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Estimation of antioxidants dietary intake in wet age-related macular degeneration patients

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Abstract

Aims: **The aim of this study was to estimate the intake of antioxidant nutrients in wet age-related macular degeneration (AMD) patients, a degenerative and progressive disorder of the macula, which is the central part of the retina, associated with central vision loss.**

Methods: **A sample (n = 52, 78.9 ± 6.6 years old, 40.4% females and 59.6% males) of patients diagnosed of AMD was interviewed. Anthropometric measurements, two 24-h recalls, a semi-quantitative food frequency questionnaire and a general questionnaire incorporating questions related to socio-demographic and lifestyle variables were used.**

Results: **Most of wet AMD patients showed inadequate antioxidant nutrient intake (< 2/3 of Recommended Dietary Intake, RDI), and more than 60% of patients showed serious deficient intake (< 1/3 RDI) of lutein and zeaxanthin. Most consumed antioxidant rich foods only represented low contributions to antioxidant intake. Although adiposity is a factor risk for AMD progression; the fat and saturated fatty acids (SFA) intake of study participants were higher than the recommendations; the prevalence of overweight was 61.9% men and 58.1% in women; and 83% of patients (90.5% men and 77.4% women) showed fat mass over the cut-off limits.**

Conclusions: **The food pattern of wet AMD patients should be improved by means of an increase in the consumption of antioxidant rich foods, and a decrease in SFA rich foods.**

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Key words: *Antioxidants. Wet age-related macular degeneration. Lutein. Zeaxanthin.*

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ESTIMACIÓN DE LA INGESTA DE ANTIOXIDANTES EN PACIENTES CON DEGENERACIÓN MACULAR ASOCIADA CON LA EDAD; VARIEDAD HÚMEDA

Resumen

Objetivos: **El objetivo de este estudio fue estimar la ingesta de nutrientes antioxidantes en pacientes con degeneración macular asociada a la edad (AMD) variedad húmeda, un trastorno degenerativo y progresivo de la mácula, la parte central de la retina, asociada con la pérdida de la visión central.**

Métodos: **En una muestra de pacientes diagnosticados de AMD (n = 52, 78,9 ± 6,6 años, 40,4% mujeres y 59,6% hombres) se registraron medidas antropométricas, dos recordatorios de 24 h, un cuestionario semicuantitativo de frecuencia de consumo de alimentos y cuestiones sociodemográficas y de estilo de vida.**

Resultados: **La mayoría de los pacientes con AMD húmeda mostraron una ingesta inadecuada de nutrientes antioxidantes (< 2/3 de las Ingestas Dietéticas Recomendadas, RDI) y más de 60% de los pacientes mostraron un déficit grave (< 1/3 RDI) de luteína y zeaxantina. Los alimentos ricos en antioxidantes más consumidos sólo aportaron bajas contribuciones a la ingesta de antioxidantes. Aunque la adiposidad es un factor de riesgo para la progresión de la AMD, el consumo de grasas y ácidos grasos saturados (SFA) de los pacientes fueron superiores a las recomendaciones; la prevalencia de sobrepeso fue del 61,9% hombres y 58.1% en las mujeres; y el 83% de los pacientes (90,5% hombres y 77,4% mujeres) mostró una masa grasa superior a los límites.**

Conclusiones: **El patrón alimentario de los pacientes con AMD debería mejorarse aumentando el consumo de alimentos ricos en antioxidantes y disminuyendo los alimentos ricos en SFA.**

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Palabras clave: *Antioxidantes. Degeneración macular asociada a la edad. Luteína. Zeaxantina.*

Non-standard abbreviations

AMD: Age-related macular degeneration
AREDS: Age-Related Eye Disease Study
OCT: optical coherence tomography
RAP: retinal angiomatous proliferation
PCV: polypoidal choroidal vasculopathy

Introduction

Age-related macular degeneration (AMD) is a degenerative and progressive disorder of the macula, the central part of the retina, associated with central vision loss. It is the leading cause of visual impairment and blindness in people over the age of 60 years in industrialized countries[1-4].

