietary models over the subsequent decades. Finally we examine the health correlates of the high-fat Greek diet found under modern lifestyle conditions. We conclude that the argument used to defend the value in the Greek diet of an abundance of dietary fat as long as it is olive oil, is based on a misunderstanding of the fat content of the traditional ‘Greek’ diet, is confined to IHD and neglects the deteriorating health associated with a rising fat content in the Greek diet. There is an urgent need for those respon-

sible for public health in Greece to accept the current international consensus on the need for modest (30%) or even lower (20–25%) fat diets if Greece is to avoid rapidly deteriorating health.

### The Greek diet in the early 1960s

The different estimates of the dietary fat content in the early Greek studies are presented in Table 1. The first dietary survey ever conducted in Greece was never published in a peer-reviewed scientific journal (Allbaugh, 1953). Then Ancel Keys published the first of the Seven Countries Study analyses (Keys *et al*, 1968). The Greek cohort lived on two islands, Crete and Corfu. A 7 day assessment of the foods consumed in three villages in Crete by 30–33 adult males (age 40–59) and by 34 and 40 men in two villages in Corfu was performed. The survey was repeated three times in Crete—in September 1960, May–June 1962 and February 1965—and twice in Corfu, ie in September 1961 and March–April 1963. Ample methodological details were provided (Keys *et al*, 1968), but it still remains unclear whether the Greek survey was one of the 13 out of the 16 base-line surveys conducted within the Seven Countries Study, where the foods were recorded as the edible part of the raw food products, or one of the other three studies where the foods were recorded as consumed (Menotti *et al*, 1999). Furthermore, detailed information on the individual foods contributing to these diets became available for the first time only about 30y later when the original survey records were re-examined (Kromhout *et al*, 1989). Kromhout and colleagues explained that the original Greek records had been lost and the diet had to be reconstructed on the basis of the information provided in the text of the original Keys paper (Keys *et al*, 1968); some items (fruit and vegetables) were not

**Table 1** The dietary fat content in Crete and Corfu in the 1960s, as assessed in the Seven Country Study

Dietary survey method	Place	Time of survey	Study sample no.	Dietary fat			
				by calculation <sup>a</sup>		by chemical analysis	
				Total fat	SFA	Total fat	SFA
7 day weighed survey, plus chemical analysis	Crete	September 1960	30 M, 40–59y <sup>b</sup>	42	9	36	} 8 <sup>d</sup>
		May–June 1962	33 M, 40–59y	42	10	38	
		February 1965	30 M, 40–59y	37	10	35	
	Corfu	September 1961	40 M, 40–59y	34	—	26	} 5 <sup>d</sup>
		March–April 1963	34 M, 40–59y	31	6	28	
7 day weighed individual survey	Crete	Oct–Nov 1957	Adult men <sup>c</sup>	33	—	—	—
			Rest of family <sup>c</sup>	39	—	—	—

From: Keys *et al* (1968).

%en, percentage of energy.

<sup>a</sup>Calculated using international food composition tables.

<sup>b</sup>Survey repeated on same random sub-sample of subjects, three times in Crete and twice in Corfu.

<sup>c</sup>Unspecified number of subjects and households.

<sup>d</sup>Saturates with fewer than 20 carbon atoms (calculated from Table 6, p 63; Keys *et al*, 1968).

mentioned in that paper, so intakes of these items had to be assumed on the basis of food balance sheets. It is also uncertain how the original information on the total dietary fat content of the Greek diet was derived, since official tables of food composition for Greece did not exist at that time. Keys *et al* recorded that a 'special compilation' was in progress under Professor D Galanos (Keys *et al*, 1968) and that unspecified international tables of food composition were used for the original assessment, after some adjustments for the types of foods chosen on the basis of local recipes. However, given that the particular interest of the study was in the fat composition of the diet, 7 day quantitative replicas of the diets had also been collected by Keys and his colleagues and chemically analysed by Fidanza in Italy as well as in the USA (Den Hartog *et al*, 1968a). The results of the surveys obtained by the calculations based on tables of food composition are given in Table 1, which also displays the chemical data.

The estimated average consumption of fat was quite high in Crete, up to 42% total energy, but substantially lower in Corfu, 31–34%. However the chemical analyses of these same diets yielded systematically lower values: 26–28% in Corfu and 35–38% in Crete. At that time, the calculated dietary fat in Italy ranged between 25% in Montegiorgi and 27% in Crevalcore (Fidanza & Fidanza Alberti, 1968), with the highest European values being recorded in The Netherlands with 42% (Den Hartog *et al*, 1968b). The Greek surveys also showed a noticeable seasonal variation in fat intake, with a drop in calculated dietary fat in both Greek islands during the early spring months, ie a decrease to 37% in Crete and to 31% in Corfu.

Therefore it is evident that, of the two Greek study sites, at least one, ie the island of Corfu, cannot be claimed to have had a high-fat diet. In fact, it might even be considered to have a moderately low-fat diet if the chemical data are relied upon. Chemical analyses were performed of dietary duplicates, which yielded values of 26–28% fat energy. One would normally consider the chemical analysis of duplicate diets to provide more robust information than those obtained by unvalidated and unofficial data sets of food composition. Indeed, the comparison of chemical analyses with locally derived estimates of intake based on tables of food composition in the other countries of the Seven Countries Study matched well (Den Hartog *et al*, 1968b; Pekkarinen, 1968; Fidanza & Fidanza Alberti, 1968; Buzina *et al*, 1968). Ancel Keys, however, when confronted with the discrepancies of the Greek survey, considered that mistakes might have crept in at various stages either in the collection of the duplicate dietary samples or in the aliquoting step of chemical analysis. In practice, if he had to rely on chemical analyses alone, this would have substantially limited the sample size as the chemical analyses had been performed on a smaller number of subjects (in Italy on 17 out of the 62 subjects; in Finland on 20 out of 60 subjects). It is obviously difficult to establish the reliability of data obtained so long ago, but of interest is an earlier survey conducted by Keys in

Crete in 1957 (Keys *et al*, 1968), where he compared the dietary intakes of adult men with those of the rest of their families. In this survey the men's fat intake obtained by computation was 33% energy, thus further questioning the validity of the higher computation and reinforcing the idea that the traditional Mediterranean diet was only moderately rich in fat. These values are appreciably lower than the 40% level, still recently claimed in the literature (Trichopoulou, 2000). This is confirmed by one of the authors who sampled and analysed the Cretan diet and noted the non-fatty nature of the sample for analysis contrary to the modern claim that they were particularly high in fat (Fidanza, personal communication).

