Original Communication

Omega 3 and Omega 6 Fatty Acids Intake and Dietary Sources in a Representative Sample of Spanish Adults

Liliana G. González-Rodríguez, Aránzazu Aparicio, Ana M. López-Sobaler, and Rosa M. Ortega

UCM Research Group VALORNUT (920030), Department of Nutrition, Faculty of Pharmacy, Complutense University of Madrid, Spain

Received: July 11, 2012; Accepted: May 3, 2013

Abstract: The present study analyzes the intake of omega 3 (n-3 PUFAs) and omega 6 (n-6 PUFAs) and dietary sources in a representative sample of Spanish adults. For this purpose 418 adults (18–60 y), from 15 Spanish provinces were studied. The intake of energy and nutrients [specifically, the n-3 polyunsaturated fatty acids (PUFAs,) α-linolenic acid (ALA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA); and the n-6 PUFA, linoleic acid (LA)] was determined using a 24-hour recall questionnaire for two days. The Multiple Source Method (MSM) was used to estimate participants' usual fatty acid intake. The total n-3 PUFAs intake was 1.8 ± 0.60 g/day (ALA: 1.3 ± 0.32, EPA: 0.16 ± 0.14, and DHA: 0.33 ± 0.21 g/day) and n-6 PUFA intake was 11.0 ± 2.7 g/day (LA: 10.8 ± 2.7 g/day). A high proportion of participants did not meet their nutrient intake goals for total n-3 PUFAs (84.7 %), ALA (45.0 %), and EPA plus DHA (62.9 %). The main food sources for ALA were oil, dairy products, and meat; for EPA fish; for DHA, fish, eggs, and meat; and for LA, oils, meat, and cereals. Therefore, an increase in the intake of foods rich in n-3 PUFAs or the use of supplements with n-3 PUFAs might help to improve the n-3 PUFA intake.

Key words: omega-3 fatty acids, eicosapentaenoic acid, docosahexaenoic acid, omega-6 fatty acids, dietary sources, adults

Introduction

Omega-3 (n-3) and omega-6 (n-6) polyunsaturated fatty acids (PUFAs) are well recognized as necessary nutrients for human health. Recently, there have been significant advances that have highlighted the importance of some n-3 PUFAs [1, 2]. Studies have demonstrated the role of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in the prevention and treatment of different diseases, such as cardiovascular disease, arteriosclerosis, hypertension, breast and colorectal cancers, type 2 diabetes, inflammatory bowel disease, asthma in children, rheumatoid arthritis, depression, bipolar disorder, aggression, hostility, antisocial behavior, age-related macular degeneration, and cognitive decline [1–3].

Despite the fact that southern European countries such as Spain often follow the traditional Mediterranean diet, the adoption of a Westernized diet is becoming more frequent, and this has led to a change in the intake of fatty acids (FAs) and a clear reduction in the intake of n-3 PUFAs among the population [3].

Moreover, the dietary recommendations for fats and FAs have recently been modified according to the last report published by the Food and Agriculture Organization of the United Nations (FAO). For instance, the recommendation of maintaining a proper n-6/n-3 PUFAs ratio has been questioned in several studies [2, 3]. In this connection, the FAO has noted that there is no sufficient evidence for a specific recommendation, if intakes of both types of FAs lie within the recommendation [2].

The information published so far regarding the intake of n-3 and n-6 PUFAs in Spain is not sufficient [4]. Although several studies have been carried out in Spain [4–7], they do not represent the entire Spanish adult population. Moreover some reports have analyzed the intake of FA using food availability or household food intake data [8], but not data from individual food intake surveys [4]. Additionally, none of those studies have assessed the intake of FAs in the Spanish population since the last recommendations for fats and FAs were proposed by FAO [2].

The aim of the present study was to determine n-3 and n-6 PUFAs intakes, compare them with current national and international recommendations, and identify the main food sources in a representative sample of Spanish adults.

Subjects and Methods

Subjects

Data was obtained from the FANPE Study ("*Fuentes Alimentarias de Nutrientes en Población Española*" – Dietary Sources of Nutrients in the Spanish Population), which was conducted by a contract with the Spanish Agency for Food Safety and Nutrition (AESAN) to determine the food sources of energy and nutrients (with particular attention to sodium intake) in the Spanish population [9].

A sample of 418 adults (196 men and 222 women) with ages ranging from 18 to 60 years was selected as a representative sample of the entire Spanish adult population.

The sample size was calculated, taking into account data provided by the Spanish Intersalt study [10], and the national population size of 18–60 years to be representative for each gender and for that range of age of the Spanish population, assuming a dropout rate of 25 %. The initial sample size calculated was set at 406 participants. Fifteen provinces were randomly selected with the proviso that the great majority of Spain's autonomous regions were represented, including the capital city of each province and a semi-urban/rural town (randomly chosen). The total number of cities/towns included was 30. The number of subjects for each sampling point was allocated proportionally, according to the proportions for each subgroup of gender (male/female) and for the groups of age (18–30, 31–44, and 45–60 years) from the entire population.

All selected participants were healthy and lived in their own homes; neither hospitalized people nor those living in institutions were included in the present study. Individuals with a diagnosis of diabetes, hypertension or renal disease, or who had been prescribed diuretics, were excluded.

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Ethics Committee of the Faculty of Pharmacy (Universidad Complutense, Madrid, Spain). Written informed consent was obtained from all subjects.

Participants were randomly selected among the residents of each population and were invited to take part in the study via telephone (or in person in some of the rural areas). In each of the 30 sampling areas, when a participant was excluded at any site, or when participation was declined, another person of the same gender and age group was recruited. A group of 1835 individuals was initially recruited, and only 492 (26.8 %) agreed to take part in the study. From these, 74 individuals were excluded. The final study sample size was 418 participants (53.1 % women) (22.8 % of the originally contacted sample).

