Dietary Fat Intake and Metabolic Syndrome in Older Adults

Alicia Julibert 1, Maria del Mar Bibiloni 1, David Mateos 1, Escarleta Angullo 1,2 and Josep A. Tur 1,*

1 Research Group on Community Nutrition & Oxidative Stress, University of Balearic Islands, IDISBA & CIBEROBN, 07122 Palma de Mallorca, Spain
2 Escola Graduada Primary Health Care Center, IBSalut, 07001 Palma de Mallorca, Spain
* Correspondence: pep.tur@uib.es; Tel.: +34-971-1731; Fax: +34-971-173184

Received: 1 July 2019; Accepted: 12 August 2019; Published: 14 August 2019

Abstract: Background: Metabolic Syndrome (MetS) is associated with higher rates of cardiovascular disease (CVD), type 2 diabetes mellitus, and cancer worldwide. Objective: To assess fat intake in older adults with or without MetS. Design: Cross-sectional nutritional survey in older adults living in the Balearic Islands (n = 477, 48% women, 55–80 years old) with no previous CVD. Methods: Assessment of fat (total fat, MUFA, PUFA, SFA, TFA, linoleic acid, α-linolenic acid, marine and non-marine ω-3 FA, animal fat and vegetable fat, cholesterol) and macronutrient intake using a validated food frequency questionnaire, and its comparison with recommendations of the US Institute of Medicine (IOM) and the Spanish Society of Community Nutrition (SENC). Results: Participants with MetS showed higher BMI, lower physical activity, higher total fat and MUFA intake, and lower intake of energy, carbohydrates, and fiber than participants without MetS. Men and women with MetS were below the Acceptable Macronutrient Distribution Range (AMDR) proposed by IOM for carbohydrates and above the AMDR for total fat and MUFAs, and women were below the AMDR proposed for α-linolenic acid (ALA) compared with participants without MetS. Conclusions: Subjects with MetS were less likely to meet IOM and SENC recommendations for fat and macronutrient intakes as compared to non-MetS subjects.

Keywords: older adults; macronutrient intake; dietary intake; fat intake; metabolic syndrome

1. Introduction

Metabolic syndrome (MetS) is a clinical condition characterized by several metabolic risk factors [1,2] associated with higher prevalence of cardiovascular disease (CVD), type 2 diabetes (T2DM), and cancer worldwide [3]. These factors involve abdominal obesity, blood pressure, glycaemia, triglyceridemia (TG), and high-density lipoprotein cholesterol (HDL-c) [1].

The prevalence of MetS has been increasing over the years and is now reaching epidemic proportions [4]. In Western countries, the prevalence of MetS is approximately one-fifth of the adult population and increases with age. However, the prevalence of MetS will vary according to the population studied, age, gender, race, and ethnicity, as well as the definition applied [5,6].

MetS is also influenced by nutrient intake, alcohol consumption, physical exercise, or smoking [3]. Unhealthy eating patterns and lifestyle, such as malnutrition and inactivity, can worsen the clinical status, with accumulation of body fat and alteration of the parameters that characterize MetS [7].

As shown in the ANIBES study, the macronutrient distribution is worsening and somewhat moving away from the recommendations and traditional Mediterranean dietary pattern, although the negative changes are less pronounced as age increases [8]. Age, sex, lower levels of education,
economic status, smoking status, and alcohol intake predict lower dietary variety. There is evidence that older Spanish adults with MetS had a high risk of inadequate nutrient intake [9].

Eating patterns and their food and nutrient characteristics are the primary emphasis of the recommendations of U.S. Dietary Guidelines 2015–2020 [10]. Accordingly, there has been a focus on the roles of macronutrients (carbohydrates, fat, and proteins) [11–17] and dietary patterns [7,18–20] on MetS.

Therefore, taking into consideration the scientific evidence on nutrients in the development of MetS, this study aimed to assess fat intake in older adults with or without MetS.

2. Materials and Methods

2.1. Design and Participants

The sample had 477 participants (48% women; aged 55–80 years old) with no previously documented CVD that were engaged in social and municipal clubs, health centers, and sport clubs of a cross-sectional study conducted in the Balearic Islands. The age range was chosen since they are at high risk of suffering non-communicable disease, the association of MetS with CVD, and because the increasing prevalence of MetS with age is known [21]. Exclusion criteria included being institutionalized, suffering from a physical or mental illness that limited their participation in physical fitness or their ability to respond to questionnaires, chronic alcoholism or drug addiction, and intake of drugs for clinical research over the past year.

The study protocols followed the Declaration of Helsinki ethical standards, and were approved by the Ethics Committee of Research of Balearic Islands (refs. CEIC-IB2251/14PI and CEIC-IB1295/09PI). All participants provided informed written consent.

2.2. Anthropometric Measurements

Anthropometric variables were measured by trained personnel to minimize the inter-observer coefficients of variation. Weight and height were measured with high-quality electronic calibrated scales and a wall-mounted stadiometer, respectively. Height was determined using a mobile anthropometer (Seca 213, SECA Deutschland, Hamburg, Germany) to the nearest millimeter, with the participant’s head maintained in the Frankfort Horizontal Plane position. Body weight and body fat were determined using a Segmental Body Composition Analyzer (Tanita BC-418, Tanita, Tokyo, Japan). The participants were weighed in bare feet and light clothes (0.6 kg was subtracted for their clothing). Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m$^2$). Waist circumference (WC) was measured half-way between the last rib and the iliac crest by using an anthropometric tape. Blood pressure was measured using a validated semi-automatic oscillometer (Omron HEM-705CP, Hoofddorp, The Netherlands) after 5 min of rest in between measurements while the participant was in a seated position. All anthropometric variables were determined in duplicate, except for blood pressure (in triplicate).

2.3. Blood Collection and Analysis

Blood samples were collected after an overnight fast and biochemical analyses were performed on fasting plasma glucose, total cholesterol, HDL-c, and TG concentrations in local laboratories using standard enzymatic methods. Participants were classified as “with MetS” ($n = 333$) and “without MetS” ($n = 144$) according to the updated harmonized definition of the International Diabetes Federation and the American Heart Association and National Heart, Lung, and Blood Institute [2].

2.4. Dietary Intake Assessment

Licensed dieticians administered a semiquantitative, 137-item food frequency questionnaire (FFQ), repeatedly validated in Spain [22]. For each item, a typical portion size was included and consumption frequencies were registered in 9 categories that ranged from “never or almost never”
to “≥6 times/day”. Energy and nutrient intakes were calculated as frequency multiplied by nutrient composition of specified portion size for each food item, using a self-made computerized program based on available information in the Spanish food composition tables by Moreiras et al. [23]. When foods in the Spanish food composition tables were not available, the BEDCA food database was used in order to complete missing information [24]. Dietary intake of energy, carbohydrates (CHOs), proteins, total fat, monounsaturated fatty acids (MUFSAs), polyunsaturated fatty acids (PUFSAs) and SFAs, trans-fatty acid (TFA), linoleic acid (LA), α-linolenic acid (ALA), marine and non-marine ω-3 fatty acid (ω-3 FA), animal fat and vegetable fat, cholesterol, and fiber were estimated. The vegetable fat included vegetables, fruits, nuts, legumes, total cereals, olives, oils, cookies, fritters, cocoa powder, mustard, ketchup, fried tomato, sugar, marmalade, and snacks. The animal fat included total dairy products, total meat, total fish, pizza, butter, lard, bakery goods, nougat, ready-to-eat meals, salad cream, and honey. The fat quality index (FQI) was also calculated as previously described [25]. Briefly, the FQI was calculated using the ratio (MUFA + PUFA)/(SFA + TFA) as a continuous variable.

Macronutrients and different fat intakes were compared with Institute of Medicine (IOM) and Spanish Society of Community Nutrition (SENC) recommendations. The dietary references intakes (DRIs) values proposed by IOM [26] were used, which are quantitative estimates of nutrient intakes to assess and plan diets for healthy people, including the Acceptable Macronutrient Distribution Range (AMDR) values. The prevalence of inadequate macronutrient intake according to the 2020 Nutritional Objectives for Spanish Population proposed by SENC [27] was used.

2.5. Socioeconomic and Lifestyle Determinants

Sociodemographic and lifestyle characteristics were collected from each participant. Educational level was ranked into primary school, secondary school, and university. Physical activity was measured using the validated Spanish version of the Minnesota Leisure Time Physical Activity Questionnaire [28,29]; it was taken by interview with trained research assistants and measured leisure time physical activities (LTPA), including household activities, over the previous 12 months. The Minnesota questionnaire was used to estimate physical activity levels by using metabolic equivalents of tasks (METs) [30]. METs are calculated by multiplying the intensity (showed by the MET-score) and the duration spent on that activity (measured in minutes). The MET-score can be derived from tables (the Compendium of Physical Activities) [31] that show the intensity of the activity relative to resting (METHours/week) spent on physical activity refer to the energy that is spent on activities, over and above existing levels of resting energy expenditure. Finally, information related to individual medical history, current medication use, and smoking status were also obtained.