Another crucially important attribute of the fat of these Mediterranean Diets is their low content of SFA. The SFA content of both the Cretan and Corfu diets was in those years well below 10% energy, reflecting the almost exclusive presence of olive oil in these diets. The slightly higher SFA intake in Crete (Table 1) results from an appreciable consumption of milk, probably goat's or sheep's, amounting to about one quarter of a litre per day (Kromhout *et al*, 1989).

A second issue concerns the validity of extrapolating the Crete and Corfu dietary profiles to Greece. This concern is amplified by an historical perspective. The diet in Corfu was likely to have been influenced by the Italian dietary style, given the long-standing cultural dominance of Venice, and perhaps more closely resembled that of northern Italy. On the other hand, Crete has a geographic location and a long history that places it apart from mainland Greece. It was the cradle of the Minoan civilization, and its population has a dialect, a culture and a style of life that, then and now, sets it apart from mainland Greece (Detorakis, 1994). In fact, there were substantial differences in foods used in the two Greek islands. Cretans not only used more added fats but their diet was also more diverse than that in Corfu. The amount of fruit and vegetables consumed is uncertain as they were unrecorded, but the diet in Corfu was based on bread and fish, while the surprisingly large amount of fresh milk (235 g/day) drunk in Crete contrasted with almost none (70 g/day) in Corfu. Given these substantial differences, we question the validity of extending one or other of the dietary models to the rest of Greece.

In conclusion, the great value of these Key's studies is that they provide a coherent basis for the only cohort diet-health study published from anywhere in Greece so far. They also provide direct support for the value of a moderate fat (about 30%), low saturated fatty acid (< 10%) intake in conjunction with a known but unquantified high vegetable and fruit intake. The major feature of the dietary fat was its almost exclusive olive oil content, with its low proportion of SFA and high MUFA content. However, the diets of these two islands, Crete and Corfu differed from each other rather markedly with an appreciably higher fat content in Crete. Moreover, the available evidence on the Greek diet in the 1960s is limited to only two specific and possibly atypical

and unrepresentative island sites, so it would be unwise to extrapolate the diets of either of these islands to the mainland as only 5 and 1% of the Greek population lives in Crete and Corfu.

### The evolution of the Greek diet

An exhaustive search of the literature on food consumption of Greek residents has yielded a total of 15 publications with original information on dietary fat intakes. However, none

of these 15 studies are nationally representative, except for one survey conducted on school children in the early 1990s (Roma-Giannikou *et al*, 1997). A summary of these surveys with the fat intakes, is presented in Table 2. Methodological issues are dealt with later.

Table 2 shows that, after the Seven Countries Study, there was a long lag before any new information on the diet of the Greeks was published. The first paper, in the late 1980s, described the dietary intakes of a small and non-representative number (97) of school children of two rural villages in

**Table 2** The fat content of the Greek diet as assessed in various surveys over the years

Author	Site of survey	Date of survey	n	Study sample		Dietary fat	
				Age (y)	sex	Total fat (%en)	SFA (%en)
<i>National</i>							
Trichopoulou and Efstathiadis (1989)	Greece, FBS <sup>a</sup>	1956–1960				27	
		1961–1965				28	
		1966–1970			National data	30	—
		1971–1975				32	
		1976–1980				35	
Serra-Majem <i>et al</i> (1993)	Greece, FBS <sup>a</sup>	1981–1985				36	
		1961 1987			National data	33 37	—
<i>Adults</i>							
Kafatos <i>et al</i> (1991)	Crete, urbans	1980s	181	~20–64	M	36	10
			131		F	42	13
Trichopoulou <i>et al</i> (1993)	Athens <sup>b</sup>	1980s	228	40–79	M	42	17
			610		F	46	20
Euronut SENECA Investigators (1991)	Crete, rural	1988–1989	31	73–78	M	43	12
			45		F	44	11
	Greece, Markopoulo		33	73–78	M	42	9
			27		F	45	10
			200	49–70	M+F	47	19
Katsouyanni <i>et al</i> (1991)	Athens <sup>b</sup>	1989	42	25–67	M	41	13
			38		F	42	14
Katosouyanni <i>et al</i> (1997)	Athens <sup>c</sup>	1990	38		F	42	14
			16	18–30	M	43	15
Jackson <i>et al</i> (2000)	Crete <sup>d</sup>	1990	76	65–91	M	43	10
Kafatos <i>et al</i> (1993)	Crete <sup>e</sup>	1990s	88		F	44	9
			141	23–64	M	38	11
Hulshof <i>et al</i> (1999)	Crete <sup>f</sup>	1995	107		F	42	13
			45	50–65	M	35	10
Van de Vijver <i>et al</i> (2000)	Crete <sup>g</sup>	1995–1996	37		F	39	11
Moschandreas and Kafatos (1999)	Crete, urbans	1998	470	18–64	M+F	40	12
Kafatos (unpublished data)	Crete <sup>h</sup>	1997–1999	521	20–59	M	41	12
			32	60–75	M	36	11
			184	> 75	M	40	11
			470	20–59	F	40	13
			46	60–75	F	42	11
<i>Children</i>							
Aravanis <i>et al</i> (1988)	Crete, rural	1986	97	7–9	M	46	10
Roma-Giannikou <i>et al</i> (1997)	Greece, 3 counties	1990	1936	2–14	M	40	15
					F	41	15
Manios and Kafatos (1999)	Crete <sup>i</sup>	1992 1998	90	6–12	M+F	43	15
						42	14
			453	10–12	M	39	14
Kafatos (unpublished data)	Crete <sup>j</sup>	1999–2000	67	14	M	38	14
			254	15–16	M	39	13
			458	10–12	F	39	14
			91	14	F	40	14
			312	15–16	F	40	14

<sup>a</sup>FAO food balance sheets; <sup>b</sup>hospital-based case-control studies; <sup>c</sup>school teachers; <sup>d</sup>university students; <sup>e</sup>elderly; <sup>f</sup>TRANSFAIR I; <sup>g</sup>TRANSFAIR II; <sup>h</sup>Mixed sample: university employees, medical students, inhabitants of nearby villages, follow-up of Seven Country Study subjects; <sup>i</sup>primary school children; <sup>j</sup>secondary school children.

Crete (Aravanis *et al*, 1988). The food weights consumed over two consecutive days was recorded by their mothers, and the USDA tables of food composition were used to convert the food records to nutrient intakes. The results suggest that, over the intervening 20y, the Cretan diet had probably changed, with an estimated fat content now of 46% energy! There was also a substantial inter-individual variation in the estimated fat intake, on the basis of which it can readily be calculated that about a fifth of the children must have consumed a diet with no less than 52% fat energy. The SFA intake had also increased, and now reached an average of 10%.