Methods

Data were collected from January to September 2009. All the interviews and measurements were carried out by previously trained field workers following the same protocol. Also, all participants received the same instructions to complete the questionnaires.

Anthropometric information

Weight and height were determined using a digital electronic scale (Seca Alpha, GmbH & Company, Igni, France; range 0·1–150 kg, precision ±100 g) and a Harpenden digital stadiometer (Pfifter, Carlstadt, NJ, USA; range 70–205 cm, precision ±1 mm), respectively. For both measurements, participants were barefoot and wore only underwear. All data were measured by trained field workers following the norms set out by the World Health Organization (WHO) [11]. Body mass index (BMI) was calculated from the body weight (kg) and height (m) measurements.

Dietary information

Dietary intake was recorded using an interviewer-administered 24-hour recall questionnaire, conducted on two consecutive days [12]. All interviews were conducted by trained field interviewers. Participants were asked to report all foods and beverages consumed on the previous day. They were also asked about the food items included in the menu or recipes, the method of preparation, condiments added, the weight or size of the portions consumed (approximate weights or household measures such as cups, bowls, plates, etc.), indicating whether these weights or sizes corresponded to raw or cooked food, with or without bone or skin, as well as the brand names of the manufactured food, and the name of the menu for restaurants or other foods eaten outside of home. Additionally, participants were asked to indicate the intake of fortified or functional foods and provide information about the use, type, frequency of use, and the amount of dietary supplements.

The energy and nutrient intake were then calculated using food composition tables [13–16]. DIAL software (Alce Ingeniería, 2004) was used to analyze all dietary data [17]. The present study was focused on the intake of saturated fatty acids (SFA); monounsaturated fatty acids (MUFAs); polyunsaturated fatty acids (PUFAs); total n-3 PUFAs, α-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA); and total n-6 PUFAs and linoleic acid (LA), expressed in grams per day (g/day) and in percentages of total energy (%E). The intakes of FAs (mainly, n-3 and n-6 PUFAs) were compared to national and international recommended dietary intakes [2, 18].

The number of servings of the different groups of food consumed by the participants was calculated dividing the grams consumed by the size of the standard serving [13, 19]. These were compared with the recommended servings established in the dietary guidelines for the Spanish population: (cereals and pulses: 6–10 servings/day; greens and vegetables: 3–5 servings/day; fruits: 2–4 servings/day; dairy products: 2–3 servings/day; meat, fish and eggs: 2–3 servings/day) [20].

The contribution of each food group to the total intake of each FA was calculated as a percentage, by dividing the amount of each fatty acid provided by each food group for all persons by the total intake of this same fatty acid from all foods for all persons [21].

Physical activity

Participants completed two physical activity questionnaires [22] describing the time spent on different daily activities, such as sleeping, eating, walking, resting, exercising, etc. One questionnaire asked about physical activity during the weekdays and the other during weekend.

An activity coefficient was established for each participant by multiplying the time spent in each activity by coefficients related with the activity type: a coefficient of 1 for sleeping and resting; 1.5 for very light activities (those that can be done sitting or standing up such as ironing, typing, or painting); 2.5 for light activities (e. g., walking); 5 for moderate activities (e. g., playing tennis, skiing, and dancing); and 7 for intensive activities (e. g., cutting down trees and playing basketball). The sum of these values was then divided by 24. The weekday coefficient was multiplied by 6, the Sunday coefficient was then added to the weekday result, and the total was divided by 7. This provided the physical activity level (PAL) for each participant [23, 24].

Basal energy expenditure was obtained using body weight, age, and the gender of each subject using the equations proposed by WHO [23,24], which was then multiplied by the individual PAL to provide the theoretical energy expenditure (TEE) for each participant.

Evaluation of self-reported dietary information

The dietary data were validated by taking into consideration the discrepancy between the energy intake and the theoretical energy expenditure of each participant. The discrepancy was determined with the following equation:

(Theoretical energy expenditure-energy intake) x 100/Theoretical energy expenditure

In participants with stable body weight, the energy intake should be similar to the theoretical energy expenditure; divergences indicate either an under- or overestimation of energy intake [25, 26].

Health variables

Participants completed a questionnaire indicating the existence of disease and the intake of medication (data required to determine whether the participants met the inclusion criteria).

In addition, blood pressure was measured in the right arm of seated participants following a 5-minute rest period, using an Omron HEM-907XL automated sphygmomanometer (Omron Health Care, Inc., Vernon Hills, IL, USA) by a trained field technician. To assess blood pressure in participants, the values of systolic (>140 mmHg) and/or diastolic (>90 mmHg) were considered indicative of hypertension [27].

Statistical Analysis

Mean and standard deviation (SD) were calculated for all studied variables. Preliminary analysis was carried out to test homoscedasticity of variances and normality of the data using Levene's test and the Kolgomorov-Smirnov test, respectively. The differences by sex were assessed using Student's *t*-test with quantitative data where the data was normally distributed, or using the Mann-Whitney test otherwise. Pearson's and Spearman's correlation coefficients were used to explore the relation between the different variables. The statistical significance was set at $p < 0.05$. All calculations were made using SPSS software (version 19.0 for windows; SPSS Inc., Chicago, IL).

The usual dietary intake for foods, food groups, and nutrients was estimated by using the Multiple Score Method (MSM) https://msm.dife.de/ [28]. The MSM analysis was performed assuming that all participants were habitual consumers, since frequency of food consumption was not available. No covariates were included in the analysis. After the MSM was applied, due to the inter-correlation of energy intake with nutrients and food items, an adjustment of these variables for total energy intake using the residual method was performed [29,30].