2.6. Statistical Analyses

Analyses were performed with the SPSS statistical software package version 25.0 (SPSS Inc., Chicago, IL, USA). All analyses were stratified by sex and MetS status. Data are shown as mean, standard deviation (SD), or median and interquartile range (IQR). Normality of data was assessed using Kolmogorov–Smirnov test. Difference in medians between two comparison groups were tested by the Mann-Whitney U-test when variables were not normally distributed, and difference in means between the two comparison groups were tested by unpaired Students’ t-test when variables were normally distributed. Differences in prevalence of MetS or not among participants were examined using χ² (all p values are two-tailed). Logistic regression analyses with the calculation of corresponding odds ratio (OR) and the 95% confidence interval (95% Confidence Interval, CI) were also used to assess the association between pathological features of MetS and macronutrients, specific types of fat, and dietary intake. Results were adjusted for sex, age (continuous variable), BMI (continuous variable), energy intake (continuous variable), and total physical activity (continuous variable, expressed as METmin/hour) to control for potential confounders. Results were considered statistically significant if p-value (2 tailed) <0.05.
3. Results

Comparison of socioeconomic and lifestyle characteristics between the two study groups stratified by sex are shown in Table 1. Participants with MetS showed higher BMI and lower total physical activity than participants without MetS. As expected, the groups differed in all MetS components, except for blood pressure in women. A higher percentage of patients with MetS showed pathological cut-off values than patients without MetS in all MetS components.

Male MetS patients with high blood pressure plus hyperglycemia plus high abdominal fat comprised 64.5% of the total MetS population; those with high blood pressure plus hypertriglyceridemia plus low HDL-c comprised 42.6% of the MetS population. Female MetS patients with high blood pressure plus hyperglycemia plus high abdominal fat comprised 59.3% of the total MetS population; those with high blood pressure plus hypertriglyceridemia plus low HDL-c comprised 38.7% of the MetS population.

Comparisons of nutrient intakes and food consumption between the two study groups stratified by sex are shown in Tables 2 and 3, respectively. Participants with MetS showed higher total fat and MUFA intake but lower intake of energy, carbohydrates, and fiber than those without MetS ($p < 0.05$). Participants with MetS also showed higher FQI than non-MetS participants. Women with MetS reported higher intake of proteins but lower intake of TFA, ω-3 FA, LA, ALA, and marine and non-marine ω-3 FA than women without MetS. Participants with MetS reported lower consumption of fruits, potatoes, total cereals, whole grain bread, and rice and pasta than participants without MetS. Men with MetS reported lower consumption of ready to-eat-meals than those without MetS. On the other hand, women reported lower consumption of bakery goods and alcohol than those without MetS.

Table 4 shows that participants with MetS, for both men and women, were more likely to be below the AMDR proposed by IOM for carbohydrates and ALA (except for men) and more likely to be above the AMDR for total fat and MUFAs than participants without MetS. Similar results were obtained when the 2020 Nutritional Objectives for the Spanish population were assessed (Table 5). Participants with MetS were also more likely to be below the acceptable nutritional range for carbohydrates and more likely to be above the acceptable nutritional range for total fat and MUFAs than participants without MetS. Finally, participants with MetS were more likely to be below the 2020 Nutritional Objectives for the Spanish population for TFA but also for total fiber, such as in fruits and vegetables.

Multivariate adjusted odds ratio (OR) for the association between pathological features of the MetS components and dietary macronutrient intake in participants with and without MetS showed, after adjustment for potential confounders (i.e., age, sex, BMI, energy and physical activity), that hypertension (equal or higher pathological cut-off value was OR reference: 1.00) is related with lower intake of PUFA (OR: 0.95; 95% CI: 0.91–0.98), SFA (OR: 0.95; 95% CI: 0.92–0.99), TFA (OR: 0.95; 95% CI: 0.91–0.99), LA (OR: 0.94; 95% CI: 0.90–0.98), and ALA (OR: 0.95; 95% CI: 0.91–0.99). However, abdominal obesity (equal or higher pathological cut-off value was OR reference: 1.00) was associated with high PUFA intake (OR: 1.10; 95% CI: 1.01–1.19), LA (OR: 0.12; 95% CI: 1.02–1.23) and vegetable fat (OR: 1.05; 95% CI: 1.01–1.08). No other relationships were found between other pathological components of MetS and dietary macronutrient intake.
Table 1. Socioeconomic and lifestyle characteristics of participants “with Metabolic Syndrome” \((n = 333)\) and “without Metabolic Syndrome” \((n = 144)\) stratified by sex.

|                                | Men Without MetS \((n = 63)\) | Men With MetS \((n = 183)\) | p-Value * | Women Without MetS \((n = 81)\) | Women With MetS \((n = 150)\) | p-Value * |
|--------------------------------|-------------------------------|-----------------------------|-----------|-------------------------------|-------------------------------|-----------|
| Age (y)                        | Mean ± SD 63.8 ± 5.9          | Median (IQR) 64.0 (59.0, 67.0) | 0.544     | Mean ± SD 66.8 ± 5.0          | Median (IQR) 66.0 (63.0, 70.0) | 0.340     |
| BMI (kg/m²)                    | 27.0 ± 3.2                    | 27.5 (24.9, 28.7)           | <0.001    | 25.3 ± 3.3                    | 25.6 (22.9, 27.4)              | <0.001    |
| Current smoking habit (%)      | Yes                           | 6.3                         | 0.081     | Yes                           | 6.2                          | 0.119     |
|                                | No                            | 93.7                        | 93.8      | No                            | 93.8                        | 0.595     |
| Education (%)                  | Primary                       | 39.7                        | 0.660     | 53.1                          | 60.0                        |          |
|                                | Secondary                     | 39.7                        | 36.5      | 26.9                          | 26.9                        |          |
|                                | University or graduate        | 20.6                        | 16.0      | 13.1                          | 13.1                        |          |
| Total physical activity (MET·hour/week)† | 63                            | 158                         |           | 81                           | 131                         |           |
| MetS components                |                               |                             |           |                               |                              |           |
| Systolic blood pressure (mmHg) | 137.0 ± 19.0                  | 134.5 (124, 143)            | 0.038     | 135.9 ± 15.8                  | 136 (125, 146.3)             | 0.280     |
| Diastolic blood pressure (mmHg)| 81.5 ± 9.4                    | 81.5 (74.5, 88.5)           | 0.362     | 79.9 ± 9.0                    | 80.5 (74.3, 86.3)            | 0.828     |
| Hyperglycaemia (mg/dL)         | 98.3 ± 32.2                   | 97 (71, 119)                | <0.001    | 89.0 ± 8.0                    | 89 (83, 94)                  | <0.001    |
| Hypertriglyceridemia (mg/dL)   | 96.2 ± 9.2                    | 95 (93, 100)                | <0.001    | 84.5 ± 27.2                   | 80 (64, 100)                 | <0.001    |
| Low HDL-cholesterol (mg/dL)    | 51.5 ± 9.9                    | 50 (45, 55)                 | <0.001    | 63.3 ± 11.9                   | 63 (55.5, 71)                | <0.001    |
| Abdominal obesity (cm)         | 92.9 ± 10.1                   | 94 (87.7, 99.2)             | <0.001    | 79.9 ± 7.7                    | 80 (75.4, 85.4)              | <0.001    |

Abbreviations: BMI, body mass index; FA, fatty acids; FQI, fat quality index; IQR, interquartile range; MetS, Metabolic Syndrome; MET, metabolic equivalent of task; MUFAs, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acids; SD, standard deviation; SFAs, saturated fatty acids. * Differences in means between participants without and with MetS were tested by unpaired Students’ \(t\)-test. † Participants who did not respond to the physical activity questionnaires were excluded from the analysis (i.e., 25 men and 19 women). ‡ Percentage (%) of patients without and with MetS. § Differences between participants without and with MetS were tested by \(\chi^2\).
Table 2. Nutrient intake in participants “with Metabolic Syndrome” (n = 333) and “without Metabolic Syndrome” (n = 144) stratified by sex.