The population-based studies suggest that approximately 30% of people aged 75 years or older shows early signs of disease, and 7% shows an advanced stage[5]. The overall prevalence of AMD is 1% in 65-74 year old persons, 5% in 75-84 y-o, and 13% in ≥ 85 y-o[5]. The prevalence of late AMD is 0.8% in 60-69 y-o, 3.2% in 70-79 y-o and 19.7% in ≥ 80 y-o[6]. In Spain, AMD prevalence is 13% in people over age 65, and ranges from 0.5% at age 55, up 7% on ager over 75[7]. Based on the Spanish population pyramid, it has been estimated that by 2015, 400.000 Spanish people will suffer AMD and more than 1 million people may be at risk[8].

Risk factors associated with AMD include sex, iris color, heredity, cardiovascular health, nutrient status, body mass index, age and smoking[9]. Foods contain many nutrients that could interact on the risk for multifactorial diseases such as AMD[10]. It has been suggested that the condition of AMD may improve in people fed vitamins, antioxidants (carotenoids, vitamins C and E) and minerals (selenium and zinc) rich diets[11]. Age-Related Eye Disease Study (AREDS) recommended that to take an antioxidant supplementation (15 mg β-carotene, 500 mg vitamin C, 400 IU vitamin E and 80 mg zinc plus 2 mg copper) is successful in preventing the development of advanced AMD by 25%, and AREDS-2 included lutein, zeaxanthin and omega-3 fatty acids in the analysis of late AMD progression[9].

AMD shows two clinics forms, an atrophic form that progresses slowly and represents 80-90% of cases, and a wet form characterized by the appearance of a choroidal membrane that promoted acute vision loss, represents 10-20%, and is responsible of 90% of blindness[12]. To our knowledge, no studies have been undertaken on antioxidant nutrient intake and the wet AMD.

The aim of the present study was to estimate the intake of antioxidant nutrients in wet AMD patients.

Subjects and methods

Selection of participants, recruitment and approval

Fifty-two patients (40.4% females and 59.6% males, and mean age 78.9 (SD 6.6) years old) diagnosed of wet age-related macular degeneration, living in the Balearic Islands, Spain, were selected. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Balearic Islands Ethics Committee. Written informed consent was obtained from all subjects.

Wet AMD diagnosis

Wet AMD was diagnosed from a baseline ophthalmic examination. Visual acuity (Snellen chart), slit lamp examination, intraocular pressure, fundus photographs (Canon 60 CFUD, Japan), fluorescein and indocyanine green angiography (HRA, Heidelberg Engineering), and optical coherence tomography, OCT (Cirrus™ HD-OCT, Carl Zeiss Meditec, Oberkochen, Germany) were taken. Wet AMD was defined by the presence of a subretinal neovascular membrane. Choroidal neovascularitation (CNV) was classified by location into 3 groups: subfoveal, juxta-foveal and extrafoveal, by type into 4: occult, classic, retinal angiomatous proliferation (RAP) and polypoidal choroidal vasculopathy (PCV). Ophthalmic characteristics of participants are summarized in table I.

Anthropometric measurements

Body weight was determined to the nearest 100 g using a digital scale (BAS 60, 00788, Básculas y Balanzas Año Sayol SL, Barcelona, Spain). Height was determined using the scale's anthropometer (BAS 60, 00788, Básculas y Balanzas Año Sayol SL, Barcelona, Spain) to the nearest mm, with the subject's head in the Frankfurt plane. The subjects were weighed and measured in light clothes and without shoes.

Table I
Ophthalmic characteristics of participants

Patients	n = 52
CNV active eye:	n = 59
Right eye	n = 21 (40.4%)
Left eye	n = 24 (46.1%)
Both eyes	n = 7 (13.5%)
Visual Acuity Mean (Snellen Chart)	0.21 (SD 0.1)
CNV type:	
Classical (or predominant classical membrane)	n = 17 (28.8%)
Occult (or predominant occult membrane)	n = 26 (44.2%)
Retinal Angiomatous Proliferation	n = 15 (25.4%)
Polypoidal Choroidal Vasculopathy	n = 1 (1.6%)
CNV Location	
Subfoveal	n = 41 (69.5%)
Juxtafoveal	n = 16 (27.1%)
Extrafoveal	n = 2 (3.4%)

CNV: Choroidal neovascularitation. SD: Standard Deviation.