Results

Personal, anthropometric, and dietary intake characteristics of the studied participants were analyzed by sex. Weight, height, BMI, and systolic and diastolic blood pressure were higher in men than in women (Table I). It is noteworthy that although this study was conducted in a healthy population, 11.5 % of the participants had blood pressure values suggesting hypertension.

Moreover, energy intake, total energy expenditure, discrepancy of intake compared with total energy expenditure (expressed as kcal/day and percentage), and the intake of meat (g/day) and cereals and pulses (servings/day), and meat, fish, and eggs (servings/day) were higher in men than in women. Nevertheless, the intake of sugars, appetizers, condiments, and sauces were higher in women than in men (Table I).

Mean daily servings of food groups (Table I) were contrasted with the recommended servings for the Spanish population [20]. Mean daily servings of cereals and pulses (4.6 ±1.7 servings/day), greens and vegetables (2.9 ± 1.4 servings/day), and fruits (1.4 ± 1.0 servings/day) were lower than the recommended servings (6–10 servings/day, 3–5 servings/day, and 2–4 servings/day, respectively). Servings of dairy products (2.1 ± 0.4 servings/day) were in accordance with the recommended servings of 2–3 servings/day. In contrast, the servings of the group of meat, fish, and eggs (3.2 ± 0.3 servings/day) were higher than the 2–3 servings/day recommended. However, when this food group was disaggregated, mean daily servings of meat (2.0 ± 1.3 servings/day) were higher than the servings of fish (0.89 ± 0.90 servings/day) and eggs (0.32 ± 0.35 servings/day).

A positive and significant correlation was found between age and the intake of vegetables ($r = 0.170$, $p < 0.001$), fruits ($r = 0.217$, $p < 0.001$), fish ($r = 0.217$, $p < 0.001$), and oils ($r = 0.102$, $p < 0.05$).

The mean daily intakes of total fat and FAs (expressed as g/day and %E) were analyzed by sex. The intakes of total MUFAs (%E), total PUFAs (%E), total n-3 PUFAs (%E), ALA (%E), EPA plus DHA (%E), total n-6 PUFAs, and LA (g/day and %E) were significantly higher in women than in men (Table II).

A positive and significant correlation was observed between the age and the intake of total n-3 PUFAs ($r = 0.147$, $p < 0.01$), ALA ($r = 0.119$, $p < 0.05$), EPA ($r = 0.181$, $p < 0.001$), DHA ($r = 0.125$, $p < 0.05$), and EPA plus DHA ($r = 0.158$, $p < 0.01$).

Also, a positive and significant correlation was found between the intake of total fat and the intake of SFAs ($r = 0.743$, $p < 0.001$), MUFAs (0.873, $p < 0.001$), PUFAs ($r = 0.420$, $p < 0.001$), total n-3 PUFAs ($r = 0.260$, $p < 0.001$), ALA ($r = 0.360$, $p < 0.001$), n-6 PUFAs ($r = 0.385$, $p < 0.001$), and LA ($r = 0.381$, $p < 0.001$). No significant correlation was found between the total fat intake and the intake of EPA, DHA, and EPA plus DHA.

In addition, a positive and significant correlation was found between the intake of SFAs and MUFAs

Table I: Personal, anthropometric, and dietary intake characteristics of the study population by sex.

	Total	Men	Women
n	418	196	222
Age (years)	36.4±11.7	36.1±11.6	36.6±11.9
Weight (kg)	71.8±14.8	81.1±13.1	63.5±10.8***
Height (cm)	168.0±9.9	175.5±7.3	161.3±6.6 ***
BMI (kg/m^2)	25.3±4.1	26.3±4.1	24.4±4.0***
Systolic blood pressure (mmHg)	116.6±16.3	123.6±16.2	110.4±13.7***
Diastolic blood pressure (mmHg)	73.8±11.2	75.8±11.6	72.1±10.5***
Energy intake (kcal/day) [1]	2176±553.0	2395±555.0	1982±474.3***
Total energy expenditure (kcal/day)	2589±488.0	3019±332.5	2209±207.8***
Discrepancy intake/expenditure (kcal/day) [1]	413.3±609.9	623.9±629.8	227.5±527.0****
Discrepancy intake/expenditure (%)[1]	14.3±22.4	19.9±19.5	9.43±23.8***
Food intake (g/day)			
Cereals (g/day)[1,2]	171.5±51.8	174.6±59.3	168.9±44.1
Pulses (g/day)[1,2]	22.1±26.9	20.4±23.5	23.5±29.5
Vegetables (g/day)[1,2]	283.6±121.6	281.5±115.9	285.5±126.6
Fruits (g/day)[1,2]	255.0±170.1	244.0±165.5	264.7±173.8
Dairy products (g/day)[1,2]	357.8±164.7	351.9±183.1	362.9±146.8
Meat (g/day)[1,2]	164.2±54.1	172.3±55.8	157.0±51.6**
Fish (g/day)[1,2]	89.1±54.1	89.1±55.9	89.1±52.5
Eggs (g/day)[1,2]	28.4±9.6	28.1±9.8	28.7±9.5
Sugars (g/day)[1,2]	22.2±23.2	19.9±22.3	24.3±23.9*
Oils (g/day)[1,2]	35.1±10.2	34.6±10.8	35.6±9.7
Beverages (g/day)[1,2]	840.7±607.3	852.3±646.5	830.4±571.6
Precooked food (g/day)[1,2]	50.5±146.7	54.1±195.5	47.3±82.7
Appetizers (g/day)[1,2]	7.6±9.0	7.0±9.5	8.1±8.6**
Condiments and sauces (g/day)[1,2]	10.9±6.7	10.1±6.4	11.5±6.8*
Other foods (g/day)[1,2]	0.63±8.0	0.97±11.7	0.33±0.76***
Food intake (servings/day)			
Cereals and pulses (servings/day)[1]	4.6 ±1.7	5.0±1.8	4.2±1.5***
Greens and vegetables (servings/day)[1]	2.9±1.4	2.9±1.3	2.9±1.4
Fruits (servings/day)[1]	1.4±1.0	1.4±1.0	1.5±1.0
Dairy products (servings/day)[1]	2.1±0.4	2.2±1.0	2.1±0.87
Meat, fish, and eggs (servings/day)[1]	3.2±0.3	3.5±1.0	2.8±0.3***