| Nutrient                  | Without MetS (n = 63) | With MetS (n = 183) | p-Value * | Without MetS (n = 81) | With MetS (n = 150) | p-Value * |
|---------------------------|-----------------------|---------------------|-----------|-----------------------|---------------------|-----------|
| Energy intake (kcal/day)  | Mean ±SD Median (IQR) | Mean ±SD Median (IQR) |           | Mean ±SD Median (IQR) | Mean ±SD Median (IQR) |           |
| Carbohydrate intake (% total E) | 44.7 ± 6.2 44.7 (41.3, 48.3) | 40.0 ± 6.8 40.7 (34.9, 45.2) | <0.001 | 44.6 ± 5.2 44.3 (40.7, 47.1) | 41.0 ± 6.9 40.9 (36.4, 45.5) | <0.001 |
| Fat intensity (% total E)  | 15.9 ± 2.4 15.6 (14.3, 17.6) | 16.3 ± 3.1 15.9 (14.3, 17.7) | 0.599 | 16.9 ± 3.0 16.4 (14.9, 18.5) | 18.0 ± 3.2 18.0 (15.7, 20.4) | 0.010 |
| Fiber intake (g)          | 6.1 ± 3.4 6.3 (5.3, 9.1) | 7.5 ± 3.0 6.7 (5.5, 8.8) | 0.673 | 8.0 ± 3.6 6.6 (5.8, 8.9) | 8.1 ± 4.1 6.7 (5.6, 9.2) | 0.941 |
| Protein intake (% total E) | 17.5 ± 6.1 18.6 (14.5, 19.7) | 19.3 ± 5.0 18.8 (15.9, 22.2) | 0.007 | 18.9 ± 4.4 18.3 (15.5, 21.1) | 21.1 ± 5.9 20.3 (17.1, 24.6) | 0.003 |
| PUFAs (% total E)         | 7.6 ± 3.4 6.3 (5.3, 9.1) | 7.5 ± 3.0 6.7 (5.5, 8.8) | 0.673 | 8.0 ± 3.6 6.6 (5.8, 8.9) | 8.1 ± 4.1 6.7 (5.6, 9.2) | 0.941 |
| MUFA (% total E)          | 26.0 ± 36.0 26.0 (18.9, 35.5) | 21.2 ± 29.8 9.2 (12.1, 18.2) | 0.135 | 26.5 ± 34.5 9.4 (8.7, 35.2) | 21.8 ± 34.0 8.9 (10.1, 17.9) | 0.003 |
| Linoleic acid (g/d)       | 16.2 ± 10.5 12.5 (8.8, 21.2) | 14.5 ± 8.9 11.2 (8.5, 18.8) | 0.298 | 14.7 ± 9.8 11.7 (8.7, 16.8) | 12.9 ± 9.6 10.0 (6.5, 16.3) | 0.034 |
| ω-3 FA (g/d)              | 26.0 ± 36.0 26.0 (18.9, 35.5) | 21.2 ± 29.8 9.2 (12.1, 18.2) | 0.135 | 26.5 ± 34.5 9.4 (8.7, 35.2) | 21.8 ± 34.0 8.9 (10.1, 17.9) | 0.003 |
| Linolenic acid (g/d)      | 7.0 ± 9.0 2.8 (2.5, 5.5) | 5.8 ± 7.5 2.8 (0.8, 5.1) | 0.168 | 7.1 ± 8.6 3.1 (2.4, 9.2) | 5.8 ± 8.5 2.6 (0.6, 4.9) | 0.003 |
| Marine ω-3 FA (g/d)       | 12.7 ± 18.0 4.4 (12.9, 1) | 10.3 ± 14.9 4.3 (0.3, 8.9) | 0.111 | 13.0 ± 17.3 4.5 (4.1, 17.4) | 10.7 ± 17.0 4.2 (0.3, 8.8) | 0.009 |
| Non-marine ω-3 FA (g/d)   | 13.2 ± 18.0 4.9 (4.5, 10) | 10.9 ± 14.9 4.9 (0.9, 9.9) | 0.161 | 13.5 ± 17.3 5.1 (4.5, 17.9) | 11.1 ± 17.0 4.6 (0.7, 9.2) | 0.002 |
| Animal fat (g/d)          | 49.8 ± 18.2 46.1 (38.5, 59.7) | 48.3 ± 19.6 43.7 (34.8, 59.2) | 0.307 | 41.5 ± 23.1 38.6 (27.3, 50.0) | 36.0 ± 13.2 35.0 (26.2, 44.1) | 0.091 |
| Vegetable fat (g/d)       | 65.7 ± 23.4 62.3 (45.2, 85.4) | 64.9 ± 22.8 62.8 (48.1, 79.9) | 0.799 | 57.7 ± 19.9 56.1 (41.8, 69.2) | 58.3 ± 23.9 56.6 (41.9, 70.4) | 0.987 |
| FQI score                 | 1.9 ± 0.5 1.7 (1.6, 2.1) | 2.0 ± 0.4 1.9 (1.7, 2.3) | 0.048 | 1.8 ± 0.4 1.8 (1.6, 2.0) | 2.1 ± 0.5 2.0 (1.7, 2.4) | <0.001 |
| Cholesterol (mg/d)        | 362 ± 105 358 (289, 425) | 348 ± 115 334 (274, 399) | 0.146 | 303 ± 122 286 (243, 349) | 288 ± 79 283 (250, 355) | 0.819 |

Abbreviations: E, energy; FA, fatty acids; FQI, fat quality index; IQR, interquartile range; MetS, Metabolic Syndrome; MUFA, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acids; SD, standard deviation; SFAs, saturated fatty acids. * Difference in means between participants without and with MetS were tested by unpaired Students’ t-test.
Table 3. Food consumption in participants “with Metabolic Syndrome” ($n = 333$) and “without Metabolic Syndrome” ($n = 144$) stratified by sex.

| Nutrients                  | Without MetS ($n = 183$) | With MetS ($n = 81$) | p-Value * | Without MetS ($n = 144$) | With MetS ($n = 63$) | p-Value |
|----------------------------|--------------------------|----------------------|-----------|--------------------------|----------------------|---------|
| **Men**                    |                          |                      |           |                          |                      |         |
| Fruits (g/day)             | 467 ± 105                | 495 (344, 627)       | 402 ± 229 | 364 (220, 546)           | 0.002                |         |
| Vegetables (g/day)         | 346 ± 147                | 341 (232, 426)       | 311 ± 157 | 284 (192, 415)           | 0.075                |         |
| Potatoes (g/day)           | 96.7 ± 45.8              | 95.7 (57.1, 149.8)   | 70.2 ± 45.2 | 56.0 (31.4, 97.4)       | <0.001               |         |
| Legumes (g/day)            | 20.5 ± 14.7              | 16.6 (12.0, 25.1)    | 18.9 ± 12.9 | 16.1 (12.1, 24.8)       | 0.901                |         |
| Olives and EVOO (g/day)    | 34.7 ± 34.0              | 28.3 (10.0, 46.4)    | 39.3 ± 28.2 | 32.0 (21.0, 50.0)       | 0.070                |         |
| Other olive oils           | 14.3 ± 16.7              | 10.0 (0.0, 25.0)     | 13.0 ± 16.4 | 4.2 (0.0, 25.0)         | 0.563                |         |
| Other oils and fats        | 4.4 ± 9.2                | 1.3 (0.0, 4.3)       | 4.9 ± 8.9   | 0.8 (0.0, 5.0)          | 0.856                |         |
| Nuts (g/day)               | 15.8 ± 17.3              | 8.6 (4.0, 25.7)      | 13.3 ± 13.3 | 8.4 (4.0, 21.0)         | 0.594                |         |
| Total fish (g/day)         | 96.3 ± 36.2              | 88.1 (68.1, 120.5)   | 87.7 ± 45.2 | 80.3 (56.6, 111.3)      | 0.049                |         |
| Blue fish                  | 25.4 ± 19.7              | 21 (10, 21)          | 26.3 ± 22.4 | 21.0 (10.1, 21.4)       | 0.620                |         |
| Seafood                    | 35.6 ± 14.6              | 30.7 (26.7, 45.9)    | 31.1 ± 23.7 | 30.8 (17.4, 35.2)       | 0.096                |         |
| Canned fish/seaweed        | 11.7 ± 10.5              | 7.1 (3.5, 21.4)      | 11.0 ± 9.6  | 7.0 (3.4, 21.0)         | 0.215                |         |
| Total cereal (g/day)       | 229.3 ± 131.7            | 222.8 (131.4, 251.6) | 159 ± 89   | 135.9 (91.8, 217.7)     | <0.001               |         |
| Whole grain bread          | 105.2 ± 122.3            | 75.0 (50.0, 187.5)   | 61.4 ± 73.8 | 31.5 (5.0, 75.0)        | 0.012                |         |
| Refined grain bread        | 85.3 ± 108.0             | 32.1 (5.0, 187.5)    | 66.6 ± 83.1 | 31.5 (5.0, 75.0)        | 0.329                |         |
| Rice and pasta             | 34.5 ± 14.7              | 34.3 (17.1, 51.4)    | 27.6 ± 18.2 | 25.2 (12.4, 35.3)       | <0.001               |         |
| Total dairy products (g/day)| 295 ± 168                | 289 (215, 342)       | 303 ± 216  | 269 (181, 363)          | 0.612                |         |
| Dairy esserts              | 31.9 ± 34.6              | 19.9 (7.6, 47.2)     | 33.6 ± 42.2 | 15.3 (6.7, 43.0)        | 0.930                |         |
| Cheese                     | 32.9 ± 26.9              | 25.4 (21.4, 44.5)    | 32.1 ± 31.2 | 24.4 (14.0, 42.9)       | 0.395                |         |
| Skimmed dairy              | 84.8 ± 137.6             | 8.3 (0.0, 250.0)     | 115 ± 202  | 52.5 (0.0, 156.0)       | 0.215                |         |
| Whole-fat dairy            | 144.1 ± 141.3            | 125.0 (83.3, 208.3)  | 120 ± 141  | 84.0 (0.0, 200.0)       | 0.090                |         |
| Total meat (g/day)         | 152.0 ± 61.7             | 137 (112, 202)       | 166 ± 71.7 | 154 (117, 204)          | 0.247                |         |
| Processed meat             | 40.7 ± 27.0              | 34.0 (27.0, 52.0)    | 46.9 ± 34.7 | 39.1 (21.0, 62.0)       | 0.433                |         |
| Other meats                | 108.4 ± 48.8             | 84.3 (71.4, 135.7)   | 116 ± 57   | 107 (76, 149)           | 0.500                |         |
| Bakery goods (g/day)       | 60.4 ± 44.5              | 51.2 (26.7, 72.4)    | 52.1 ± 45.0 | 44.5 (20.6, 66.7)       | 0.101                |         |
| Ready-to-eat-meals         | 35.0 ± 34.2              | 26.2 (13.6, 37.6)    | 27.8 ± 40.3 | 15.4 (9.4, 30.0)        | 0.003                |         |
| Alcohol (g/day)            | 230 ± 183                | 198 (82, 337)        | 291 ± 322  | 200 (76, 367)           | 0.753                |         |