Waist circumference (WC, measured at the navel in men, and midway between the bottom of the ribs and the top of the hip bone in women) and hip circumference (HC, measured at the tip of the hip bone in men, and at the widest point between the hips and the buttocks in women) both were measured on light clothes. Mid-upper-arm circumference (MUAC, mid-acromiale-radiale distance of the right arm parallel to the long axis of the humerus when the subject was standing erect and the relaxed arm was hanging by the sides). WC, HC and MUAC were measured to the nearest 0.1 cm, using a non-stretchable measuring tape (KaWe, 43972; Kirchner & Wilhelm GmbH, Asperg, Germany). Triceps skin-fold thickness was measured in the right arm using a Holtain skinfold caliper (Tanner/Whitehouse, Crymych, UK), and the mean of three measurements (right arm) was used. Fat mass (FM) was estimated using validated digital bioimpedance (Omron Body Fat Monitor BF306, Omron Healthcare Europe B.V. Hoofddorp, The Netherlands)[14], applying the following procedure: Stand with both feet slightly apart; hold the grip electrodes (wrap middle finger around the groove of the handle, place the palm of hand on the top and the bottom electrodes, and put thumbs up, resting on top of the unit); hold arms straight out, at a 90 degree angle to the body, not moving during the measurement; display the measure holding the electrodes. Blood pressure was measure in mmHg using automated machines (Omron No. RX3 Plus, Omron Healthcare Europe B.V., Hoofddorp, The Netherlands). All anthropometric measurements were performed by a well-trained observer in order to avoid the inter-observer coefficients of variation.

Body mass index (BMI, kg/m^2), waist-to-hip ratio (WHR, cm = WC/HP), mid-upper arm area (MUAA, cm^2 = MUAC^2/4π), mid-upper arm muscle area (MUAMA, cm^2 = MUAC^2/4π), and mid-upper arm fat area (MUAFA, cm^2 = MUAA-MUAMA) were also calculated[15].

According to the anthropometric reference parameters for the Spanish elderly[13] and the European Society for Clinical Nutrition and Metabolism guidelines for Nutrition Screening in the elderly[16,17], the prevalence of underweight BMI < 22.0 kg/m^2, normal weight 22.0 ≤ BMI < 27.0 kg/m^2, and overweight/obesity BMI ≥ 27.0 were calculated.

Waist-hip ratio (WHR) cut-off limits for men and women described elsewhere (> 1 in men, and > 0.9 in women)[18,19] were also considered. The prevalence of central obesity was calculated based on WC, using the following cut-off points[20,21]: > 94 cm in men and > 80 cm in women (moderate risk of cardiovascular diseases, CVD), and > 102 cm in men and > 88 cm in women (high risk of CVD). Fat mass (%) cut-off limits of obesity were > 25% in men and > 33% in women[21]. MUAMA and the MUAFA (cm^2) were compared with the percentiles of reference for the Spanish elderly population[13]. Considered hypertension cut-off limits were DBP ≥ 90 mmHg and/or SBP ≥ 140 mmHg[21,22].

Questionnaires

During the visit to the hospital, the participants underwent a standardized interview with a trained dietitian based on an overall questionnaire incorporating socio-demographic status and lifestyle factors, two 24-hour recalls and a validated semi-quantitative food frequency questionnaire[23]. Socio-demographic variables included (place of residence, place and date of birth, familiar family origin, sex, marital status, home-mates, work situation, and time to residence in Balearic Islands.

Food and nutrient intake

Conversion of food into nutrients was made using a self-made computerized program based on Spanish, European and American Food tables[24-27]. Composition Tables, and complemented food composition data available for Majorcan food items. Food composition data were specific for raw and cooked foods. Recommended Dietary Intake (RDI) for Spanish population age and gender specific compared the intake of antioxidants[26], whereas lutein and zeaxanthin were compared with international references[28].

Statistics

Analyses were performed with Statistical Package for the Social Sciences version 21.0 (SPSS, Inc., Chicago, IL, USA). All tests were stratified by sex and age. Significant differences in prevalence were calculated by means of χ^2. Differences between groups' means were tested using ANOVA. Sequential Bonferroni's test was applied to control type-I error[29]. The level was established for *P* values < 0.05.

Results

Table II shows the anthropometric characteristics for participants, stratified by sex and age. Two age groups were made (< 80 and ≥ 80 years old persons) according to the p50 distribution of the sample. No significant differences were observed between sex and age distribution, but also in anthropometric parameters between age group in men. Young women showed higher weight (kg), BMI (kg/m^2), MUAC (cm) and MUAFA (cm^2) than their old peers. Moreover, men showed higher weight (kg), height (cm), MUAMA (cm^2) and WC (cm), whereas women showed higher MUAFA (cm^2), WHR, and FM (%).