Values are means and standard deviations.
[1]Data adjusted for MSM method, [2]Data adjusted for energy intake
Differences by sex *$p<0.05$ **$p<0.01$, ***$p<0.001$

($r=0.466$, $p<0.001$) and ALA ($r=0.099$, $p<0.05$). A negative and significant correlation between the intake of SFAs and the intake of EPA ($r=-0.108$, $p<0.05$), DHA ($r=-0.121$, $p<0.05$), and EPA plus DHA ($r=-0.176$, $p<0.001$).

When blood pressure was analyzed by n-3 and n-6 PUFAs intake, no significant correlation was found between systolic blood pressure and total n-3 PUFAs (g/day) nor the intake of total n-3 PUFAs (%E). On the other hand, a negative correlation was found be-

Table II: Fatty acids intake by sex (g/day and %E).

		Total	Men	Women
n		418	196	222
Total Fat	(g/day)[1,2]	100.7 ± 13.1	100.1 ± 14.6	101.3 ± 11.8
	(% E)[1]	41.8 ± 5.6	41.3 ± 5.5	42.1 ± 5.6
SFAs	(g/day)[1,2]	32.5 ± 6.3	32.3 ± 7.2	32.7 ± 5.5
	(% E)[1]	13.4 ± 2.5	13.4 ± 2.6	13.4 ± 2.5
MUFAs	(g/day)[1,2]	46.2 ± 7.1	46.1 ± 7.8	46.3 ± 6.5
	(% E)[1]	19.3 ± 3.2	18.9 ± 3.1	19.6 ± 3.2*
PUFAs	(g/day)[1,2]	13.2 ± 3.0	12.9 ± 3.1	13.5 ± 3.0
	(% E)[1]	5.5 ± 1.3	5.4 ± 1.2	5.7 ± 1.3**
Total n-3 PUFAs	(g/day)[1,2]	1.8 ± 0.60	1.8 ± 0.70	1.8 ± 0.54
	(% E)	0.77 ± 0.24	0.75 ± 0.25	0.79 ± 0.23*
ALA	(g/day)[1,2]	1.3 ± 0.32	1.3 ± 0.33	1.3 ± 0.31
	(% E)[1]	0.54 ± 0.14	0.52 ± 0.14	0.56 ± 0.14***
EPA	(g/day)[1,2]	0.16 ± 0.14	0.16 ± 0.20	0.16 ± 0.13
	(% E)[1]	0.07 ± 0.06	0.07 ± 0.06	0.07 ± 0.06
DHA	(g/day)[1,2]	0.33 ± 0.21	0.34 ± 0.24	0.33 ± 0.19
	(% E)[1]	0.14 ± 0.08	0.14 ± 0.09	0.14 ± 0.08
EPA + DHA	(g/day)[1,2]	0.50 ± 0.34	0.50 ± 0.38	0.48 ± 0.30
	(% E)[1]	0.22 ± 0.14	0.20 ± 0.15	0.23 ± 0.14**
Total n-6 PUFAs	(g/day)[1,2]	11.0 ± 2.7	10.7 ± 2.7	11.3 ± 2.6*
	(% E)[1]	4.6 ± 1.1	4.4 ± 1.1	4.7 ± 1.1**
LA	(g/day)[1,2]	10.8 ± 2.7	10.5 ± 2.7	11.1 ± 2.6*
	(% E)[1]	4.5 ± 1.1	4.3 ± 1.1	4.6 ± 1.1**

Values are means and standard deviations.
[1]Data adjusted for MSM method, [2]Data adjusted for energy intake
Differences by sex *p<0.05, **p<0.01, ***p<0.001

tween systolic blood pressure and total n-6 (g/day) (r=-0.104, $p < 0.05$), total n-6 PUFAs (%E) (r=-0.118, $p < 0.05$), LA (g/day) (r=-0.106, $p < 0.05$), and LA (%E) (r=-0.117, $p < 0.05$). Similarly, a significantly higher proportion of participants with blood pressure values suggestive of hypertension was found when the ratio of n-6/n-3 was ≤4 than when the ratio of n-6/n-3 was > 4 (22.6 % vs. 10.6 %; $p < 0.01$, respectively).

The proportion of participants who did not meet the nutrient intake goals for FAs is shown in Table III. There were a high proportion of participants who exceeded the nutrient intake goals in relation to total fat and SFAs. Also, a high proportion of participants had intakes of total n-3 PUFAs, ALA, and EPA plus DHA below the nutrient intake goals.

Only 0.5 % (n = 2) of the participants declared the use of supplements containing n-3 PUFAs. The percentage contribution of the different food groups to n-3 and n-6 PUFAs in the population studied is shown in Table IV. The main food sources for ALA were oils (20.1 %), dairy products (18.4 %), and meat (16.4 %); for EPA fish (98.0 %); and for DHA fish (76.0 %), eggs (12.8 %), and meat (10.3 %). Oils (26.3 %), meat (17.1 %), and cereals (15.1 %) were the major contributors to LA intake.

Discussion

There are few studies regarding the intake of n-3 and n-6 PUFAs in the Spanish population and none of those studies have been performed in a representative sample of the population [5,8]. This study adds updated information concerning the intake of n-3 and n-6 PUFAs and also shows the main dietary sources

Table III: Percentage of adults with inadequate intakes of fatty acids by sex (%).