**Abbreviations:** EVOO, extra virgin olive oil; IQR, interquartile range; MetS, Metabolic Syndrome; SD, standard deviation. * Difference in means between participants without and with MetS were tested by unpaired Students’ t-test.
Table 4. Percentage of participants “with Metabolic Syndrome” and “without Metabolic Syndrome” below, inside, and above Acceptable Macronutrient Distribution Range (AMDR) proposed by the Institute of Medicine.

| Variable | AMDR | Group      | % below | % inside | % above | p *  |
|----------|------|------------|---------|----------|---------|------|
| Carbohydrate | 45–65% | Without MetS | 55.6    | 44.4     | 0.0     | <0.001 |
|          |       | With MetS  | 72.7    | 27.3     | 0.0     | 0.510 |
| Protein  | 10–35% | Without MetS | 0.0     | 100.0    | 0.0     | 0.001 |
|          |       | With MetS  | 0.3     | 99.7     | 0.0     | 0.001 |
| Total fat | 20–35% | Without MetS | 0.0     | 39.6     | 60.4    | 0.001 |
|          |       | With MetS  | 0.0     | 24.9     | 75.1    | 0.001 |
| MUFAs    | >20%  | Without MetS | 72.2    | -        | 27.8    | 0.001 |
|          |       | With MetS  | 55.6    | -        | 44.4    | 0.001 |
| LA       | 5–10%  | Without MetS | 66.7    | 20.1     | 13.2    | 0.159 |
|          |       | With MetS  | 64.9    | 26.4     | 8.7     | 0.001 |
| ALA      | 0.6–1.2% | Without MetS | 21.5    | 29.2     | 49.3    | 0.005 |
|          |       | With MetS  | 36.3    | 21.0     | 42.6    | 0.005 |
| Men      |       |            |         |          |         |       |
| Carbohydrate | 45–65% | Without MetS | 52.4    | 47.6     | 0.0     | 0.003 |
|          |       | With MetS  | 72.7    | 27.3     | 0.0     | 0.557 |
| Protein  | 10–35% | Without MetS | 0.0     | 100.0    | 0.0     | 0.001 |
|          |       | With MetS  | 0.5     | 99.5     | 0.0     | 0.001 |
| Total fat | 20–35% | Without MetS | 0.0     | 46.0     | 54.0    | 0.001 |
|          |       | With MetS  | 0.0     | 27.9     | 72.1    | 0.001 |
| MUFAs    | >20%  | Without MetS | 77.8    | -        | 22.2    | 0.025 |
|          |       | With MetS  | 62.3    | -        | 37.7    | 0.025 |
| LA       | 5–10%  | Without MetS | 65.1    | 22.2     | 12.7    | 0.276 |
|          |       | With MetS  | 66.7    | 26.8     | 6.6     | 0.001 |
| ALA      | 0.6–1.2% | Without MetS | 22.2    | 38.1     | 39.7    | 0.119 |
|          |       | With MetS  | 35.0    | 27.3     | 37.7    | 0.119 |
| Women    |       |            |         |          |         |       |
| Carbohydrate | 45–65% | Without MetS | 58.0    | 42.0     | 0.0     | 0.023 |
|          |       | With MetS  | 72.7    | 27.3     | 0.0     | 1.000 |
| Protein  | 10–35% | Without MetS | 0.0     | 100.0    | 0.0     | 0.001 |
|          |       | With MetS  | 0.0     | 100.0    | 0.0     | 0.001 |
| Total fat | 20–35% | Without MetS | 0.0     | 34.6     | 65.4    | 0.029 |
|          |       | With MetS  | 0.0     | 21.3     | 78.7    | 0.029 |
| MUFAs    | >20%  | Without MetS | 67.9    | -        | 32.1    | 0.003 |
|          |       | With MetS  | 47.3    | -        | 52.7    | 0.003 |
| LA       | 5–10%  | Without MetS | 67.9    | 18.5     | 13.6    | 0.427 |
|          |       | With MetS  | 62.7    | 26.0     | 11.3    | 0.001 |
| ALA      | 0.6–1.2% | Without MetS | 21.0    | 22.2     | 56.8    | 0.019 |
|          |       | With MetS  | 38.0    | 13.3     | 48.7    | 0.019 |

Abbreviations: ALA, α-linolenic acid; LA, linoleic acid; MetS, metabolic syndrome; MUFAs, monounsaturated fatty acids. * The differences in prevalence across the two comparison groups was examined using χ².
Table 5. Percentage of participants “with Metabolic Syndrome” and “without Metabolic Syndrome” below, inside, and above the 2020 Nutritional Objectives for the Spanish Population proposed by the Spanish Society of Community Nutrition.

| Variable       | Nutritional Objectives | Group     | % Below | % Inside | % Above | p *  |
|----------------|------------------------|-----------|---------|----------|---------|------|
| Carbohydrate   | 50–55%                 | Without MetS | 83.3    | 12.5     | 4.2     | 0.004|
|                |                        | With MetS  | 93.1    | 5.7      | 1.2     |      |
| Protein        | 10–20%                 | Without MetS | 0.0     | 100.0    | 0.0     | 1.000|
|                |                        | With MetS  | 0.0     | 100.0    | 0.0     |      |
| Total fat      | 30–35%                 | Without MetS | 9.7     | 29.9     | 60.4    | 0.001|
|                |                        | With MetS  | 9.3     | 15.6     | 75.1    |      |
| MUFAs          | 20%                    | Without MetS | 72.2    | -        | 27.8    | 0.001|
|                |                        | With MetS  | 55.6    | -        | 44.4    |      |
| PUFAs          | 5%                     | Without MetS | 14.6    | -        | 85.4    | 0.774|
|                |                        | With MetS  | 15.6    | -        | 84.4    |      |
| LA             | 3%                     | Without MetS | 18.1    | -        | 81.9    | 0.217|
|                |                        | With MetS  | 23.1    | -        | 76.9    |      |
| ALA            | 1–2%                   | Without MetS | 42.4    | 30.6     | 27.1    | 0.417|
|                |                        | With MetS  | 48.6    | 28.5     | 22.8    |      |
| SFA            | 7–8%                   | Without MetS | 2.8     | 3.5      | 93.8    | 0.952|
|                |                        | With MetS  | 3.3     | 3.6      | 93.1    |      |
| Trans FA       | <1%                    | Without MetS | 21.5    | -        | 78.5    | 0.001|
|                |                        | With MetS  | 36.6    | -        | 63.4    |      |
| DHA            | 300 mg                 | Without MetS | 100.0   | -        | 0.0     | 1.000|
|                |                        | With MetS  | 100.0   | -        | 0.0     |      |
| Total fiber    | M: 35 g/d F: 25 g/d    | Without MetS | 27.8    | -        | 72.2    | <0.001|
|                |                        | With MetS  | 52.0    | -        | 48.0    |      |
| Cholesterol    | <300 mg/d              | Without MetS | 41.0    | -        | 59.0    | 0.123|
|                |                        | With MetS  | 48.6    | -        | 51.4    |      |
| Fruits         | >300 g/d               | Without MetS | 11.1    | -        | 88.9    | <0.001|
|                |                        | With MetS  | 35.4    | -        | 64.6    |      |
| Vegetables     | >250g/d                | Without MetS | 24.3    | -        | 75.7    | 0.032|
|                |                        | With MetS  | 34.2    | -        | 65.8    |      |
| Sugar foods    | <6%                    | Without MetS | 0.7     | -        | 99.3    | 0.905|
|                |                        | With MetS  | 0.6     | -        | 99.4    |      |

Abbreviations: ALA, α-linolenic acid; DHA, docosahexaenoic acid; FA, fatty acid; LA, linoleic acid; MetS, metabolic syndrome; MUFAs, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acids; SFAs, saturated fatty acids. * Differences in prevalence between groups were assessed by χ².
4. Discussion

Subjects with MetS and without MetS showed differences for energy and macronutrient intake, as well as for intake of specific fat subtypes.

