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ORIGINAL CONTRIBUTION

Association between food and nutrient intakes and cognitive capacity in a group of institutionalized elderly people

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Abstract
Background Some authors have indicated that the cognitive decline may be due to an inadequate nutritional status.
Aim of study To determine the association between food and nutrient intakes and cognitive capacity score in a group of institutionalized elderly people.
Methods The study subjects were 178 elderly (≥65 years of age) institutionalized people from the Madrid region. The diets of these subjects were recorded using the precise weighing method over a 7-day period, and their cognitive capacity assessed using the Short Portable Mental Status Questionnaire (SPMSQ). Subjects were grouped into those who did not incur errors (SPMSQ = 0) and who incurred one or more errors (SPMSQ > 0). Since an association was seen between the SPMSQ test score and age ($r = 0.2030$; $p < 0.01$), the subjects were also grouped according to whether they were above or below the percentile 50 (P_{50}) for this variable (83 years).
Results The subjects with no errors in the SPMSQ test (32%) consumed greater quantities of cereals, eggs, oils, and fats. After adjusting for energy intake and educational level an inverse association was seen between fish and vegetable consumption and cognitive capacity score. In addition, these subjects had greater intakes of carbohydrates, polyunsaturated fatty acids, riboflavin, and vitamins C, D, and E. After adjusting for energy intake, a negative relationship was found between cognitive capacity score and the intake of fibre, vitamin B_6, and folic acid.
Conclusion In general, the subjects of our study showed an adequate mental capacity, but those who made no errors in the SPMSQ test had more satisfactory diets. This shows the importance of the diet in the maintenance of cognitive function.

Keywords Cognitive capacity · SPMSQ · Food · Nutrients · Elderly persons

Abbreviations

SPMSQ	Short Portable Mental State Questionnaire
MMSE	Mini Mental State Examination
BMI	Body mass index
PUFAs	Polyunsaturated fatty acids
MUFAs	Monounsaturated fatty acids
SFAs	Saturated fatty acids

Introduction

Many studies report that the population of elderly people is growing, and as the number of elderly persons increases, an increase in the number of people showing cognitive decline is to be expected [1, 2]. The loss of cognitive capacity is one of the most important factors affecting the quality of life of elderly people and their family members, and is one of the main reasons for people entering nursing homes [3]. To some extent this cognitive decline may be due to an inadequate nutritional status [4]. For example, certain group B vitamins, such as folic acid, cyanocobalamine, and

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pyridoxine are essential for the correct functioning of the brain, and several authors report a relationship between deficiencies in these vitamins and reduced cognitive function [5–7]. In addition, oxidative stress and the accumulation of free radicals have been linked to cognitive decline [8–10], and it has been suggested that an adequate intake of vitamins C and E and beta-carotene may help to protect against such decline by limiting the negative effects of these radicals [2, 11, 12].

The aim of the present work was to study the association between food and nutrient intake and cognitive capacity in a group of institutionalized elderly people.

Materials and methods

The study subjects were 178 men and women aged ≥65 years (65–97 years), all of whom lived in four nursing homes (randomly selected from among 15) in the Madrid region of Spain. Table 1 shows the subjects' characteristics; the same sample has been described in other studies [8, 13, 14].

Subjects suffering from any health problem that might affect their digestion, absorption, or use of nutrients (cancer, cirrhosis, abnormal liver function, poor intestinal absorption, etc.) were excluded. Exclusion criteria included those who showed cognitive deterioration as defined by a Mini Mental State Examination (MMSE) score of ≤23 (cutoff point for institutionalized people [15]), those in whom >10% of the daily energy intake was supplied by alcohol, and those who did not give written consent to be included. The study was approved by the Ethics Committee of the Faculty of Pharmacy, Complutense University of Madrid.

Dietetic study

The food provided to all four homes was supplied by the same catering company. All subjects were offered two choices of first and second course and desert at both lunch and dinner. All the menus were designed by the nursing home's chefs and were regular. The food consumed by each subject was recorded using the precise weighing method over a period of seven consecutive days. All data were taken at the same time of year and under the same conditions at all four centres. All food consumed outside mealtimes and outside the nursing homes were recorded using a food record [16]. The intake of supplements was also recorded. The energy and nutrient content of all food and drink consumed was determined using DIAL software [17], which takes into account the Food Composition Tables of the Department of Nutrition, Complutense University of Madrid [18]. Nutrient intake was expressed in terms of daily intake and density (i.e., per 1,000 kcal) to examine the adequacy of the diets.

The subjects' energy needs were established using equations proposed by the WHO [19] for the calculation of the basal metabolic rate, and then multiplying by an activity coefficient. The latter was determined by asking the subjects to complete a questionnaire (adapted for elderly persons from Dalloso et al. [20]) that recorded the number of hours they spent in different activities of daily living (e.g., eating, walking, reading, etc.).

Anthropometric study

Body weight and height were measured using a Seca Alpha digital balance (range 0.1–150 kg) and a Harpenden digital stadiometer (range 70–205 cm), respectively. These data were used to determine the body mass index (BMI) (kg/m^2). All measurements were taken by trained personnel, with the subjects wearing only underwear and barefoot, as outlined in WHO [21] norms.