The prevalence of underweight was 4.8% men and 9.7% in women, and prevalence of overweight was 61.9% men and 58.1% in women. There were no differences between sexes, but older women showed higher proportions of underweight and lower over-

Table II
Anthropometric measurements of participants

	Men							Women							
	Total (n = 21)		< 80 y.o. (n = 15)		≥ 80 y.o. (n = 6)			Total (n = 31)		< 80 y.o (n = 18)		≥ 80 y.o. (n = 13)			
	Mean	SEM	Mean	SEM	Mean	SEM	p^1	Mean	SEM	Mean	SEM	Mean	SEM	p^1	p^2
Weight (kg)	75.3	1.9	76.0	2.5	73.6	2.6	NS	64.4	2.1	68.8	2.5	58.4	2.7	*	**
Height (cm)	165.2	1.2	165.1	1.3	165.5	2.9	NS	152.2	1.2	152.9	1.5	151.2	2.1	NS	***
BMI (kg/m^2)	27.6	0.6	27.8	0.8	26.9	0.9	NS	27.8	0.9	29.4	1.0	25.7	1.3	*	NS
Prevalence of underweight (%)	4.8		6.7		0.0		NS	9.7		0.0		23.1		*	NS
Prevalence of normal weight (%)	33.3		26.7		50.0		NS	32.3		27.8		38.5		NS	NS
Prevalence of overweight/obesity (%)	61.9		66.7		50.0		NS	58.1		72.2		38.5		*	NS
MUAC (cm)	29.2	0.5	29.5	0.6	28.4	0.5	NS	29.8	0.8	31.7	1.0	27.1	1.0	**	NS
MUAMA (cm^2)	49.2	1.5	49.7	2.2	48.0	0.5	NS	38.3	2.2	41.6	3.3	33.7	2.1	NS	**
MUAFA (cm^2)	18.9	1.7	20.0	2.1	16.3	2.5	NS	34.0	2.4	40.0	2.9	25.7	2.9	**	***
WC (cm)	102.6	2.0	102.8	2.5	102.2	3.5	NS	91.8	2.0	93.1	2.3	89.9	3.7	NS	**
WC ≥ cut-off limits moderate risk (%)	19.0		13.3		33.3		NS	22.6		16.7		30.8		NS	NSWC
≥ cut-off limits high risk (%)	57.1		60.0		50.0		NS	58.1		72.2		38.5		NS	NS
HC (cm)	104.6	1.5	104.1	1.9	105.7	1.7	NS	107.4	1.8	110.2	2.2	103.4	2.6	NS	NS
WHR	0.98	0.01	0.99	0.02	0.97	0.03	NS	0.86	0.01	0.85	0.01	0.87	0.02	NS	***
WHR ≥ cut-off limits (%)	42.9		46.7		33.3		NS	32.3		27.8		38.5		NS	NS
FM (%)	31.9	1.4	32.1	1.56	31.5	3.0	NS	38.6	1.2	39.9	1.4	36.8	1.9	NS	**
FM > cut-off limits (%)	90.5		93.3		83.3		NS	77.4		83.3		69.2		NS	NS
SBP (mmHg)	149.2	5.4	145.0	6.1	159.7	11.0	NS	156.8	4.6	155.9	4.6	158.1	9.2	NS	NS
DBP (mmHg)	81.6	3.2	79.2	3.9	87.7	4.8	NS	80.1	1.8	81.7	1.8	77.8	3.4	NS	NS
BP > cut-off limits (%)	38.1		33.3		50.0		NS	45.2		55.6		30.8		NS	NS

Abbreviations: y.o., years old; BMI, body mass index; MUAC, mid-upper arm circumference; MUAMA, mid-upper arm muscle area; MUAFA, mid-upper arm fat area; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; FM, fat mass; SBP, systolic blood pressure; DBP, diastolic blood pressure; BP, blood pressure. Significant differences between age group (P^1) and sex (P^2) by ANOVA (for means) and ^{2} (for proportions): *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. NS: not significant. All p-values are corrected by sequential Bonferroni's test to control type-I error.

weight than their young peers. According to the FM (%) cut-offs around 83% of subjects (90.5% of men and 77.4% of women) were overweighed. Around 79% of participants (76.1% of men and 80.7% of women) showed a risk of CVD, and 42.3% of the studied population (38.1% of men and 45.2% of women) showed hypertension.