The only nationally informative analysis on the Greek diet was published in 1989 by Trichopoulou (Trichopoulou & Efstathiadis, 1989), but presents only food disappearance data as given by food balance sheets (FBS; Table 2) and not actual food consumption values. In this paper, the fat content of the national Greek diet was reported to have been as low as about 27% energy in the late 1950s (ie similar to the fat intake of Cretan men in 1957), and to have climbed steadily to reach 36% in the mid 1980s. Similar results were reported in 1993 by (Serra-Majem *et al*, 1993), who calculated 33 and 37% fat for 1961 and 1987 using the same information source. These FAO FBS are recognised to be of lower reliability than good quality weighed dietary surveys, but may still be considered an authoritative source for comparative purposes on inter country differences and time trend data.

Later surveys on Crete and Greek diets were all conducted, with only one exception, on small unrepresentative groups such as the 76 elderly subjects studied in Crete and 60 elderly in Markopoulo (in mainland Greece) as part of the EURO-NUT SENECA study (Euronut SENECA investigators, 1991). There were also a series of case-control hospital-based studies carried out in Athens in the early 1980s, and eventually published in 1991 and reviewed in 1993 (Trichopoulou *et al*, 1993; Katsouyanni *et al*, 1991). The first attempt at a mainland representative survey (of schoolchildren) was that carried out by Roma-Giannikou *et al* (1997) in the early 1990s and involved 1936 school-age children from three of the 52 countries within Greece. Then the Athens group made use of the 1993–1994 representative household budget survey data collected on 6756 households in 13 regions (Trichopoulou & Lagiou, 1998), for estimating intakes. Unfortunately, the fat composition and content of the diet has not yet been published. Moreover, an independent validation of the Greek data set has yet to be performed to corroborate the reliability of this new and interesting approach to the use of household budget data. Another potentially valuable source of information is that of the EPIC study, but no information on the dietary fat of the Greek cohort is as yet available and the reliability of the Greek part of the study, which included a large sample of 14 281 adult volunteers, is of concern (see below; Trichopoulou *et al*, 2000).

On the whole, all these recently available data suggest that the current fat intake in Greece is very high, ranging

from a minimum average of 35% (van de Vijver *et al*, 2000) to a maximum of 47% (Katsouyanni *et al*, 1991). Given these group averages and assuming a hypothetical but realistic standard deviation for fat intake of 10%, a substantial proportion of Greeks may now be consuming a diet whose fat content exceeds 50%. Although on a global basis this appears to be unusual, one could argue that it may in fact be the result of the persistent advocacy in Greece of a high olive oil intake. This advice appears to be based on the assumption that reducing the consumption of olive oil might lead to a reduction in the consumption of vegetables (Trichopoulou, 2000). Published evidence shows, however, that the Greek high-fat consumers are not consuming more vegetables than the low-fat consumers and also that the high vegetable consumers do not consume more fat, as shown in Tables 3 and 4 (Moschandreas & Kafatos, 1999). In practice, a four-fold increase in meat and dairy consumption has occurred over the same time period and might have contributed to the appreciable increase of the fat in the Greek diet.

On the other hand, while waiting for the validation of these surprisingly high estimates of fat intake, a worrying progressive upward shift in the SFA content of the Greek diet appears to be taking place. The SFA content rose steadily from the 5–8% values of the 1960s in Crete and Corfu to the 15% of Crete adolescents recorded some 20–30 y later (Kafatos *et al*, 2000), and to the remarkably high values of 19 and 20% energy in Athens (Katsouyanni *et al*, 1991; Trichopoulou *et al*, 1993). It should be noted, however, that at least in one case, when the SFA content was assessed by chemical analysis (van de Vijver *et al*, 2000), the directly assessed value was 9.5 and 10.8%, ie considerably lower and only marginally above the internationally agreed 10% goal.

In conclusion, although the available information on the amount and quality of the fat of the current Greek diet may be somewhat contradictory and of uncertain quality, the

**Table 3** Consumption in Crete of selected food items by quartiles of fat

Food intake (g/day)	Quartiles of total fat intake	
	Lower (< 33.4%en)	Upper (> 47.29%en)
Cereals	381	340
Bread	126	81
Vegetables	260	292
Potatoes	191	147
Added fats	19	37

**Table 4** Consumption in Crete of fat by quartiles of fruit and vegetables intake

Dietary fat (% en)	Quartiles of fruit and vegetables intake	
	Lower (< 200 g/day)	Upper (> 616 g/day)
Fat	41	38
SFA	14	10

%en, percentage energy.

From Moschandreas and Kafatos, (1999).

converging evidence points to a remarkable increase of both total fat and SFA content.

### Methodological considerations

Three methodological issues regarding the Greek dietary studies will now be considered, ie the representative nature of the study samples, the survey methods employed and their validation, and the methods used to convert the food intakes into nutrients intakes. The overall picture is presented in Table 5.

#### (a) Sampling

Of the 15 reported surveys, two were hospital-based with patient and case controls in Athens. Six of the other studies involved less than 100 subjects and, apart from the FBS analyses and the schoolchildren's study, were all conducted

in either Crete or Athens. The only study which attempted representative sampling in three out of the 52 Greek counties, provided no information about the differences between sites (Roma-Giannikou *et al*, 1997), so again the national validity of the data is uncertain.

#### (b) Dietary recalls and history methods

Most of the surveys conducted in Greece, with the exception of the survey by Manios and Kafatos (Manios & Kafatos, 1999) and the two conducted on Crete children (Aravanis *et al*, 1988), were performed retrospectively. The need to validate locally these survey techniques and the inappropriateness of extrapolating food compositional data from elsewhere, such as, for example the USA, to rural Greece or Crete was recognised by national experts. In 1990 a regionally specific validation was conducted in the context of the EPIC study (Katsouyanni *et al*, 1997), and the self-adminis-