Energy and nutrient intake in MetS subjects revealed a diet lower in calories and carbohydrates, but higher in total fat and MUFA than those without MetS. Carbohydrate intake of MetS subjects was below the recommended limits (45–65% of total energy intake) and total fat intake of the same subjects was above the recommended limits (20–35% of total energy intake). Women with MetS showed more energy intake from protein than those without MetS (18% vs. 16.9%, respectively) \((p < 0.01)\), but both were within recommended ranges \([26,27]\). A similar nutrient distribution among Spanish population with MetS \([32]\) and healthy adults has been previously shown \([8]\). Differences were also previously observed between subjects with and without MetS for total energy intake, sugar intake, dietary glycemic load, percentage of dietary protein, PUFA, and fiber intake \([33]\).

Despite women with MetS reporting lower consumption of bakery goods than those without MetS, differences in sugary food intake (bakery goods, dairy desserts, beverages, fruit juices, breakfast cereals, marmalade, ice creams, chocolate, and ready-to-eat meals) between subjects with and without MetS were not found in our study when the 2020 Nutritional Objectives for the Spanish population were assessed. Total sugar intake was also quantified in the ANIBES study: results were higher in children (17.18%) and adolescents (16.33%) and markedly lower in adults (15.34%) and older adults (12.97%) \([8]\). The inhabitants of Northern Spain, especially men, consumed more sugar and sweets than adult from other Spanish areas \([32]\). Conversely, the World Health Organization (WHO) recommended <10% of energy intake be provided by sugars \([34]\), whereas <5% has been recommended in the United Kingdom \([35]\). It is well known that simple sugar intake is associated with significantly higher risk of developing MetS, including increased blood pressure, central obesity, and serum TG and glucose levels \([36–38]\). Frequent consumption of sugar-containing foods can also increase the risk of dental caries \([39]\).

This study also demonstrated an association of gender and fat intake for MetS risk. Women showed an inverse association between fat intake and MetS, irrespective of fatty acid type. Women consumed less \(\omega-3\) and \(\omega-6\) FA, which could be related to the lower consumption of nuts observed in this group. Previously, Bibiloni et al. \([40]\) showed that nut consumers were less likely to be below the estimated average requirement (EAR) for some nutrients and above the adequate intake (AI) for others than non-nut consumers. Other studies showed that European Food Safety Authority (EFSA) recommendations for intake of different types of \(\omega-3\) and \(\omega-6\) FA, such as LA, ALA, and eicosapentaenoic acid (EPA) + DHA, were not met in around half, one-quarter, and three-quarters of the European countries, respectively \([41]\). The most recent reviews also concluded that in half of the countries worldwide, the reported average PUFA intake was lower than the recommended range of 6–11% of energy \([42–44]\). In addition, the \(\omega-3\) and \(\omega-6\) FA intake was inversely associated with MetS prevalence in females \([45]\). In our study, total PUFA and specific types of PUFA (LA or ALA) intake were inversely associated with high blood pressure and positively associated with abdominal obesity. Evidence from observational and intervention studies supports the benefits of both \(\omega-3\) and \(\omega-6\) PUFA in reducing MetS \([37,46–49]\), although other studies showed conflicting results \([49–51]\). Particularly, the adequate intake of MUFA and PUFAs in the PREvención con DIeta MEDiterránea (PREDIMED) study, mainly due to a high consumption of nuts and olive oil, has been previously associated with better adherence to the Mediterranean diet (MedDiet) \([40]\) and to lower risk of CVD \([52]\). Moreover, other dietary patterns (Dietary Approaches to Stop Hypertension (DASH), new Nordic and vegetarian diets) have also been proposed as alternatives to the MedDiet for preventing MetS \([5]\).

It is also worth noting that no differences were observed between subjects with and without MetS for SFA and animal fat, although participants without MetS showed higher consumption of bakery goods than those with MetS. Moreover, an association between pathological features of MetS and dietary macronutrient intake showed that hypertension was inversely associated with SFA. Contrarily to our results, a positive association between SFA intake and MetS components has been observed.
in most studies [46,50,53–56], although other studies pointed to a lack of association [49,57]. On the other hand, increased vegetable fat intake was positively associated with abdominal obesity; certain vegetable products may also have high saturated fat contents, such as coconut oil and palm kernel oil, along with many prepared foods [10,58]. Moreover, most of the countries reported an average higher SFA intake than the recommended maximum of 10% of energy [42–44]. A prospective study with an older adult population at high risk of cardiovascular disease also observed an average higher SFA intake (10.3%) [59]. However, there is evidence that the intake of these fats is lower in the adults and older adults in the Mediterranean population, who consume low amounts of processed food; olive oil and meat ranked as the primary individual contributors [8].

Moreover, our findings show that women with MetS consumed more energy from TFA than those without MetS (6.4% versus 7.8%, respectively) (p < 0.005). Accordingly, TFA intake was inversely associated with hypertension. In a previous study, plasma TFA concentrations were significantly associated with MetS prevalence and its individual components, except for blood pressure [60]. In another study, the reduction in TFA intake over 1 year was significantly associated with a reduction in low-density lipoprotein particle number (LDL-P), a novel marker of CVD risk [61]. Actually, the 2015–2020 U.S. Dietary Guidelines for Americans and the IOM both recommend that individuals should limit TFA intake as much as possible to avoid their adverse effects on health [62].

Otherwise, the current findings showed that participants with MetS consumed less dietary fiber than the recommended dietary allowances (35 g for males and 25 g for females of this age group), which may be linked to low consumption of fruits and vegetables in our population study. This outcome is according to the outcomes of a previous meta-analysis that provided a potential link between dietary fiber consumption and MetS risk factors [63]. Previous studies also showed a protective effect of fruit intake on MetS development [17,64–66], as well as a protective role on CVD development [67].

Finally, our results also show higher BMI and lower total physical activity in participants with MetS (p < 0.001), which is in agreement with a previous study that also showed higher level of physical activity in the control group compared to the MetS group, although this difference disappeared when the subjects were separated by sex and adjusted for total energy intake [16]. Another previous study showed that participants with lower levels of physical activity, being overweight and obese, were associated with higher risk of CVD. Accordingly, the impact of physical activity on CVD might outweigh that of BMI among middle-aged and elderly participants [68]. There is evidence that interventions including regular physical activity practice in patients with MetS improves MetS risk factors [69–75], indicating that maintaining a good physical condition would be essential for a healthy status.

**Strengths and Limitations of the Study**

This study has several strengths. First, to our knowledge our study provides data on the intake of macronutrients and different types of fat in older adults with MetS or without it, which has been scarcely reported previously. Our research also provides information about dietary fat intake in comparison to national and international recommendations, which may provide references for future public policies. Some methodological limitations should be acknowledged. First, the cross-sectional study nature; thus, causal inferences cannot be drawn. Second, the relatively small sample size, specifically in the non-MetS group; for this reason, these findings cannot be generalized to the broader community based on this study alone. Third, the FFQ, the source of information to assess dietary fat intake, could overestimate the intake of certain food groups, even those that have been validated. In our study, a trained dietician conducted the interviews to collect the food frequency data; it is hoped that this approach (as compared with self-administration) reduced any potential misclassification bias. Another limitation of this study was that the used food composition databases showed missing or uncalculated data for several fats and fatty acid contents; these missing data are lower than 5% of all analyzed foods (for total fat, SFA, MUFA, PUFA, and cholesterol contents) and lower than 10% of foods (LA, ALA,
trans-fat, EPA, DHA, and DPA are mainly from marine species and may change according to season, source, such as wild or from a fish farm, and cooking method [76].

5. Conclusions

Subjects with MetS were less likely to meet IOM and SENC recommendations for fat and macronutrient intake as compared to non-MetS subjects. A healthy lifestyle is critical to prevent or delay the onset of MetS in older adults and to prevent CVD in those with existing MetS. Thus, healthy diet and lifestyle patterns can be recommended for all people with MetS and should emphasize the consumption of a variety of legumes, cereals (whole grains), fruits, vegetables, fish, and nuts, which have a high nutrient content and are more likely to meet dietary recommendations. This study also raises the possibility that future recommendations and educational campaigns should be most effective in preventing MetS via lifestyle changes.

Author Contributions: M.d.M.B. and J.A.T. designed the study and wrote the protocol. A.J., D.M., and E.A. collected data, conducted literature searches, and provided summaries of previous research studies. M.D.M.B. conducted the statistical analysis. M.D.M.B., A.J., and J.A.T. wrote the first draft of the manuscript. All read and approved the final manuscript.