Estimation of energy, macro and micronutrient intake stratified by sexes are showed in table III. There were no differences between sexes, except for higher protein, phosphorus and alcohol intake observed in men. The fat and SFA intake of study participants were higher than recommendations for a healthy diet.

Table IV summarizes the estimation of antioxidant nutrient intake of participants. Men and women showed no different intakes, which did not cover recommendations for vitamin E, lutein and zeaxanthin, and zinc. Moreover, high proportion of participants showed inadequate antioxidant nutrient intake, which was more prevalent for lutein and zeaxanthin, zinc,

Table III
Estimation of energy and nutrients daily intake of participants

	Total (n = 52)		*Sex: Men (n = 21)*		*Sex: Women (n = 31)*		
	Mean	*SEM*	*Mean*	*SEM*	*Mean*	*SEM*	*p*
Energy (kcal)	2035.4	72.8	2187.1	123.6	1932.6	85.8	NS
From carbohydrate (%)	48.9	1.1	46.5	1.6	50.5	1.3	NS
From protein (%)	15.6	0.5	16.5	0.7	15.0	0.6	*
From fat (%)	35.5	1.1	37.1	1.5	34.4	1.5	NS
From SFA (%)	9.4	0.4	9.9	0.5	9.1	0.5	NS
From MUFA (%)	17.3	0.7	18.3	0.9	16.7	0.9	NS
From PUFA (%)	4.2	0.2	4.1	0.3	4.2	0.3	NS
Cholesterol (mg)	272.0	25.3	317.2	52.6	241.4	22.4	NS
Fibre (g)	20.8	1.2	19.6	1.8	21.6	1.5	NS
Alcohol (g)	8.0	1.7	13.4	3.4	4.3	1.2	**
VITAMINS							
Vitamin A (μg RE)	1477.5	423.2	1635.0	661.0	1370.8	559.0	NS
Retinol (μg)	760.3	409.4	820.4	618.3	719.6	552.5	NS
Carotenoid (μg)	4300.2	656.8	4876.4	865.7	3909.8	937.7	NS
α-Carotene (μg)	463.8	146.8	302.6	181.5	573.1	213.6	NS
β-Carotene (μg)	2995.7	598.3	4086.2	1232.1	2257.0	538.7	NS
Lutein+Zeaxanthin (μg)	851.8	140.6	845.0	264.2	856.3	157.6	NS
Vitamin C (mg)	171.4	17.1	154.1	25.8	183.1	22.9	NS
Vitamin D (μg)	1.8	0.3	1.5	0.3	2.0	0.4	NS
Vitamin E (mg)	8.6	0.5	8.9	0.9	8.3	0.7	NS
Thiamin (mg)	5.4	0.8	6.8	1.5	4.4	0.8	NS
Riboflavin (mg)	7.5	1.1	8.9	2.1	6.5	1.2	NS
Niacin (mg)	18.3	1.2	19.3	1.7	17.6	1.6	NS
Vitamin B_6 (mg)	2.3	0.5	1.8	0.1	2.6	0.8	NS
Folic Acid (μg)	334.8	24.6	332.4	44.3	336.5	28.9	NS
Vitamin B_{12} (μg)	7.2	1.8	10.6	4.1	4.9	1.4	NS
Pantothenic Acid (mg)	5.5	0.4	5.5	0.5	5.6	0.5	NS
MINERALS							
Calcium (mg)	758.3	33.6	793.1	56.0	734.8	41.9	NS
Iron (mg)	20.3	1.7	21.9	2.5	19.2	2.2	NS
Magnesium (mg)	298.5	13.2	306.1	19.9	293.3	17.7	NS
Phosphorus (mg)	1203.3	42.0	1312.2	71.5	1129.5	47.7	*
Potassium (mg)	3254.9	143.9	3289.0	226.1	3231.8	189.7	NS
Sodium (mg)	1720.5	115.4	1862.2	202.9	1624.4	136.5	NS
Zinc (mg)	10.5	1.0	10.4	1.2	10.5	1.6	NS
Copper (mg)	2.4	0.1	2.2	0.2	2.6	0.2	NS
Iodine (μg)	131.6	8.9	127.5	12.4	134.4	12.5	NS
Selenium (μg)	102.5	6.6	108.7	10.9	98.4	8.3	NS

Abbreviations: SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids. Significant differences between sexes (*$P < 0.05$; **$P < 0.01$; NS: not significant) by ANOVA. All p-values are corrected by sequential Bonferroni's test to control type-I error.