		Total	Men	Women
n		418	196	222
Total Fat	>35 % E [1,2]	89.5	88.8	90.1
SFAs	≥10 % E [1,2]	90.2	89.3	91.0
PUFAs	<4 % E [1]	7.2	10.2	4.5*
	>12 % E [1]	0.00	0.00	0.00
	<6 % E [2]	70.8	76.0	66.2*
	>11 % E [2]	0.5	0.5	0.5
Total n-3 PUFAs	<1% E [1]	84.7	85.7	83.8
	>2% E [1]	0.00	0.00	0.00
	<0.5% E [2]	7.7	11.2	4.5*
	>2% E [2]	0.00	0.00	0.00
ALA	≤0.5%E [1,2]	45.0	52.0	38.7*
EPA plus DHA	≤0.5g/day [1]	62.9	62.2	63.5
	<0.25g/day [2]	18.4	20.4	16.7
	>2g/day [2]	0.2	0.5	0.00
LA	<3%E [1]	3.6	5.6	1.8*
	>10%E [1]	0.2	0.5	0.00
	<2.5%E [2]	0.5	0.00	0.9
	>9%E [2]	0.5	0.5	0.5

Values are proportions. Differences by sex *p<0.05
[1] Nutrient intake goals for Spanish population [18]
[2] FAO recommended dietary intakes [2]

Table IV: Food sources of n-3 and n-6 PUFAs among Spanish adults (%).

	n-3 PUFAs	ALA	EPA	DHA	n-6 PUFAs	LA
Cereals	6.9	9.7	0.10	0.61	11.5	15.1
Pulses	2.2	2.8	0.00	0.00	2.8	2.6
Vegetables	0.00	9.1	0.10	0.00	0.00	4.4
Fruits	7.8	10.4	0.00	0.00	9.3	8.5
Dairy products	14.2	18.4	0.00	0.07	4.2	3.7
Meat	15.9	16.4	1.8	10.3	19.7	17.1
Fish	27.8	3.4	98.0	76.0	5.8	5.1
Eggs	4.1	1.9	0.00	12.8	3.4	2.9
Sugars, sweets, and pastries	0.8	1.1	0.00	0.01	1.4	1.3
Oils	14.5	20.1	0.00	0.00	27.2	26.3
Beverages	0.86	1.1	0.00	0.00	1.07	0.97
Precooked food	1.1	1.2	0.00	0.00	2.7	2.4
Appetizers	0.81	1.1	0.01	0.00	2.3	2.2
Condiments and sauces	3.0	3.6	0.00	0.01	8.7	7.8
Other foods	0.00	0.00	0.00	0.00	0.01	0.01

in the adult Spanish population. The results of this study may be useful for Spain and for other developed countries and are crucial from the standpoint of nutrition and health.

Compared with the recommended daily servings for the different food groups [20], the number of servings of the group of dairy products (Table I) were adequate, while the number of servings of cereals and pulses and vegetables and fruits were low, and the number of servings of the group of meat, fish, and eggs were slightly high. Nevertheless, when the number of servings of the group of meat, fish, and eggs was disaggregated, the number of servings of fish and eggs were low in comparison with the number of servings of meat. These data are consistent with the results of previous studies carried out in Spain [31,32].

In this population, the intake of total n-3 PUFAs, ALA, EPA, DHA, and EPA plus DHA of the participants increased with age. This is consistent with the results of another study performed in the Australian population that showed that older adults had higher intake of n-3 PUFAs (particularly EPA and DHA intakes) than younger adults, probably due to higher intake of fish and seafood products among older adults [33]. In our study, age also was positively associated with the intake of fish, as well as with the intake of vegetables, fruits, and oils, which could explain the higher intake of n-3 PUFAs among older adults. So it seems necessary to promote the intake of vegetables, fruits, and fish in young people.

Differences by sex in the intake of MUFAs, PUFAs, total n-3 PUFAs, ALA, EPA plus DHA, total n-6 PUFAs, and LA were observed (Table II). This could be due to the fact that women had higher intake of sugars, sweets, pastries, appetizers, and sauces than men (Table I), since these foods usually contain a significant amount of oils, margarine, and shortenings among their ingredients, which are a major source of FAs in these nutrients [34].

High fat intake is habitually accompanied by an increase in the intake of SFAs [35]. The results of this study showed a positive and significant association between the intake of total fat and the intake of SFAs, MUFAs, PUFAs, total n-3 PUFAs, ALA, n-6 PUFAs, and LA. However, no association was found with respect to the intakes of EPA, DHA, and EPA plus DHA. This confirms that an excess of fat in the diet (as in most of the participants) may not provide an adequate intake of EPA and DHA.

Additionally, a positive correlation was found between the intake of SFAs and MUFAs and ALA. It is necessary to emphasize that a negative correlation was found between the intake of SFA and the intakes of EPA, DHA, and EPA plus DHA. This suggests that it is advisable to meet the recommended number of servings for the group of meat, fish, and eggs, reduce meat intake (which was high in the population), and increase fish and egg intake (which was low in the population), since an increment in the intake of SFAs may displace the intake of n-3 PUFAs.

Several studies have showed a positive effect of n-6 PUFAs intake on blood pressure control [2, 3]. This study showed a negative and significant correlation between systolic blood pressure and both total n-6 PUFAs and LA intakes. Moreover, in contrast to the recommendation of maintaining an n-6/n-3 ratio of 4:1 [3], the results of this study showed a significantly higher proportion of participants with blood pressure values suggestive of hypertension when the n-6/n-3 ratio was ≤ 4 than when it was higher.

Moreover, n-3 and n-6 PUFAs intakes were lower in comparison with other studies performed in Spain and Australia [5, 8, 33], but were similar to other studies carried out in French and Belgian populations [36, 37] (Table V).