Acknowledgments: This study was supported by the official funding agency for biomedical research of the Spanish Government, Institute of Health Carlos III (ISCIII) through the Fondo de Investigación para la Salud (FIS), which is co-funded by the European Regional Development Fund (Projects 11/01791, 14/00636, and 17/01827, Red Predimed-RETIC RD06/0045/1004, and CIBERONB CIB12/03/30038), Fundació La Marató TV3 (Spain) project ref. 201630.10, Grant of support to research groups no. 35/2011 and Grant no. AAE997/2017 (Balearic Islands Gov.), and E.U. Cost ACTION CA16112. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflicts of Interest: The authors declare that they have no conflict of interest.

References

1. Grundy, S.M.; Hansen, B.; Smith, S.C., Jr.; Cleeman, J.I.; Kahn, R.A.; American Heart Association; National Heart, Lung, and Blood Institute; American Diabetes Association. Clinical management of metabolic syndrome: Report of the American Heart Association/National Heart, Lung, and Blood Institute/American Diabetes Association conference on scientific issues related to management. Circulation 2004, 109, 551–556. [CrossRef] [PubMed]
2. Alberti, K.G.; Eckel, R.H.; Grundy, S.M.; Zimmet, P.Z.; Cleeman, J.I.; Donato, K.A.; Fruchart, J.C.; James, W.P.; Loria, C.M.; Smith, S.C., Jr.; et al. Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention. Circulation 2009, 120, 1640–1645. [CrossRef] [PubMed]
3. O’Neill, S.; O’Driscoll, L. Metabolic syndrome: A closer look at the growing epidemic and its associated pathologies. Obes Rev. 2015, 16, 1–12. [CrossRef] [PubMed]
4. Beltran-Sanchez, H.; Harhay, M.O.; Harhay, M.M.; McElligott, S. Prevalence and trends of metabolic syndrome in the adult U.S. population, 1999–2010. J. Am. Coll. Cardiol. 2013, 62, 697–703. [CrossRef] [PubMed]
5. Pérez-Martinez, P.; Mikhailidis, D.P.; Athyros, V.G.; Bulló, M.; Couture, P.; Covas, M.I.; de Koning, L.; Delgado-Lista, J.; Diaz-Lopez, A.; Drevon, C.A.; et al. Lifestyle recommendations for the prevention and management of metabolic syndrome: An international panel recommendation. Nutr. Rev. 2017, 75, 307–326. [CrossRef] [PubMed]
6. De Carvalho-Vidigal, F.; Bressan, J.; Babio, N.; Salas-Salvadó, J. Prevalence of metabolic syndrome in Brazilian adults: A systematic review. BMC Public Health 2013, 13, 1198. [CrossRef] [PubMed]
7. Godos, J.; Zappalà, G.; Bernardini, S.; Giambini, I.; Bes-Rastrollo, M.; Martinez-Gonzalez, M. Adherence to the Mediterranean diet is inversely associated with metabolic syndrome occurrence: A meta-analysis of observational studies. Int. J. Food Sci. Nutr. 2017, 68, 138–148. [CrossRef]
8. Ruiz, E.; Avila, J.M.; Valero, T.; Del Pozo, S.; Rodriguez, P.; Aranceta-Bartrina, J.; Gil, Á.; González-Gross, M.; Ortega, R.M.; Serra-Majem, L.; et al. Macronutrient Distribution and Dietary Sources in the Spanish Population: Findings from the ANIBES Study. Nutrients 2016, 8, 177. [CrossRef]
9. Cano-Ibáñez, N.; Gea, A.; Martínez-González, M.A.; Salas-Salvadó, J.; Corella, D.; Zomeño, M.D.; Romaguera, D.; Vioque, J.; Aros, F.; Wärnberg, J.; et al. Dietary Diversity and Nutritional Adequacy among an Older Spanish Population with Metabolic Syndrome in the PREDIMED-PlusStudy: A Cross-Sectional Analysis. *Nutrients* 2019, 11, 958. [CrossRef]

10. U.S. Department of Health and Human Services; U.S. Department of Agriculture. *2015–2020 Dietary Guidelines for Americans*, 8th ed.; Government Printing Office: Washington, DC, USA, 2015.

11. McKeown, N.M.; Meigs, J.B.; Liu, S.; Saltzman, E.; Wilson, P.W.; Jacques, P.F. Carbohydrate Nutrition, Insulin Resistance, and the Prevalence of the Metabolic Syndrome in the Framingham Offspring Cohort. *Diabetes Care* 2004, 27, 538–546. [CrossRef]

12. Freire, R.D.; Cardoso, M.A.; Gimeno, S.G.; Ferreira, S.R. for the Japanese-Brazilian Diabetes Study Group Dietary Fat Is Associated With Metabolic Syndrome in Japanese Brazilians. *Diabetes Care* 2005, 28, 1779–1785. [CrossRef] [PubMed]

13. Bruscast, N.M.; Vieira, J.L.D.C.; Nascimento, N.M.R.D.; Canto, M.E.P.; Nascimento, N.M.R.D.; Canto, M.E.P.; Nascimento, N.M.R.D.; Canto, M.E.P.; Nascimento, N.M.R.D.; Canto, M.E.P.; Nascimento, N.M.R.D.; Canto, M.E.P.; Nascimento, N.M.R.D.; Canto, M.E.P. Dietary intake is not associated to the metabolic syndrome in elderly women. *North. Am. J. Med. Sci.* 2010, 2, 182–188.

14. Guo, X.F.; Li, X.; Shi, M.; Li, D. n-3 Polyunsaturated Fatty Acids and Metabolic Syndrome Risk: A Meta-Analysis. *Nutr. 2017, 9, 703.* [CrossRef] [PubMed]

15. da Cunha, A.T.; Pereira, H.T.; de Aquino, S.L.; Sales, C.H.; Sena-Evangelista, K.C.; Lima, J.G.; Lima, S.C.; Pedrosa, I.F. Inadequacies in the habitual nutrient intakes of patients with metabolic syndrome: A cross-sectional study. *Diabetol. Metab. Syndr.* 2016, 8, 32. [CrossRef] [PubMed]

16. Al-Daghri, N.M.; Khan, N.; Alkhafif, K.M.; Al-Attas, O.S.; Alowais, H.A.; Aloothman, A.; Vanhoutte, P.M. Selected Dietary Nutrients and the Prevalence of Metabolic Syndrome in Adult Males and Females in Saudi Arabia: A Pilot Study. *Nutrients* 2013, 5, 4587–4604. [CrossRef] [PubMed]

17. de Oliveira, E.P.; McLellan, K.C.; Vaz de Arruda Silveira, L.; Burini, R.C. Dietary factors associated with metabolic syndrome in Brazilian adults. *Nutr. J.* 2012, 11, 3. [CrossRef] [PubMed]

18. Zhao, M.; Chiriboga, D.; Olendzki, B.; Xie, B.; Li, Y.; McGonigal, L.; Maldonado-Contreras, A.; Ma, Y. Substantial Increase in Compliance with Saturated Fatty Acid Intake Recommendations after One Year Following the American Heart Association Diet. *Nutrients* 2018, 10, 1486. [CrossRef] [PubMed]

19. Zhang, L.; Pagoto, S.; May, C.; Olendzki, B.; Tucker, L.K.; Ruiz, C.; Cao, Y.; Ma, Y. Effect of AHA dietary counselling on added sugar intake among participants with metabolic syndrome. *Eur. J. Nutr.* 2018, 57, 1073–1082. [CrossRef] [PubMed]

20. Rodríguez-Monforte, M.; Sánchez, E.; Barrio, F.; Costa, B.; Flores-Mateo, G. Metabolic syndrome and dietary patterns: A systematic review and meta-analysis of observational studies. *Eur. J. Nutr.* 2017, 56, 925–947. [CrossRef]

21. Amor, A.J.; Masana, L.; Soriguier, F.; Goday, A.; Calle-Pascual, A.; Gaztambide, S.; Rojo-Martínez, G.; Valdés, S.; Gomis, R.; Ortega, E.; et al. Estimating Cardiovascular Risk in Spain by the European Guidelines on Cardiovascular Disease Prevention in Clinical Practice. *Rev. Esp. Cardiol. (Engl. Ed).* 2015, 68, 417–425. [CrossRef]

22. Fernandez-Ballart, J.D.; Piñol, J.L.; Zaze, I.; Corella, D.; Carrasco, P.; Toledo, E.; Perez-Bauer, M.; Martinez-González, M.A.; Salas-Salvadó, J.; Martín-Moreno, J.M. Relative validity of a semi-quantitative food-frequency questionnaire in an elderly Mediterranean population of Spain. *Br. J. Nutr.* 2010, 103, 1808–1816. [CrossRef]

23. Moreiras, O.; Carbajal, A.; Cabrera, L.; Cuadrado, C. *Tablas de Composición de Alimentos*, 17th ed.; Food Composition Tables; Pirámide: Madrid, Spain, 2015.