**Table 5** Methodological aspects of dietary surveys conducted in Greece over the years

Author	Surveys method	Table of food composition	Notes and remarks
Trichopoulou and Efstathiadis (1989)	FBS <sup>a</sup>	'Appropriate' food composition factors	FAO national data set
Serra-Majem <i>et al</i> (1993)	FBS <sup>a</sup>	'Appropriate' food composition factors	FAO national data set
Kafatos <i>et al</i> (1991)	24 h recall	USDA 1963 + 20 chemical analyses	Bank employees
Trichopoulou <i>et al</i> (1993)	1 y dietary history	University of Massachussets database + Greek recipes (Polychronopoulou-Trichopoulou, 1982)	Compilation of hospital based case-control studies; 47 food items in questionnaire
Euronut SENECA Investigators (1991)	3 day records + 1 month food frequency questionnaire	USDA 1976 + unpublished Greek food composition tables	SENECA Study
Katsouyanni <i>et al</i> (1991)	1 y dietary history	University Massachussets database + Greek recipes	Compilation of hospital based case-control studies; only combined value for males and females; 110 food questionnaire
Katsouyanni <i>et al</i> (1997)	24 h recall	Food composition database (Trichopoulou <i>et al</i> , 1992) 'adapted'	Pilot EPIC validation study on schoolteachers; 175 food items in questionnaire
Jackson <i>et al</i> (2000)	Food frequency questionnaire + 1 day dietary diary 24 h recall	Unspecified	Healthy volunteers
Kafatos <i>et al</i> (1993)	24 h recall	USDA + chemical analysis of 10 Cretan cheeses	Free-living elderly
Hulshof <i>et al</i> (1999)	24 h recall	National operational database (chemical analyses + national databases + literature data)	TRANSFAIR I, data from previous dietary survey (Mamalakis <i>et al</i> , 1998)
Van de Vijver <i>et al</i> (2000)	1 month dietary history + portion sizes	National operational database (chemical analyses + national databases + literature data)	TRANSFAIR III, + dietary survey
Moschandreas and Kafatos (1999)	24 h recall	500 foods Cretan database + chemical analyses	Only combined values for males and females
Kafatos (unpublished data)	24 h recall	Cretan database with 500 foods (USDA 'adapted' + chemical analyses)	Overview of several studies on university employees, medical students, inhabitants of nearby villages, follow-up of Crete Seven Country Study subjects
Aravanis <i>et al</i> (1988)	2 day weighed survey	USDA, 'adapted'	Crete, rural school children, males
Roma-Giannikou <i>et al</i> (1997)	3 day dietary record in household measures	German (1986) + recipes of Greek foods (Trichopoulou, 1982)	First national survey, school children
Manios and Kafatos (1999)	3 day weighed survey	Unspecified	Crete, primary school children
Kafatos (unpublished data)	24 h recall	Cretan database with 500 food (USDA 'adapted' + chemical analyses)	Crete, secondary school children

<sup>a</sup>FAO food balance sheets.

tered semi-quantitative food-frequency survey protocol was validated against repeated 24 h recalls. The Greek authors concluded that the food-frequency method was 'a reasonably reliable measure of intake'. Unfortunately this positive conclusion does not seem to be shared by the principal author of EPIC (Kaaks *et al*, 1997), who dropped the Greek dietary data from subsequent analyses (Slimani *et al*, 2000). The Greek validation study has three main limitations. First the subjects chosen for the validation were a highly selected, well-educated group, ie school teachers in Athens; they were further biased by the marked self-selection (only 35% of the selected sample agreed to participate in the study). To assume that the general population, especially in rural areas, can respond to the questionnaire with the same precision as this highly selected, educated group seems unjustified. Secondly, the validation process involved the use of the same book of recipes for the calculation of food ingredients by both the test and the reference methods. Approximately one-third (60/175) of the items listed in the food frequency questionnaire were prepared foods and therefore based on a standard recipe for their fat content. Therefore, any error associated with an inappropriate recipe would affect similarly both the survey and the validating procedure, and would thus violate the principle of independence of measurement errors (Kaaks *et al*, 1997). A third problem is that the questionnaire surprisingly did not list olive oil! Information on the presence and the amount of olive oil used appears to have been retrieved from standard recipes. This is clearly a problem, as the appreciably different cooking practices in different households cannot be taken into account.

Despite the fact that this inappropriate standardisation protocol reduced the variance of the two sets of data, the validity coefficients that were obtained for fat intake were surprisingly poor, as indicated by the energy-adjusted, de-attenuated correlation coefficients ranging between 0.26 and 0.09 for total fat (Kaaks *et al*, 1997), of 0.39–0.64 for SFA and 0.28–0.44 for MUFA, the values varying depending on the sex of the respondents and the test survey method (Katsouyanni *et al*, 1997). These validity coefficients represent maximum estimates of the data's validity. The validity of the estimates of dietary fat in other European countries with different dietary habits appears to have been far higher, except for Italy—another country where added fats represent a high proportion of total fats and where there is ample recourse to domestic preparation and consumption of meals. Here the validity coefficients for total fat ranged between 0.31 and 0.41 (Kaaks *et al*, 1997). So it would seem that the level of confidence in the Greek fat data remains low.

### (c) Food composition tables

When assessing the Greek dietary surveys, a major feature is the lack of official, unified, national tables of food composition, which persists to this day (Moschandreas & Kafatos, 1999). Various authors have therefore used a variety of food

composition tables, ranging from various editions of the USDA tables to the nutrient data base of the University of Massachusetts or, the German or British tables. In 1992, food composition databases were developed by the Department of Nutrition and Biochemistry of Athens School of Public Health from the 1976 edition of the British tables (Paul & Southgate, 1978) with adjustment for different Greek recipes. These tables, although described as official, do not appear to be used by all Greek authors and are not cited in the studies set out here. Inevitably, therefore, there is limited comparability of the results between surveys. Both the Athens and Crete schools have attempted to compensate for this, but their independent adjustment of their different tables to local recipes might well have introduced a further element of uncertainty and again limits the comparability of the Greek surveys. Another source of uncertainty is the fact that, in retrospective surveys (such as the dietary history method, the food-frequency questionnaires, and the 24 h recall) prepared/cooked foods are recorded as consumed, and ingredients such as its fat or sugar content can only be back-calculated from recipe books. In practically all the food frequency questionnaires used in Greece, no attempt appears to have been made to directly estimate the consumption of oils and surprisingly only butter and margarine figure in the list of items. This inevitably weakens the reliability of the fat intake data.

### Health indicators in relation to fat

For this analysis (see Table 6) we have considered obesity, cardiovascular disease, hypertension and diabetes mellitus and their risk factors, but excluded the range of cancers. Recent analyses suggest that few if any cancers are strongly linked to dietary fat (WCRF & AICR, 2000); the presumed high fruit and vegetable intakes are probably more important in determining the low cancer rates reported in Greece. However, recently the Athens school has challenged this consensus and hypothesised that olive oil may reduce the risk of ovarian cancer (Tzonou *et al*, 1993) as well as peripheral arterial occlusive disease (Katsouyanni *et al*, 1991) and even rheumatoid arthritis (Linos *et al*, 1999).