Table IV
Estimation of antioxidant nutrient daily intake of participants

		% RDI[1]	*< RDI*[2]	*< 2/3 RDI*[3]	*< 1/3 RDI*[4]
Vitamin A	Total	183.9 ± 50.8	59.6	36.5	11.5
	Men	181.5 ± 73.5	47.6	28.6	9.5
	Women	185.5 ± 70.2	67.7	41.9	12.9
Vitamin C	Total	233.7 ± 23.7	19.2*	17.3	1.9
	Men	192.7 ± 32.2	33.3	28.6	0.0
	Women	261.6 ± 32.6	9.7	9.7	3.2
Vitamin E	Total	80.8 ± 5.1	69.2	38.5	11.5
	Men	75.2 ± 7.4	76.2	38.1	14.3
	Women	84.6 ± 6.9	64.5	38.7	9.7
Lutein+Zeaxantin	Total	47.1 ± 7.6	82.7	73.1	63.5
	Men	42.3 ± 13.2	85.7	76.2	66.7
	Women	50.4 ± 9.3	80.6	71.0	61.3
Selenium	Total	169.3 ± 11.0	19.2	5.8	0.0
	Men	155.3 ± 15.6	23.8	4.8	0.0
	Women	178.8 ± 15.0	16.1	6.5	0.0
Zinc	Total	80.2 ± 8.5	86.5	63.5**	38.5***
	Men	69.0 ± 8.2	90.5	90.5	90.5
	Women	87.8 ± 13.0	83.9	45.2	3.2
Copper	Total	270.2 ± 15.3	1.9	0.0	0.0
	Men	242.9 ± 22.3	0.0	0.0	0.0
	Women	288.7 ± 32.6	3.2	0.0	0.0

[1]Percentage of Recommended Dietary Intake (RDI) covered by the participants' dietary intake. References were RDI for the Spanish population[25] with the exception of Lutein + Zeaxantin, who's RDI, comes from US Food and Nutrition Board[27].
[2]Proportion of participants with intakes below RDI, [3]below 2/3 of RDI, and [4]below 1/3 of RDI.
Significant differences between sex were tested by ANOVA (for means) and χ^2 (for proportions): *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. All p-values are corrected by sequential Bonferroni's test to control type-I error.

vitamin E, vitamin A and vitamin C. Zinc deficient intake was more prevalent in men than in women.

The food source (%) of antioxidant nutrients of participants was also assessed (table V). The major foods contributors of antioxidants were green beans (vitamin E), carrots (α-carotenes), chard and spinach (lutein and zeaxanthin), cabbage, tomato and carrots (vitamin A), orange, cabbage, pepper and tomato (vitamin C), carrots, chard and spinach (β-carotenes), olive oil (linoleic acid), poultry (zinc), bread, fish and whole grain (selenium), and coffee/infusions (copper).

The percentage of consumers of antioxidant rich foods are shown in table VI. Milk, cheese, egg, carrots, and butter and margarine (vitamin A sources), cauliflower, cabbage, orange, pepper, and strawberry (vitamin C), butter & margarine (vitamin E), green beans, banana, carrots, and mandarin (α-carotenes), tomato, cabbage, and apricot (β-carotenes), tomato, cabbage, and lettuce (lutein and zeaxanthin), olive oil, and nuts (linoleic acid), meta & poultry, and cheese (zinc), legumes, fish, pasta, shellfish & squid, and tuna (selenium), and peas, and butter & margarine (copper) are consumed by at least half of the participants.

Discussion

This estimation of antioxidant intake showed that most of wet AMD patients usually showed very low intake of lutein and zeaxanthin, zinc, vitamin A and vitamin E. Moreover, high proportion of patients also showed inadequate intake of vitamin C and selenium. The intake of other antioxidant nutrients widely achieved the recommendations. These results suggest that any intervention on wet AMD patients must to be carried out to enhance the antioxidant nutrient intake that were below the recommendations, which is in accordance with previous findings on AMD patients[3,30].