For the purpose of providing a guide for the intake of FAs, a wide range of dietary recommendations has been established by different health and nutrition organizations [2,38–41]. However, setting a global recommendation for fats and FAs is complex due to the existence of different dietary patterns and the lack of convincing evidence [42]. The FAO has recently updated the recommended dietary intakes for FAs, based on the scientific developments in the field of fats and FAs during the past fifteen years [2]. Thus, in order to assess total fat and FA intakes of study participants, the nutrient intake goals set for the Spanish population [18] and the recent recommended dietary intakes established by FAO [2] were used.

According to the results obtained in this representative sample of adults aged 18 to 60 years, an excess in the intake of total fat was clearly observed. Most of the studied population exceeded the nutrient intake goals for total fat (<35 %E) [2,18] and for SFAs (<10 %E) [2,18]. Otherwise, the proportion of participants who did not meet the minimum values of the recommendations used for this study varied considerably (7.2 to 70.8 %) [2, 18] (Table III).

Furthermore, the intake of n-3 PUFAs was also inadequate (Table II). A high proportion of participants (84.7 %) did not meet the nutrient intake goals for n-3 PUFAs (1–2 %E) [18] (Table III). Moreover, more than half of the participants did not meet the Spanish nutrient intake goals for EPA plus DHA (>0.5 g/day) [18], most likely due to the lower intake of fish among the population (Table I) (61.9 % of the participants consumed less than one serving of fish per day). Regarding this, it is important to note that although Spain is a country with a high availability of fish, a clear tendency to reduce the intake of fish due

Table V: Comparison of fatty acid intake in the current study with other studies carried out in Spain, Australia, and Europe.

Source	Age (years)	Group (n)	Method	Mean intake % E (g/day)						
				n-3	ALA	EPA	DHA	EPA+DHA	n-6	LA
León, Spain Capita, *et al.*, 2003 [5]	20-40	M(24) F(76)	Food record questionnaire	2.4 1.6	(1.9) (1.4)	(0.16) (0.07)	(0.31) (0.15)	0.47 0.22	n/a n/a	(17.3) (14.6)
Spain Ministry of Environment and Rural and Marine, 2006 [8]	-	Households (8,200)	Household budget survey	1.5	n/a	n/a	n/a	n/a	n/a	n/a
Australia Meyer, *et al.*, 2003 [33]	19-64	M(2,840) F(3,178)	24-h recall questionnaire	1.6 1.1	(1.4) (1.0)	(0.06) (0.04)	(0.12) (0.09)	0.18 0.13	(13.4) (9.4)	(13.2) (9.4)
France Astorg, *et al.*, 2004 [36]	M 45–63 F 35–63	M(5,028) F(7,713)	24-h recall questionnaire	n/a n/a	0.36(0.94) 0.38(0.74)	0.06(0.14) 0.06(0.11)	0.11(0.27) 0.12(0.22)	0.49 0.33	n/a n/a	4.1(10.6) 4.2(8.1)
Belgium Sioen, *et al.*, 2006 [37]	F 18–39	F(641)	Food record questionnaire	0.75(1.7)	0.64(1.4)	0.04(0.08)	0.06(0.13)	0.10(0.21)	5.3(11.9)	5.3(11.9)
Spain Current, 2010	18-60	M(196) F(222)	2 x 24-h recall questionnaire	0.75(1.8) 0.79(1.8)	0.52(1.3) 0.56(1.3)	0.07(0.16) 0.07(0.16)	0.14(0.34) 0.14(0.33)	0.20(0.50) 0.23(0.48)	4.4(10.7) 4.7(11.3)	4.3(10.5) 4.6(11.1)

Values are means. n/a: data not available
M: males. F: females.

to changes in dietary patterns among the population has been observed [3].

The minimum intake values for essential FA to prevent deficiency symptoms are estimated in 0.5 %E for ALA plus 2.5 %E for LA [2,18]. Regarding this, we found a high percentage of the population did not meet the minimum intake for ALA (45.0 %), in contrast with the low percentage (0.5 %) that did not meet the recommendation for LA (Table III).

Moreover, the recommendation of maintaining a proper ratio of n-6/n-3 PUFAs is still controversial. The WHO/FAO in 2003 indicated an intake of n-6 as 5–8 %E and n-3 PUFAs as 1–2 %E as essential for health [41]. However, the last report on fats and FAs by FAO notes that an increasing LA intake does not result in increased arachidonic acid (AA) in plasma or platelet lipids and does not increase formation of proinflammatory mediators. Furthermore, both n-6 and n-3 FAs have been shown to have anti-inflammatory properties that are protective against atherogenic changes in vascular endothelial cells. Therefore, there is no justification for setting a recommendation for this ratio, if intakes of both FAs lie within the recommendation established by the report [2].

Additionally, the European Food Safety Authority (EFSA) has not set specific values for the n-6/n-3 ratio, since there are insufficient data on clinical and biochemical endpoints in humans to recommend a ratio independent of absolute levels of intake [38]. For this reason, it appears that more studies are needed to clarify whether it is necessary to set specific values for the n-6/n-3 ratio. Consequently, it would be appropriate to ensure that intakes of n-3 and n-6 PUFAs lie within the established recommendation.

In terms of dietary sources, our study has shown that only 0.5 % (n = 2) of the study participants declared the use of supplements containing n-3 PUFAs, suggesting a very low intake of these type of supplements among the Spanish population.

In relation to food sources of n-3 PUFAs, the main sources for ALA found in this study were oils, followed by dairy products and meat. As expected, fish was the main source for EPA (98.9 %) and for DHA (76.0 %). This was also found in studies performed in Australian, French, and Belgian populations [33, 36, 37]. Considering that fish is the major source of EPA and DHA in the Spanish population, besides recommending its regular consumption, it is important to raise population awareness about the use of published guides to choose sustainably produced seafood.