#### (a) Health in the 1960–1970s

The body mass indexes (BMIs) of the middle-aged men were only 22.8 and 23.3 in the Keys study in Crete and Corfu, respectively (Dontas *et al*, 1998). At that stage there were only 2–5% obese men and 20–22% were overweight. Such a low prevalence of obesity was a feature of the populations of the Mediterranean region in those years and is partly explained by their relatively high physical activity levels (PALs). We estimated from Keys energy intakes and predicted basal metabolic rates that the PAL of the Crete and Corfu subjects amounted to about 1.70–1.78. This compares with an internationally accepted PAL estimate for moderate activity of only 1.78 (WHO Expert Consultation, 1985). This

**Table 6** Health indicators, as assessed in various surveys conducted in Greece over the years

Author	Year of survey	Place	Age (y)	n	Sex	BMI (kg/m <sup>2</sup> )	Total cholesterol (mmol/l)	HDL cholesterol (mmol/l)	Ratio HDL/total cholesterol	Triglycerides (mmol/l)	Blood pressure	
											Systemic	Diastolic
<b>Children</b>												
Aravanis et al (1988)	1986	Crete	7–9	76	M	18	4.4	1.4	0.32	0.6	—	—
Mamalakis et al (2000)	1992	Crete <sup>a</sup>	6	466	M	16	—	—	—	—	—	—
	1995		9	243	M	17	—	—	—	—	—	—
	1998		12	366	M	20	—	—	—	—	—	—
	1992		6	424	F	16	—	—	—	—	—	—
	1995		9	226	F	17	—	—	—	—	—	—
	1998		12	359	F	21	—	—	—	—	—	—
Petridou et al (1995)	1992	Peloponese + Corfu + Athens <sup>b</sup>	12–18	307	M + F	—	4.5 <sup>b1</sup>	1.6	0.36	0.5	—	—
			—	—	—	—	6.0 <sup>b2</sup>	1.6	0.27	1.1	—	—
Kafatos (unpublished data)	1999–2000	Crete	10–12	453	M	20	4.5	1.4	0.33	1.6	—	—
			14	67	M	22	4.0	1.2	0.29	2.0	—	—
			15–16	254	M	23	4.2	1.2	0.29	1.9	—	—
			10–12	458	F	20	4.4	1.4	0.31	1.9	—	—
			14	91	F	22	4.5	1.3	0.29	1.8	—	—
			15–16	312	F	22	4.5	1.4	0.32	1.8	—	—
<b>Adults</b>												
Keys (1980)	1960s	Crete	40–59	686	M	23	5.2	—	—	—	134	—
			Corfu	529	M	23	5.1	—	—	—	132	—
Christakis et al (1965)	1960s	Crete <sup>c</sup>	62	280	M	25	4.2	—	—	1.6	139	84
Kafatos et al (1997)	1960	Crete <sup>d</sup>	40–59	177	M	24	5.3	—	—	—	134	81
			45–64	177	M	25	5.6	—	—	—	129	81
			50–69	177	M	25	6.2	—	—	—	130	82
			70–89	171	M	26	5.7	—	—	—	152	97
			Total	686	M	24	5.7	—	—	—	—	—
Trichopoulou et al (1992)	1979–1980	Athens <sup>e</sup> case–control study	49–70	48 <sup>e1</sup>	M	—	4.2	0.5	0.13	1.3	—	—
			—	48 <sup>e2</sup>	M	—	4.8	0.6	0.13	1.7	—	—
			—	52 <sup>e1</sup>	F	—	4.9	0.6	0.13	1.5	—	—
			—	52 <sup>e2</sup>	F	—	5.4	0.8	0.14	1.4	—	—
			Total	129	F	25	5.5	1.3	0.24	1.0	111	76
Kafatos et al (1991)	1980s	Crete <sup>f</sup>	20–30	7	M	24	5.6	1.2	0.24	1.6	117	80
			31–40	78	M	26	6.1	1.0	0.17	1.5	122	86
			41–50	82	M	27	6.6	1.1	0.17	1.6	129	88
			51–63	83	M	27	6.3	1.0	0.18	1.6	132	88
			Total	250	M	27	6.3	1.0	0.18	1.6	128	88
			20–30	46	F	24	5.0	1.3	0.27	0.8	109	75
			31–40	55	F	26	5.7	1.3	0.23	1.0	108	75
			41–50	20	F	26	5.9	1.4	0.25	1.0	119	80
			51–63	8	F	28	6.7	1.2	0.19	1.6	121	86
			Total	129	F	25	5.5	1.3	0.24	1.0	111	76
			Total	70	M	28	6.1	1.2	0.19	1.5	—	—
Euronut SENECA investigators (1991)	1987–1988	Greece	70	23	F	30	6.1	1.5	0.26	1.1	—	—
			70	28	M	25	5.8	1.2	0.21	1.3	—	—
			70	36	F	26	5.9	1.2	0.21	1.5	—	—
Sandker et al (1993)	1986	Crete <sup>g</sup>	73	100	M	26	6.0	1.3	0.22	—	158	85
Kafatos et al (1993)	1990s	Crete <sup>h</sup>	65–91	76	M	25	5.6	1.5	0.27	1.6	—	—
			88	F	28	6.0	1.5	0.25	1.7	—	—	
Trichopoulou et al (2000)	1990s	Greece <sup>i</sup>	25–40	—	M	27	—	—	—	—	—	—
			40–55	—	M	28	—	—	—	—	—	—
			55–65	—	M	28	—	—	—	—	—	—
			65+	—	M	28	—	—	—	—	—	—
			Total	5633	M	28	—	—	—	—	—	—
			25–40	—	F	25	—	—	—	—	—	—
			40–55	—	F	27	—	—	—	—	—	—
			55–65	—	F	29	—	—	—	—	—	—
			65+	—	F	30	—	—	—	—	—	—
			Total	8648	F	28	—	—	—	—	—	—

Table 6 continued.