It is important to emphasize that the highest nutrient deficiency was observed on lutein and zeaxanthin, since more than 60% of wet AMD patients showed serious deficient intake (< 1/3 RDI) of these nutrients. POLA study[31] evaluated the diet of Mediterranean population and observed that the increase of lutein and zeaxanthin intake, by means of dietary modifications or nutritional supplements, had preventive effect of AMD and cataract. Previous findings pointed out the need to increase the knowledge on the relationship of lutein and zeaxanthin and the reduction of the risk of developing AMD or slow the progression to late-stage AMD[28]. Therefore, it would be useful to know the food source of these nutrients, and also if the diet of patients contained these foods.

A first analysis of the food source of antioxidant nutrients of participants showed the main dietary contributors of antioxidants. However, when the proportion of consumers of these foods among the participants in the study were analysed, we observed

Tabla V
Food source (%) of antioxidant nutrients among participants

Nutrient	*Food*	*Mean*	*SEM*	*Nutrient*	*Food*	*Mean*	*SEM*
Vitamin A	Cabbage	15.3	1.9	Lutein + Zeaxantin	Chard	28.8	3.8
	Tomato	14.7	1.6		Spinach	21.0	4.1
	Carrots	12.0	1.6		Courgette	11.3	1.9
	Spinach	4.8	0.9		Green been	10.0	1.9
	Pepper	4.4	0.6		Tomato	4.1	0.7
Vitamin C	Orange	16.2	1.8	Linoleic acid	Olive oil	13.6	1.4
	Cabbage	10.8	1.3		Walnut	8.5	2.0
	Pepper	10.5	1.3		Cabbage	7.4	1.0
	Tomato	10.3	1.2		Beef	5.7	0.8
	Cauliflower	4.8	0.7		Yogurt	5.3	1.1
Vitamin E	Green beans	48.5	5.8	Zinc	Poultry	7.1	0.9
	Olive oil	7.9	0.9		Bread	5.7	1.1
	Tomato	4.7	0.6		Wholegrain biscuit	5.3	1.7
	Orange	4.0	0.6		Wholegrain bread	4.6	0.6
	Other oils	3.1	1.0		Beef	4.4	0.5
α-Carotenes	Carrots	44.1	4.7		Selenium Bread	17.1	1.9
	Tomato	17.8	2.5		Fish	10.4	0.9
	Courgette	11.9	2.0		Wholegrain bread	10.4	2.0
	Mandarin	5.8	1.4		Pasta	8.8	0.8
	Pumpkin	5.4	1.2		Poultry	4.3	0.4
β-Carotenes	Carrot	17.4	2.4	Copper	Coffee and infusion	9.0	0.9
	Chard	13.2	1.9		Pulses	5.4	0.4
	Spinach	10.6	1.9		Bread	5.2	0.6
	Tomato	9.0	1.2		Wholegrain bread	4.2	0.9
	Melon	8.3	1.3		Tomato	3.5	0.4

Tabla VI
Percentage of consumers of antioxidant rich foods

Nutrient	*Food*	*% consumers*	*Nutrient*	*Food*	*% consumers*
Vitamin A	Milk & cheese	98.1	Lutein + Zeaxantin	Tomato	100.0
	Egg	92.3		Cabbage	86.5
	Carrots	71.2		Lettuce	76.9
	Butter & margarine	46.2		Pumpkin	46.2
	Foie-gras	21.2		Spinach	44.2
Vitamin C	Cauliflower & cabbage	92.3		Sweet corn	3.8
	Orange	84.6	Linoleic acid	Olive oil	96.2
	Pepper	80.8		Nuts	65.4
	Strawberry	48.1		Sunflower oil	36.5
	Spinach	44.2	Zinc	Meat & poultry	98.1
Vitamin E	Butter & margarine	46.2		Cheese	88.5
	Almond	40.4		Almond	40.4
	Sunflower oil	36.5	Selenium	Pulses	96.2
	Hazelnut	15.4		Fish	96.2
	Sunflower seed	3.8		Pasta	94.2
α-Carotenes	Green beans	96.2		Shellfish & squid	75.0
	Banana	73.1		Tuna	75.0
	Carrots	71.2	Copper	Peas	78.8
	Mandarin	59.6		Butter & margarine	46.2
	Pumpkin	46.2		Pecan nuts	44.2
β-Carotenes	Tomato	100.0		Almonds	40.4
	Cabbage	86.5		Peanuts	21.2
	Apricot	73.1			
	Carrots	71.2			
	Spinach	44.2			
	Potatoes	34.6			