With respect to n-6 PUFAs, in this study, the intake of LA was mostly provided by oils, meat, and cereals. This was consistent with results from other studies performed in Belgian, French and Australian populations [33, 36, 37]. The low intake of vegetables, fish, and eggs in the study population contributes to a low intake of PUFAs supplied by these foods.

One limitation of our study is the small sample size (418 subjects). Nevertheless, we consider that the results of the present study are valuable, taking into account that the sample had been selected from the entire national territory to be representative of the Spanish population of both sexes aged 18 to 60 years, and with the objective of collecting the variability of the Spanish diet.

In conclusion, this paper contributes to recent information on the intake of n-3 and n-6 PUFAs. These findings suggest that the intake of n-6 PUFAs (particularly LA) seems to be sufficient in the studied population. In contrast, the n-3 PUFAs intake should be improved in the adult Spanish population aged 18 to 60 years. Therefore, it is advisable to increase the intake of foods rich in n-3 PUFAs such as fish (particularly oily fish), including fortified food items, or to consider the use of supplements with n-3.

Acknowledgements

The present study was supported by the AESAN (Spanish Agency for Food and Nutritional Safety, Spanish Ministry of Health and Consumer Affairs, Spain) Project (337/2008).

References

1. Flood, V.M., Webb, K.L., Rochtchina, E., Kelly, B. and Mitchell, P. (2007) Fatty acid intakes and food sources in a population of older Australians. Asia Pac. J. Clin. Nutr. 16, 2, 322–330.
2. FAO. (2010) Fats and fatty acids in human nutrition. Report of an expert consultation. FAO Food and nutrition paper, Num. 91. Food and Agriculture Organization of the United Nations, Rome.
3. Gómez, C., Bermejo, L.M. and Loria, V. (2011) Importance of a balanced omega 6/omega 3 ratio for the maintenance of health: nutritional recommendations. Nutr. Hosp. 26, 2, 323–329.
4. Carrillo, L., Dalmau, J., Martínez, J.R., Sola, R. and Pérez-Jiménez, F. (2011) Dietary fats and cardiovascular health. Ann. Pediatr. (Barc). 74, 3, 192.e1–192.e16.
5. Capita, R. and Alonso-Calleja, C. (2003) Intake of nutrients associated with an increased risk of cardiovascular disease in a Spanish population. Int. J. Food Sci. Nutr. 54, 57–75.
6. Elmadfa, I. (2009) European Nutrition and Health Report 2009, Forum of Nutrition, Vol. 62, pp. 412, Basel Karger, Vienna.
7. Ruano, C., Henríquez, P., Bes-Rastrollo, M., Ruiz-Canela, M., López, C. and Sanchez-Villegas, A. (2011) Dietary fat intake and quality of life: the SUN project. Nutr. J. 10, 121.
8. Ministry of Environment and Rural and Marine. (2008) Evaluation of the Spanish diet according to food consumption panel of the Ministry of Agriculture, Fisheries and Food (MAFF)/Spanish Nutrition Foundation (FEN), pp. 1–68.
9. Ortega, R.M., López-Sobaler, A.M., Ballesteros, J.M., Pérez-Farinós, N., Rodríguez-Rodríguez, E., Aparicio, A. and Andrés, P. (2011) Estimation of salt intake by 24 h urinary sodium excretion in a representative sample of Spanish adults. Br. J. Nutr. 105, 5, 787–94.
10. Intersalt Cooperative Research Group. (1988) Intersalt: an international study of electrolyte excretion and blood pressure. Results for 24 hour urinary sodium and potassium excretion. BMJ. 297, 6644; 319–328.
11. World Health Organization. (1995) Physical status: use and interpretation of anthropometric. Report of a Joint FAO/WHO/UNU Expert Consultation. Technical Report Series 854. World Health Organization, Geneva..
12. Ortega, R.M., Requejo, A.M. and López-Sobaler, A.M. (2006) Questionnaires for dietetic studies and the assessment of nutritional status. In: Nutriguia. Manual of Clinical Nutrition in Primary Care (Ortega, R.M. and Requejo, A.M., eds.), pp. 456–467, Editorial Complutense, Madrid.
13. Ortega, R.M., López-Sobaler, A.M., Requejo, A.M. and Andrés, P. (2010) Food composition tables. A basic tool for assessing nutritional status. pp. 15–81, Editorial Complutense, Madrid.
14. Nubel. (2010) The Belgian food composition tables. Fifth edition, Nubel, Brussels.
15. Saxholt, E., Christensen, A.T., Møller, A. Hartkopp, H.B., Hess Ygil, K. and Hels, O.H. (2008) Danish Food Composition Databank. Department of Nutrition, National Food Institute, Technical University of Denmark. http://www.foodcomp.dk/
16. U.S. Department of Agriculture, Agricultural Research Service. (2011) USDA National Nutrient Database for Standard Reference, Release 24. Nutrient Data Laboratory Home Page: http://www.ars.usda.gov/nutrientdata.

17. Ortega, R.M., López-Sobaler, A.M., Andrés, P., Requejo, A.M., Aparicio, A. and Molinero, L.M. (2004) DIAL Software for assessing diets and food calculations. Department of Nutrition (UCM) and Alce Ingeniería, S.A, Madrid. http://www.alceingenieria.net/nutricion.htm

18. Ortega, R.M, López-Sobaler, A.M., Aparicio, A., Rodríguez-Rodríguez, E., González-Rodríguez, L.G., Perea J.M. and Navia, B. (2012) Nutrient intake goals for Spanish population. Department of Nutrition, Universidad Complutense, Madrid.