Table

Author	Year of surgery	Place	Age (y)	n	Sex	BMI (kg/m <sup>2</sup> )	Total cholesterol (mmol/l)	HDL cholesterol (mmol/l)	Ratio HDL/total cholesterol	Tirglycerides (mmol/l)	Blood pressure	
											Systemic	Diastolic
Jackson <i>et al</i> (2000)	1990	Crete	18–30	16	M	—	4.3	0.8	0.18	1.0	—	—
Van de Vijver <i>et al</i> (2000)	1995–1996	Crete <sup>j</sup>	56	45	M	—	5.9	1.2	0.20	—	—	—
			58	37	F	—	6.6	1.6	0.24	—	—	—
Kafatos (unpublished data)	1997–1999	Crete <sup>k</sup>	20–59	521	M	26	5.2	1.1	0.23	3.0	122	80
			60–75	32	M	28	6.0	1.1	0.19	3.7	142	84
			> 75	184	M	26	5.5	1.3	0.25	3.6	141	84
			20–59	470	F	24	5.0	1.4	0.29	2.1	114	74
			60–75	46	F	31	6.8	1.4	0.22	4.3	56	92

<sup>a</sup> Follow-up study of random sample of Cretan school children; <sup>b</sup> adolescents from diverse backgrounds: <sup>b1</sup> urban high income, <sup>b2</sup> urban low income, <sup>b3</sup> rural, <sup>c</sup> random sample of Cretan men aged > 45 y; <sup>d</sup> Seven Countries Study sample: longitudinal; <sup>e</sup> subjects from hospital case–control study: <sup>e1</sup> cases, <sup>e2</sup> controls; <sup>f</sup> bank employees; <sup>g</sup> Seven Countries Study: survivors in 1986; <sup>h</sup> free-living elderly in Anogia, Crete; <sup>i</sup> participants in the Greek component of European Prospective Investigation into Cancer and Nutrition (EPIC); <sup>j</sup> TRANSFAIR III study, adult volunteers (50–65 y) recruited based on first come-first served basis; <sup>k</sup> random sample of university employees, medical students, villagers.

moderate value conflicts with the reports that in Crete these men walked 13 km daily in a rugged, mountainous landscape (Christakis *et al*, 1965), which would have demanded a PAL of at least 2.2.

Around those years, Greece had the highest life expectancy, almost 72 y at birth for males (Figure 1), and the lowest IHD death rate in Western Europe and only a modest death rate for strokes (WHO, 2000). Keys' data also revealed that over the 10 and also the 25 y of follow-up of the Seven Countries Study cohorts, ie up to about 1985, the mortality rates from IHD of men in Corfu and Crete were very low and indeed lower than those in Southern Italy and Yugoslavia (Menotti *et al*, 1999). These follow-up data matched the national health statistics

so it seems reasonable to link the Keys studies with the mortality profile of Greece as a whole. Of the three major risk factors for IHD, ie smoking, hypertension and high serum cholesterol, the men from Crete and Corfu showed that, although smoking rates were high (57 and 63%, respectively; Keys, 1980), IHD rates were low. The Seven Countries Study follow-up also showed that the small increment in IHD deaths with the increasing number of cigarettes smoked was very different from the importance that smoking has in Northern Europe (Keys, 1980). These Southern European data match information from Japan and later data from China where a low fat and SFA intake explain the low IHD rates despite substantial hypertension and smoking rates.

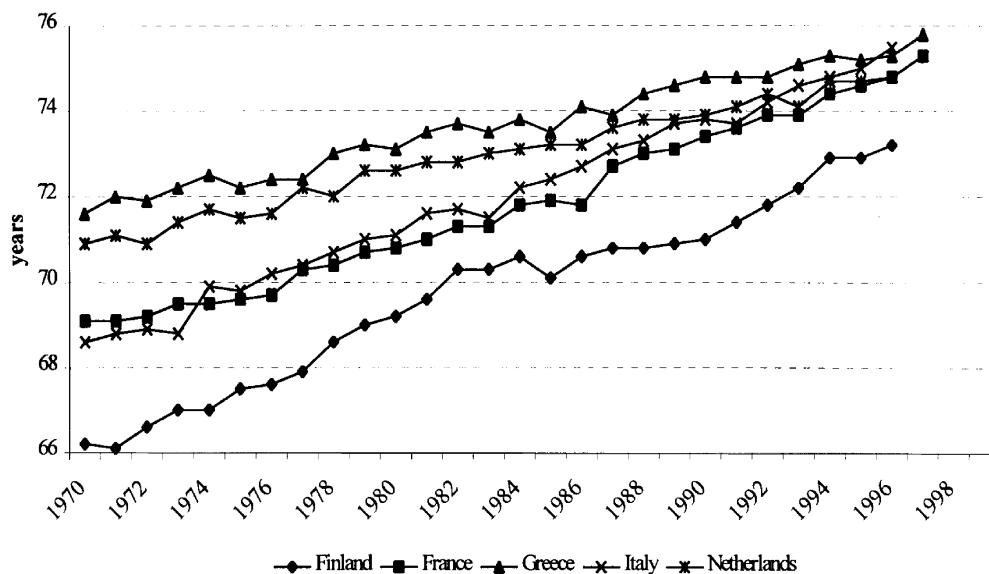


Figure 1 Life expectancy at birth, in years, males, in selected EU countries (from WHO, 2000).

We conclude that the Crete and Corfu men (and probably the rest of Greece) in the 1950s and 1960s benefited, amongst other potential protective factors, from moderately low fat intakes with appreciably high physical activity levels.

**(b) Evolution over time in disease patterns**

Figure 1 demonstrates that there has been little improvement in Greece over the last 25 y compared, for example, with Italy which further extended its life expectancy as did most of the other European countries. Figure 2 shows the percent improvement of life expectancy in the European countries between 1970 and 1997 and reveals that Greece, while starting with an enviable health profile, has lagged behind compared with the general substantial improvement recorded in all European countries except for some Central European countries. The same considerations apply also to the mortality rates for specific dietary-related chronic diseases such as IHD and cerebrovascular disease (Figure 3). It is noteworthy that in relation to the cardiovascular system, Greece was unusual among the 15 EU countries in being the only country showing a progressive increase in IHD mortality, albeit from a very low level, and little change in stroke rates. In order to understand these changes, Table 6 summarises selected risk factors reported over the years by various authors in Crete and Corfu, namely data on BMI, serum cholesterol and blood pressure.

**Obesity rates**

The BMI of Cretan children and adults has been rising at an amazing rate over the last 30 y (Table 6), and obesity is now of great concern not only in adults but also in children (Mamalakis & Kafatos, 1996; Mamalakis et al, 2000). Recently Trichopoulou et al, (2000) published the first evidence on the

BMI of the Greek cohort of the EPIC study started in 1992 on a nation-wide sample of adult men ( $n=5633$ ) and women ( $n=8648$ ). This reveals truly epidemic levels of overweight and obesity. Although only mean BMIs are given, it is clear that more than half of all adults exceed the generous upper normal BMI limit of 25.0 with over 50% of women aged 55+ being obese. Analyses of energy intakes and physical inactivity in relation to BMI show significant disadvantageous trends for both factors, but it is very striking that the authors find that energy intakes are twice as important as inactivity in their associations with higher BMIs.