that most consumed antioxidant rich foods (tomatoes, carrots, spinaches, oranges, cabbages, cheese, pulses, green beans) only represented low contributions to antioxidant intake (i.e.: All the participants stated to consume tomato, but it only contributed 14.7% of vitamin A intake, 10.3% of vitamin C, 4.7% of vitamin E, 17.8% of α-carotenes, 9.0% of β-carotenes, 4.1% of lutein & zeaxanthin, and 3.5% of copper). Therefore, it would be desirable to increase the servings or the total amount of the antioxidant rich foods, enough to widely cover the recommendations.

Furthermore, the fat and SFA intake of study participants were higher than the recommended nutritional objectives for the Spanish population[32]. It has been pointed out that a high dietary intake of fat is associated with a higher prevalence or incidence of early or late AMD[33]. Moreover, a high proportion of the participants showed fat mass over the cut-off limits[34], and it has been also pointed out that a relative lack of macular pigment is associated with adiposity, and may underlie the association between body fat and risk for AMD progression[35]. These results also agree our findings that most of participants showed a risk of CVD, and hypertension, which also support the general hypothesis that AMD shares multiple risk factors with cardiovascular disease[36].

These results give an insight into the dietary habits of wet AMD patients in the Balearic Islands, who may be successful in meeting health nutritional recommendations, thereby also providing clues for the development of future food-base dietary guidelines (FBDG) that would be relevant to the health of this population. Realistic FBDG should be established on the basis of a given socio-economic context. They must be drawn from population-based epidemiological studies, and it will be essential to analyse prevalent food consumption patterns in order to be realistic for the population[37]. Dietary guidelines need to be based on an assessment of the available scientific information on diet and the maintenance of good health. This assessment needs to include an evaluation of the prevailing diet and nutrient intake compared to any recommended optimum. Therefore, a stepwise approach is needed to address large disparities between actual and ideal dietary habits[38].

Finally, it is also necessary to consider that the study participants were elderly people (78.9 ± 6.6 y.o.) and observed antioxidants intakes deficiencies could be associated with physiological factors (partial or total loss of teeth, modifications in the senses of taste and smell, lack of appetite or a heightened feeling of satiety)[39,40], physical factors that impede the acquisition or preparation of foods; depression and other psychological factors, often associated with a lack of appetite or the rejection of food[41]; and economic and social factors that limited the purchase of certain foods[1].

In any case, the food pattern of wet AMD patients should be improved by means of an increase in the consumption of antioxidant rich foods, and a decrease in SFA rich foods, which is in accordance with a previous study that evidenced the overall diet quality, may play an important role in modulating the risk of AMD[36]. The promotion of this food pattern would constitute a good strategy to develop healthy FBDG among the Balearic Islands wet AMD patients.

Limitations of the study

The methodology of this study have some limitations, as for example the 24 h recalls provides information on food intake, and because the data collection occurs after consumption, this method does not affect an individual's food choices on a given day[42]. At least two non-consecutive administrations are necessary to assess usual intakes, to reduce dependency on intake from the previous day and by household food availability[42]. Accordingly, we applied two 24 h non-consecutive recalls in this study. Although 24 h recalls collects data soon after intake, recalls have also limitations related to memory and bias[42]. Moreover, the sample size is small (n = 52); then, only an estimation of antioxidant intake can be considered. Finally, this study was a cross-sectional study, and it can be thought of as providing a "snapshot" of the frequency and characteristics of a disease in a population at a particular point in time, However, since exposure and disease status are measured at the same point in time, it may not be possible to distinguish whether the exposure proceeded or followed the disease, and thus cause and effect relationships are not certain.

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Authors' contributions

JLO and JAT conceived, designed and devised the study, MEZ, MMB, JAA; AP, JLO and JAT collected and supervised the samples, and analyzed the data and wrote the manuscript. JLO and JAT supervised the study. JLO and JAT obtained funding.

Conflict of interest statement

The authors state that there are no conflicts of interest.

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