24. BEDCA: Base de Datos Española de Composición de Alimentos. Available online: http://www.bedca.net/ (accessed on 10 February 2019).

25. Sánchez-Tainta, A.; Zaze, I.; Bes-Rastrollo, M.; Salas-Salvadó, J.; Bullo, M.; Sorli, J.V.; Corella, D.; Covas, M.I.; Arós, F.; Gutierrez-Bedmar, M. Nutritional adequacy according to carbohydrates and fat quality. *Eur. J. Nutr.* 2016, 55, 93–106. [CrossRef] [PubMed]

26. The National Academies of Sciences Engineering Medicine; Institute of Medicine; Food and Nutrition Board. Dietary Reference Intakes (DRIs): Acceptable Macronutrient Distribution Ranges. Available online: http://nationalacademies.org/HMD/Activities/Nutrition/SummaryDRIs/DRI-Tables.aspx (accessed on 11 April 2019).
27. SENC. Objetivos nutricionales para la población española. Consenso de la Sociedad Española de Nutrición Comunitaria 2011. Rev. Esp. Nutr. Com. 2011, 17, 178–199.

28. Elosua, R.; Garcia, M.; Aguilar, A.; Molina, L.; Covas, M.I.; Marrugat, J. Validation of the Minnesota Leisure Time Physical Activity Questionnaire in Spanish Women. Med. Sci. Sports Exerc. 2000, 32, 1431–1437. [CrossRef]

29. Elosua, R.; Marrugat, J.; Molina, L.; Pons, S.; Pujol, E. Validation of the Minnesota Leisure Time Physical Activity Questionnaire in Spanish Men. Am. J. Epidemiol. 1994, 139, 1197–1209. [CrossRef] [PubMed]

30. Conway, J.M.; Seale, J.L.; Jacobs, D.R.; Irwin, M.L.; Ainsworth, B.E. Comparison of energy expenditure estimates from doubly labeled water, a physical activity questionnaire, and physical activity records1–3. Am. J. Clin. Nutr. 2002, 75, 519–525. [CrossRef]

31. Ainsworth, B.E.; Haskell, W.L.; Whitt, M.C.; Irwin, M.L.; Swartz, A.M.; Strath, S.J.; O'brien, W.L.; Bassett, D.R.; Schmitz, K.H.; Emplaincourt, P.O.; et al. Compendium of Physical Activities: An update of activity codes and MET intensities. Med. Sci. Sports Exerc. 2000, 32, 498–516. [CrossRef] [PubMed]

32. Cano-Ibáñez, N.; Bueno-Cavanillas, A.; Martínez-González, M.A.; Corella, D.; Salas-Salvadó, J.; Zomeño, M.D.; García-de-la-Hera, M.; Romaguera, D.; Martínez, J.A.; Barón-López, F.J.; et al. Dietary Intake in Population with Metabolic Syndrome: Is the Prevalence of Inadequate Intake Influenced by Geographical Area? Cross-Sectional Analysis from PREDiMED-Plus Study. Nutrients 2018, 10, 1661. [CrossRef]

33. Cabello-Saavedra, E.; Bes-Rastrollo, M.; Martínez, J.A.; Diez-Espino, J.; Buil-Cosiales, P.; Serrano-Martínez, M.; Martínez-González, M.A. Macronutrient Intake and Metabolic Syndrome in Subjects at High Cardiovascular Risk. Ann. Nutr. Metab. 2010, 56, 152–159. [CrossRef]

34. WHO. Sugars Intake for Adults and Children-Guideline. 2015. Available online: http://www.who.int/nutrition/publications/guidelines/sugars_intake/en/ (accessed on 31 May 2019).

35. Tedstone, A.; Targett, V.; Allen, R. Public Health England-Sugar Reduction. The Evidence for Action. Available online: https://www.gov.uk/government/publications/sugar-reduction-from-evidence-into-action (accessed on 31 May 2019).

36. Barrio-Lopez, M.T.; Martinez-Gonzalez, M.A.; Fernandez-Montero, A.; Beunza, J.J.; Zazpe, I.; Bes-Rastrollo, M. Prospective study of changes in sugar-sweetened beverage consumption and the incidence of the metabolic syndrome and its components: The SUN cohort. Br. J. Nutr. 2013, 110, 1722–1731. [CrossRef]

37. Chan, T.F.; Lin, W.T.; Huang, H.L.; Lee, C.Y.; Wu, P.W.; Chiu, Y.W.; Huang, C.C.; Tsai, S.; Lin, C.L.; Lee, C.H. Consumption of sugar-sweetened beverages is associated with components of the metabolic syndrome in adolescents. Nutrients 2014, 6, 2088–2103. [CrossRef] [PubMed]

38. Abdelmagid, S.A.; Clarke, S.E.; Roke, K.; Nielsen, D.E.; Badawi, A.; El-Sohemy, A.; Mutch, D.M.; Ma, D.W. Ethnicity, sex, FADS genetic variation, and hormonal contraceptive use influencedelta-5- and delta-6-desaturaseindces and plasma docosahexaenoic acid concentration in young Canadian adults: A cross-sectional study. Nutr. Metab. (Lond). 2015, 12, 14. [CrossRef] [PubMed]

39. Burt, A.B.; Pai, S. Sugar consumption and caries risk: A systematic review. J. Dent. Educ. 2001, 65, 1017–1023. [PubMed]

40. Bibiloni, M.D.M.; Julibert, A.; Bouzas, C.; Martínez-González, M.A.; Corella, D.; Salas-Salvadó, J.; Zomeño, M.D.; Vioque, J.; Romaguera, D.; Martínez, J.A.; et al. Nut Consumptions as a Marker of Higher Diet Quality in a Mediterranean Population at High Cardiovascular Risk. Nutrients 2019, 11, 754. [CrossRef] [PubMed]

41. Sioen, I.; van Lieshout, L.; Elander, A.; Fleith, M.; Lohner, S.; Zock, P.L. Intake of Fatty Acids in General Populations Worldwide Does Not Meet Dietary Recommendations to Prevent Coronary Heart Disease: A Systematic Review of Data from 40 Countries. Ann. Nutr. Metab. 2013, 63, 229–238. [CrossRef] [PubMed]

42. Harika, R.K.; Eilander, A.; Osendarp, S.J.; Zock, P.L. Intake of Polyunsaturated Fatty Acids in European Countries in Light of the Current Recommendations - Focus on Specific Population Groups. Ann. Nutr. Metab. 2017, 70, 39–50. [CrossRef] [PubMed]

43. Micha, R.; Khatibzadeh, S.; Shi, P.; Fahimi, S.; Lim, S.; Andrews, K.G.; Engell, R.E.; Powles, J.; Ezzati, M.; Mozaffarian, D.; et al. Global, regional, and national consumption levels of dietary fats and oils in 1990 and 2010: A systematic analysis including 266 country-specific nutrition surveys. BMJ. 2014, 348, g2272. [CrossRef] [PubMed]
44. Eilander, A.; Harika, R.K.; Zock, P.L. Intake and sources of dietary fatty acids in Europe: Are current population intakes of fats aligned with dietary recommendations? *Eur. J. Lipid Sci. Technol.* 2015, 117, 1370–1377. [CrossRef]

45. Park, S.; Ahn, J.; Kim, N.S.; Lee, B.K. High carbohydrate diets are positively associated with the risk of metabolic syndrome irrespective to fatty acid composition in women: The NHANES 2007–2014. *Int. J. Food Sci. Nutr.* 2017, 68, 479–487. [CrossRef] [PubMed]

46. Shab-Bidar, S.; Hosseini-Esfahani, F.; Mirmiran, P.; Hosseinpour-Niazi, S.; Azizi, F. Metabolic syndrome profiles, obesity measures and intake of dietary fatty acids in adults: Tehran Lipid and Glucose Study. *J. Hum. Nutr. Diet.* 2014, 27, 98–108. [CrossRef]

47. Baik, I.; Abbott, R.D.; Curb, J.D.; Shin, C. Intake of Fish and n-3 Fatty Acids and Future Risk of Metabolic Syndrome. *J. Am. Diet. Assoc.* 2010, 110, 1018–1026. [CrossRef]

48. Babio, N.; Toledo, E.; Estruch, R.; Ros, E.; Martínez-González, M.A.; Cañaza, O.; Bulló, M.; Corella, D.; Arós, F.; Gómez-Gracia, E.; et al. Mediterranean diets and metabolic syndrome status in the PREDIMED randomized trial. *CMAJ* 2014, 186, E649–E657. [CrossRef] [PubMed]

49. Ahola, A.; Harjutsalo, V.; Thorn, L.M.; Freese, R.; Forsblom, C.; Mäkimattila, S.; Groop, P-H. The association between macronutrient intake and the metabolic syndrome and its components in type 1 diabetes. *Br. J. Nutr.* 2017, 117, 450–456. [CrossRef]

50. Ebbesson, S.O.E.; Tejero, M.E.; Nobmann, E.D.; Lopez-Alvarenga, J.C.; Ebbesson, L.; Romenesko, T.; Carter, E.A.; Resnick, H.E.; Devereux, R.B.; Maclaur, J.W.; et al. Fatty acid consumption and metabolic syndrome components: The GOCADAN study. *J. Cardio. Metab. Syndr.* 2007, 2, 244–249. [CrossRef]

51. Lana, L.Y.; Petrone, A.B.; Pankow, J.S.; Arnett, D.K.; North, K.E.; Ellison, R.C.; Hunt, S.C.; Djoussé, L. Association of dietary omega-3 fatty acids with prevalence of metabolic syndrome: The National Heart, Lung, and Blood Institute Family Heart Study. *Clin. Nutr.* 2013, 32, 966–969.