In the 1960s there was little information on diabetes rates but the recent data released by the International Diabetes Federation, based on the returns from national diabetes societies suggests that Greece has a high prevalence of diabetes mellitus (5.9% of 20–79 y olds) with only Italy (7.1%) and crude estimates of 6.1% for Denmark and Spain (60–74 y old), and of 6.4% for Sweden exceeding this value within the EU. This rate, as with the global prevalence of diabetes mellitus, is strongly linked to excess weight gain.

Secular changes in blood pressure are difficult to assess, but in the late 1980s we noted that a very high proportion of the elderly men of the Crete cohort of the Seven Countries Study had hypertension in association with overweight and obesity which affected 4 and 12%, respectively (Kafatos et al, 1991). This is not surprising, given the crucial role of weight gain in amplifying the prevalence of hypertension. This and the high prevalence of substantial alcohol intakes in Crete (Kromhout et al, 1989; Keys et al, 1968) seems to explain their high prevalence of hypertension.

**Lipid changes**

There is only modest evidence to suggest that age- and sex-standardised serum cholesterol levels have risen in Crete, but

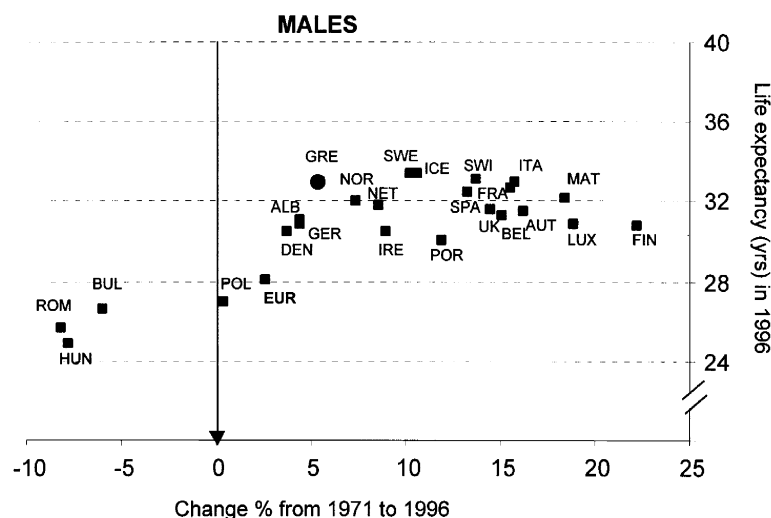
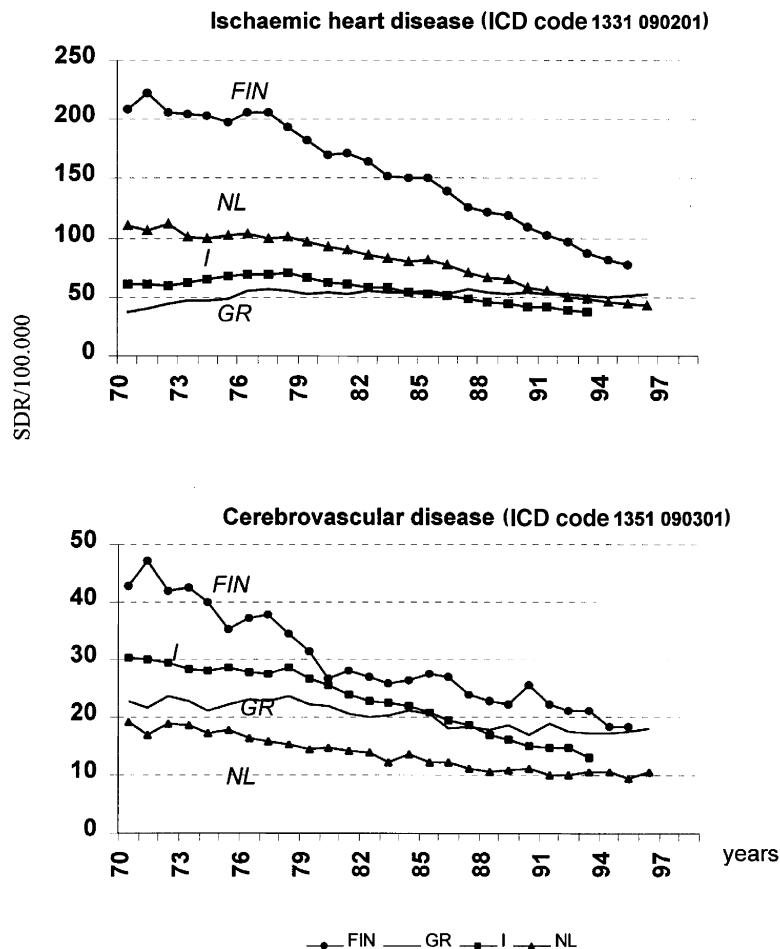


Figure 2 Percentage change in life expectancy at age 45 y of men in Europe between 1971 and 1996. From WHO, (2000).



**Figure 3** Age-standardised premature death rate (SDR) trends in Greece, Finland, Netherlands and Italy for ischaemic heart disease and cerebrovascular disease (from WHO, 2000). Males < 65 y/100 000.

there is even less evidence from elsewhere in Greece (Table 6). It is noted by both Katan and one of the authors that total serum cholesterol levels are now high in Crete, with data suggesting that HDL cholesterol levels are at the low end of the normal range (Aravanis *et al*, 1988; Sandker *et al*, 1993). More detailed studies, however, also show that Greek men and women have high fasting triglyceride levels and high postprandial lipaemic changes. Katan and ourselves have therefore expressed surprise that the IHD morbidity and mortality rate are not higher (Aravanis *et al*, 1988; Kafatos *et al*, 1997). A lag time might be the confounding factor, this lag probably being greater for disease development than disease remission. So the full health impact of the unfavourable lipidaemic profile is likely to emerge in the next few years, as set out by Law and Wald in their analysis of the so-called French paradox (Law & Wald, 1999). On the basis of current trends, Greece seems set for a progressively deteriorating health status.

## Discussion

This review has focussed on the issue of dietary fat and its potential health consequences in Greece. This analysis is warranted by the position taken in the nutrition policy arena by some Greek and USA investigators who strongly advocate a high-fat diet on the grounds that, as long as the fat source is olive oil, it is compatible with long-term good health (Willett, 1994; Trichopoulou & Lagiou, 1997). This position has recently obstructed the adoption of a European goal of a low to moderate fat intake, and has helped to promote worldwide a higher consumption of olive oil and a perception that the nutrition community is uncertain about the value of a modest fat intake. Four principal findings emerge from our review which leads to the conclusion that there are few scientific grounds for the claim that a high-fat Greek version of the traditional Mediterranean diet existed, that this had selective benefits and that the Greek experience validates the global promotion of a diet rich in olive oil.