19. Perea, J.M., Navarro, A. and Lozano, M. (2006) Tables of weights of food standard servings. In: Nutriguia. Manual of Clinical Nutrition in Primary Care (Requejo, A.M. and Ortega, R.M., eds.), pp. 469–467, Editorial Complutense, Madrid.

20. Requejo, A. and Ortega, R. (2003) Dietary guidelines. In: Nutriguia. Manual of Clinical Nutrition in Primary Care. (Requejo, A. and Ortega, R., eds.), pp. 15–26, Editorial Complutense, Madrid.

21. Krebs-Smith, S.M., Kott, P.S. and Guenther, P.M. (1989) Mean proportion and population proportion: two answers to the same question? J. Am. Diet. Assoc. 89,5, 671–6.

22. Ortega, R.M., Requejo, A.M. and López-Sobaler, A.M. (2006) Activity questionnaire. In: Nutriguia. Manual of Clinical Nutrition in Primary Care. (Ortega, R.M. and Requejo, A.M., eds.), pp. 468, Editorial Complutense, Madrid.

23 WHO. (1985) Energy and protein requirements. Reports of a Joint FAO/WHO/UNU Expert consultation. Technical report series 724. World Health Organization, Geneva.

24. Ortega, R.M., Requejo, A.M., Quintas, M.E., Sánchez-Quiles, B., López-Sobaler, A.M. and Andrés, P. (1996) Estimated energy balance in female university students: differences with respect to body mass index and concern about body weight. Internat. J. Obes. 20, 12, 1127–1129.

25. Ortega, R.M., Quintas, M.E., Sánchez-Quiles, M.B., Andrés, P., Requejo, A.M. and Encinas-Sotillos, A. (1997) Underestimation of energy intake in a group of young female university students of Madrid. Rev. Clin. Esp., 197, 8, 545–549.

26. Ortega, R.M., Requejo, A.M., Andrés, P., López-Sobaler, A.M., Redondo, M.R. and González-Fernández, M. (1995) Relationship between diet composition and body mass index in a group of Spanish adolescents. Br. J. Nutr. 74, 6, 765–773.

27. Chobanian, A.V., Bakris, G.L., Black, H.R., Cushman, W.C., Green, L.A., Izzo, J.L. and Roccella, E.J. (2003) Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 42, 6, 1206–1252.

28. Harttig, U., Haubrock, J., Knüppel, S. and Boeing, H. on behalf of the EFCOVAL Consortium. (2011) The MSM program: web-based statistics package for estimating usual dietary intake using the Multiple Source Method. Eur. J. Clin. Nutr. 65, S87–S91.

29. Willett, W. and Stampfer, M.J. (1986) Total energy intake: implications for epidemiologic analyses. Am. J. Epidemiol. 124, 1, 17–27.

30. Willett, W.C., Sampson, L., Stampfer, M.J., Rosner, B., Bain, C., Witschi, J. et al. (1985) Reproducibility and validity of a semiquantitative food frequency questionnaire. Am. J. Epidemiol. 122, 1, 51–65.

31. Rodríguez-Rodríguez, E., Navia, B., López-Sobaler, A.M. and Ortega, R.M. (2009) Vitamin D in overweight/obese women and its relationship with dietetic and anthropometric variables. Obesity (Silver Spring). 17, 4, 778–782.

32. González-Solanellas, M., Romagosa, A., Zabaleta-Del-Olmo, E., Grau-Carod, M., Casellas-Montagut, C., Lancho-Lancho, S. et al. (2011) Prevalence of food habits and nutritional status in adult population served in primary care. Nutr. Hosp. 26, 2, 337–344.

33. Meyer, B.J., Mann, N.J., Lewis, J.L., Milligan, G.C., Sinclair, A.J. and Howe, P.R. (2003) Dietary intakes and food sources of omega-6 and omega-3 polyunsaturated fatty acids. Lipids 38, 4, 391–398.

34. U.S. Department of Agriculture and U.S. Department of Health and Human Services. (2010) Dietary Guidelines for Americans. U.S. Government Printing Office, Washington, D.C.

35. Eurodiet. (2000) European Diet and Public Health: The Continuing Challenge. Working Party 1: Final Report. http://eurodiet.med.uoc.gr/

36. Astorg, P., Arnault, N., Czernichow, S., Noisette, N., Galan, P. and Hercberg, S. (2004) Dietary Intakes and Food Sources of n-6 and n-3 PUFA in French Adult Men and Women. Lipids 39, 6, 527–535.

37. Sioen, I. A., Pynaert, I., Matthys, C., De Backer, G., Van Camp, J. and De Henauw, S. (2006) Dietary intakes and food sources of fatty acids for Belgian women, focused on n-6 and n-3 polyunsaturated fatty acids. Lipids 41, 5, 415–422.

38. EFSA Panel on dietetic products nutrition and Allergies (NDA). (2010) Scientific opinion on dietary reference values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty

acids, trans fatty acids, and cholesterol. EFSA Journal 8(3),1461, [107 pp.], www.efsa.europa.eu.

39. Kris-Etherton, P.M., Harris, W.S. and Appel, L.J. American Heart Association Nutrition Committee. (2002) Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Circulation 106, 21, 2747–2757.

40. Institute of Medicine. (2005) Reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. The National Academies Press, Washington, D.C.

41. WHO/FAO. (2003) Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation. Technical report series 916; World Health Organization, Geneva.

42. Elmadfa, I. and Kornsteiner, M. (2009) Dietary fat intake–a global perspective. Ann. Nutr. Metab. 54, Suppl 1, 8–14.

Dr. Liliana G. González Rodríguez, PhD, MPH

Department of Nutrition
Faculty of Pharmacy
Complutense University of Madrid
Ciudad Universitaria
28040 Madrid
Spain
Tel.: +34 91 394 18 37
Fax: +34 91 394 18 10
lggonzal@ucm.es