52. PREDIMED Study Investigators; Guasch-Ferré, M.; Babio, N.; Martínez-González, A.M.; Corella, D.; Ros, E.; Martin-Peláez, S.; Estruch, R.; Arós, F.; Gómez-Gracia, E.; et al. Dietary fat intake and risk of cardiovascular disease and all-cause mortality in a population at high risk of cardiovascular disease. *Am. J. Clin. Nutr.* 2015, 102, 1563–1573.

53. Hekmatdoost, A.; Mirmiran, P.; Hosseini-Esfahani, F.; Azizi, F. Dietary fatty acid composition and metabolic syndrome in Tehranian adults. *Nutrition* 2011, 27, 1002–1007. [CrossRef] [PubMed]

54. Hosseinpour-Niazi, S.; Mirmiran, P.; Fallah-Ghohroudi, A.; Azizi, F. Combined effect of unsaturated fatty acids and saturated fatty acids on the metabolic syndrome: Tehran lipid and glucose study. *J. Health Popul. Nutr.* 2015, 33. [CrossRef]

55. Noel, S.E.; Newby, P.K.; Or dovas, J.M.; Tucker, K.L. Adherence to an (n-3) fatty acid/fish intake pattern is inversely associated with metabolic syndrome among Puerto Rican adults in the Greater Boston area. *J. Nutr.* 2010, 14, 1846–1854. [CrossRef]

56. Yubero-Serrano, E.M.; Delgado-Lista, J.; Tierney, A.C.; Perez-Martinez, P.; Garcia-Rios, A.; Alcalá-Dia, J.F.; Cañaza, J.P.; Tinahones, F.J.; Drevon, C.A.; Defoort, C.; et al. Insulin resistance determines a differential response to changes in dietary fat modification on metabolic syndrome risk factors: The LIPGENE study. *Am. J. Clin. Nutr.* 2015, 102, 1509–1517. [CrossRef]

57. Siri-Tarino, P.W.; Sun, Q.; Hu, F.B.; Krauss, R.M. Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease12345. *Am. J. Clin. Nutr.* 2010, 91, 535–546. [CrossRef] [PubMed]

58. Eckel, R.H.; Jakicic, J.M.; Ard, J.D.; de Jesus, J.M.; Houston, M.N.; Hubbard, V.S.; Lee, I.M.; Lichtenstein, A.H.; Loria, C.M.; Millen, B.E.; et al. American College of Cardiology/American Heart Association Task Force on Practice Guidelines.2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J. Am. Coll. Cardiol.* 2014, 63, 2960–2984.

59. Beulen, Y.; Martín-González, M.A.; van de Rest, O.; Salas-Salvadó, J.; Sorlí, J.V.; Gómez-Gracia, E.; Fiol, M.; Estruch, R.; Santos-Lopez, J.M.; Schröder, H.; et al. Quality of Dietary Fat Intake and Body Weight and Obesity in a Mediterranean Population: Secondary Analyses within the PREDIMED Trial. *Nutrients* 2018, 10, 2011. [CrossRef] [PubMed]
60. Zhang, Z.; Gillespie, C.; Yang, Q. Plasma trans-fatty acid concentrations continue to be associated with metabolic syndrome among US adults after reductions in trans-fatty acid intake. *Nutr. Res.* **2017**, *43*, 51–59. [CrossRef]  
61. Garshick, M.; Mochari-Greenberger, H.; Mosca, L. Reduction in dietary trans fat intake is associated with decreased LDL particle number in a primary prevention population. *Nutr. Metab. Cardiovasc. Dis.* **2014**, *24*, 100–106. [CrossRef] [PubMed]  
62. Institute of Medicine (U.S.). Panel on Macronutrients. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*; National Academies Press: Washington, DC, USA, 2005.  
63. Chen, J.P.; Chen, G.C.; Wang, X.P.; Qin, L.; Bai, Y. Dietary Fiber and Metabolic Syndrome: A Meta-Analysis and Review of Related Mechanisms. *Nutrients* **2017**, *10*, 24. [CrossRef]  
64. Steemburgo, T.; Dall’Alba, V.; Almeida, J.C.; Zelmanovitz, T.; Gross, J.L.; de Azevedo, M.J. Intake of soluble fibers has a protective role for the presence of metabolic syndrome in patients with type 2 diabetes. *Eur. J. Clin. Nutr.* **2009**, *63*, 127–133. [CrossRef] [PubMed]  
65. Esmaillzadeh, A.; Kimiagar, M.; Mehrabi, Y.; Azadbakht, L.; Hu, F.B.; Willett, W.C. Fruit and vegetable intakes, C-reactive protein, and the metabolic syndrome. *Am. J. Clin. Nutr.* **2006**, *84*, 1489–1497. [CrossRef]  
66. Shin, A.; Lim, S.Y.; Sung, J.; Shin, H.R.; Kim, J. Dietary Intake, Eating Habits, and Metabolic Syndrome in Korean Men. *J. Am. Diet. Assoc.* **2009**, *109*, 633–640. [CrossRef]  
67. Zhu, Y.; Bo, Y.; Liu, Y. Dietary total fat, fatty acids intake, and risk of cardiovascular disease: A dose-response meta-analysis of cohort studies. *Lipids Health Dis.* **2019**, *18*, 91. [CrossRef]  
68. Koolhaas, C.M.; Dhana, K.; Schoufour, J.D.; Ikram, M.A.; Kavousi, M.; Franco, O.H. Impact of physical activity on the association of overweight and obesity with cardiovascular disease: The Rotterdam Study. *Eur. J. Prev. Cardiol.* **2017**, *24*, 934–941. [CrossRef] [PubMed]  
69. Esposito, K.; Marfella, R.; Ciotola, M. Effect of a Mediterranean-style diet on endothelial dysfunction and markers of vascular inflammation in the metabolic syndrome. A randomized trial. *ACC Curr. J. Rev.* **2004**, *13*, 16–17. [CrossRef]  
70. Warburton, D.E.; Nicol, C.W.; Bredin, S.S. Health benefits of physical activity: The evidence. *Can. Med. Assoc. J.* **2006**, *174*, 801–809. [CrossRef]  
71. Aizawa, K.; Shoemaker, J.K.; Overend, T.J.; Petrella, R.J. Effects of lifestyle modification on central artery stiffness in metabolic syndrome subjects with pre-hypertension and/or pre-diabetes. *Diabetes Res. Clin. Pr.* **2009**, *83*, 249–256. [CrossRef]  
72. Fernández, J.M.; Rosado-Álvarez, D.; Da Silva Grigoletto, M.E.; Rangel-Zúñiga, O.A.; Landaeta-Díaz, L.L.; Caballero-Villarraso, J.; López-Miranda, J.; Pérez-Jiménez, F.; Fuentes-Jiménez, F. Moderate-to-high-intensity training and a hypocaloric Mediterranean diet enhance endothelial progenitor cells and fitness in subjects with the metabolic syndrome. *Clin. Sci. (Lond).* **2012**, *123*, 361–373. [CrossRef]  
73. Gremeaux, V.; Drigny, J.; Nigam, A.; Juneau, M.; Guilbeault, V.; Latour, E.; Gayda, M. Long-term Lifestyle Intervention with Optimized High-Intensity Interval Training Improves Body Composition, Cardiometabolic Risk, and Exercise Parameters in Patients with Abdominal Obesity. *Am. J. Phys. Med. Rehabil.* **2012**, *91*, 941–950. [CrossRef] [PubMed]  
74. Gomez-Huelgas, R.; Jansen-Chaparro, S.; Baca-Osorio, A.; Mancera-Romero, J.; Tinahones, F.; Bernal-Lopez, M. Effects of a long-term lifestyle intervention program with Mediterranean diet and exercise for the management of patients with metabolic syndrome in a primary care setting. *Eur. J. Intern. Med.* **2015**, *26*, 317–323. [CrossRef]  
75. Lee, G.; Choi, H.Y.; Yang, S.J. Effects of Dietary and Physical Activity Interventions on Metabolic Syndrome: A Meta-analysis. *J. Korean Acad. Nurs.* **2015**, *45*, 483. [CrossRef] [PubMed]  
76. FESNAD. Dietary Reference Intakes (DRI) for the Spanish Population—2010. *Act. Diet.* **2010**, *14*, 196–197. © 2019 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).