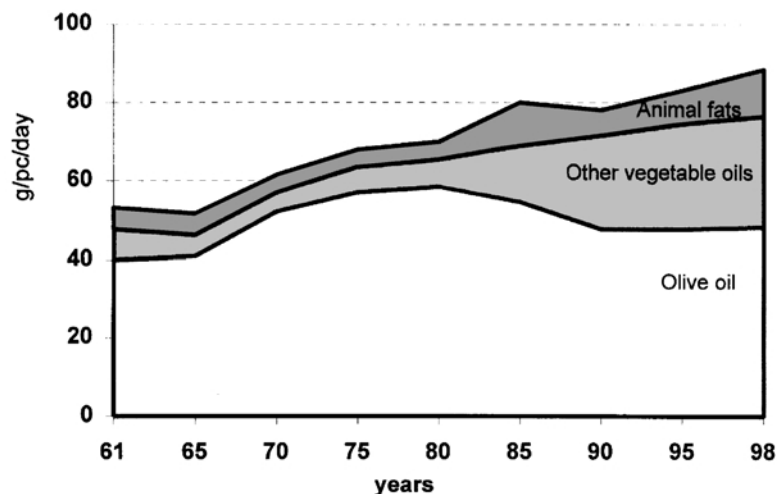


Figure 4 Time trend in consumption of olive oil and other vegetable oils in Greece (1961–1998). From FAO, (2000).

Our first finding is that there are few reliable dietary studies from Greece in relation to dietary fat, other than the detailed Seven Countries Study. Assessing dietary fat intakes seem to be particularly difficult in Greece, probably because so much of the fat is added as oil to foods and to recipes in the domestic preparation of meals. Industrial foods of standard composition seem to make only a modest contribution to the diet in Greece compared with elsewhere, and it is exceptionally difficult to identify accurately from semi-quantitative food frequency questionnaires or from standard recipe books the amount of oil used in cooking or left in the dish, unless it is assessed by the precise weighing technique in the household. This probably explains the poor validity of the fat data from Greece in the European validation tests conducted as part of the important EPIC programme (Kaaks *et al*, 1997). Nevertheless, the overall picture from food balance sheets and household budget analyses points to a substantial increase in total fat intake in Greece over the last 50 y. This phenomenon might have been generated/facilitated by the persistent promotion in Greece of the paradigm of the high-fat version of the Mediterranean diet. This increase in fat consumption in practice appears to have taken place by means of the introduction in the diet of other fat sources as well as some increase in olive oil availability, as shown in Figure 4. This phenomenon may help to explain the increase of dietary SFA, which seems to have almost tripled over 30 y. The second finding is that almost all the detailed information so far available on the dietary fat intake in Greece derives from surveys conducted on small, unrepresentative sub-samples of the population, and is limited to two specific sites, namely Athens and Crete. The legitimacy of the extrapolation to the entire Greek population of these data is very doubtful, given also the profound diversity in culture, lifestyle and environmental circumstances evident to most observers.

The third finding is that the Greek diet, as inferred from both the food balance sheets and chemical dietary analysis, showed that in the 1950s the Greek diet probably had <30% fat. During the following decades, while the cohort of the Seven Countries Study was still being monitored, the fat content of the Greek diet did rise but the morbidity and mortality rates of the Crete and Corfu cohorts over 5–10 y follow-up did not, clearly reflecting their prior beneficial exposure to earlier environmental factors. However, in the later 25 y follow-up, while the CHD rates were still modest, Crete had almost half (25 deaths/1000) the IHD rate found in Corfu (48) and this rate was lower than that in southern Italy (60), where the total fat and SFA intakes were lower. Whether these differences relate to higher fruit and vegetable intakes (Khaw *et al*, 2001) is unknown. However, the Italy/Greece ratio of age-adjusted death rates is seen to have dropped in the 25 y interval, from 2.41 to only 1.3 (Menotti *et al*, 1999) so again Italian health is improving faster. The fourth major finding is the substantial deterioration in the health profile of Greece over the last 30 y. Obesity rates are currently rampant and diabetes rates are already relatively high. The recent analyses of obesity rates throughout mainland Greece reveal that not only are >50% of women aged 65+ obese with BMIs >30, but that the majority of the total adult population is either overweight or obese. This prevalence is probably higher than that seen anywhere in the world except in the Pacific islands (WHO, 1998a). The new Greek study, which benefited from an assessment of both dietary energy intake and physical activity, suggested that there was a clear and statistically significant relationship between increasing BMIs and both a rise in dietary energy intake and a decrease in physical activity (Trichopoulou *et al*, 2000). Although the value of this study may be somewhat limited by its cross-sectional nature, it is still notable that the regression analysis showed that the

dietary energy component of energy balance was twice as important as the physical inactivity in determining weight gain. Of relevance is that, even if the recent estimates of fat intake suggesting 38–51% of energy intake in the middle-aged and elderly (Trichopoulou & Lagiou, 1997) are wrong, dietary fat intakes are clearly very high. The extraordinary increase in the average BMI and in obesity rates also implies that blood pressure levels may well have been rising despite the persisting high vegetable and fruit intakes; only a falling salt intake may have limited the impact of the increasing body weight. Certainly the death rates for stroke have not improved, making Greece again the only country in both Europe and the rest of the world (excluding the ex-Soviet Union) where stroke rates have not fallen.

The startling conjunction of these recent epidemic obesity and diabetes rates with a long life expectancy and the still quite low IHD rates presents us with an unusual situation which might be named the Greek rather than the French 'paradox'. This paradox, however, might be explained by the delay in the evidence for cumulative atherosclerosis as SFA intakes rise and the escalating obesity rates following the systematic promotion of olive oil consumption in Greece by the nutritionists as well as the food industry over the last 30 y. By having olive oil still dominating the fat intake, Greek adults have the current benefit of low IHD rates but the rise in total fat intakes evidently has brought no health gain. The high obesity rates also emphasise the importance of physical activity, but given the prevailing lifestyles in Greece and elsewhere, the data suggest the need for a marked change in Greek food policies to reduce total fat intakes to < 30% with olive oil remaining the overwhelming source of fat. The Greek data, taken in conjunction with the Keys Seven Countries Study from Crete and Corfu, further support the recent attempt by European scientists to produce coherent nutritional goals based in part on the early experience of the health consequences of the traditional Mediterranean diet. On the basis of this analysis there is a need to specify that fat intakes be less than 30% (EURODIET, 2001b) with a low SFA intake. Only exceptionally active subgroups may tolerate higher fat intakes of a suitable composition.

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