Cognitive capacity tests

The Short Portable Mental State Questionnaire (SPMSQ) [22] (translated into Spanish and validated by García-Montalvo et al. [23]) was used to determine the subjects' cognitive capacity. This test examines a subject's short- and long-term memory, orientation, knowledge of current

Table 1 Subjects' characteristics with respect to SPMSQ score and age ($X \pm$ SD)

	SPMSQ = 0		SPMSQ > 0		
	Age (years) < P_{50}	Age (years) ≥ P_{50}	Age (years) < P_{50}	Age (years) ≥ P_{50}	
Sex (female/male) (%)	46.67/53.33	62.96/37.04	68.63/31.37	71.43/28.57	–
Age (years)	76.07 ± 5.71	85.74 ± 2.52	76.24 ± 4.33	88.13 ± 3.79	–
Weight (kg)	69.34 ± 14.88	66.89 ± 13.81	68.18 ± 16.55	61.94 ± 12.25	–
Height (cm)	153.76 ± 7.49	151.38 ± 9.27	151.32 ± 6.32	147.98 ± 6.78	a, b
BMI (kg/m^2)	29.20 ± 6.10	29.35 ± 6.46	29.97 ± 7.55	28.26 ± 5.19	–

SPMSQ Short Portable Mental State Questionnaire, *BMI* body mass index

'a' differences with respect to SPMSQ score, 'b' differences with respect to age

Table 2 Food consumption (g/day) with respect to SPMSQ score and age ($X \pm$ SD)

	SPMSQ = 0		SPMSQ > 0		
	Age (years) < P_{50}	Age (years) ≥ P_{50}	Age (years) < P_{50}	Age (years) ≥ P_{50}	
Grams food (g/day)	1,942.05 ± 254.65	1,959.23 ± 250.69	1,837.89 ± 327.40	1,886.35 ± 281.64	–
Cereals (g/day)	174.42 ± 52.91	171.77 ± 52.86	155.11 ± 35.58	160.51 ± 38.85	a
Dairy products (g/day)	408.23 ± 130.19	422.36 ± 95.07	373.69 ± 129.79	424.29 ± 111.10	–
Eggs (g/day)	23.35 ± 17.47	19.49 ± 12.15	18.22 ± 9.95	16.65 ± 10.24	a
Sweets (g/day)	8.84 ± 7.15	13.19 ± 4.25	12.21 ± 6.41	10.95 ± 5.69	i
Fats and oils (g/day)	39.26 ± 17.17	36.99 ± 18.20	30.50 ± 11.49	31.60 ± 14.96	a
Vegetables (g/day)	281.93 ± 107.05	283.65 ± 82.94	276.94 ± 82.90	240.28 ± 83.59	–
Pulses (g/day)	14.98 ± 10.43	13.51 ± 9.89	18.79 ± 13.12	15.07 ± 12.07	–
Fruit (g/day)	173.00 ± 137.25	194.70 ± 173.62	178.48 ± 163.34	185.95 ± 152.34	–
Meat (g/day)	98.14 ± 41.67	93.05 ± 39.81	105.55 ± 40.38	88.90 ± 35.73	–
Fish (g/day)	45.69 ± 24.56	42.95 ± 17.77	34.62 ± 16.73	43.55 ± 22.17	–
Alcoholic drinks (g/day)	58.60 ± 91.04	14.41 ± 20.42	29.10 ± 56.82	41.93 ± 72.76	i
Others (g/day)	18.18 ± 19.32	41.56 ± 69.42	24.72 ± 22.33	40.51 ± 72.72	b
Pre-cooked food (g/day)	3.96 ± 6.44	3.71 ± 4.86	2.89 ± 4.56	5.34 ± 5.82	–

SPMSQ Short Portable Mental State Questionnaire

'a' differences with respect to SPMSQ score, 'b' differences with respect to age, 'i' interaction between the SPMSQ result and age ($p < 0.05$)

events, and calculation capacity. According to the number of errors made, the following scale is used to classify middle-level-educated subjects: 0–2 errors = intact cognitive capacity; 3–4 = mild cognitive decline; 5–7 = moderate cognitive decline; and 8–10 = serious cognitive decline. This questionnaire is very useful when dealing with populations with illiterate members since the results can be adjusted for educational level (one error more is allowed per classification if the subject has not received primary education, and one less is allowed if he or she has received higher education). The test was performed by a geriatrician experienced in this area. Subjects were grouped into those who did not incur errors (SPSMQ = 0) and those who incurred one or more errors (SPMSQ > 0).

Statistical analysis

The results were analysed by two-way ANOVA, ANCOVA, and linear regression analysis. The Chi-squared test was used to examine the differences between qualitative variables. Spearman correlation coefficients were also calculated. All calculations were made using RSIGMA BABEL software (Horus Hardware, Madrid). Significance was set at $p < 0.05$.

Results

The mean number of errors incurred in the SPMSQ test was 1.38 ± 1.35. Some 32.3% of the subjects incurred no errors at all, 47.5% incurred 1 or 2 errors, 17.5% incurred 3 or 4 errors, and 2.7% incurred 5–7 errors. No one incurred more than 7 errors.

The subjects were grouped according to whether they had an SPMSQ score of 0 or >0. Since an association was seen between age and the number of errors incurred ($r = 0.2030$, $p < 0.01$), the subjects were also grouped according to whether they were above or below the percentile 50 (P_{50}) for this variable (83 years) (Tables 1, 2, 3, 4, 5). No differences were seen neither between the age (<P_{50}: 36.15%; ≥P_{50}: 49.49%) nor between cognitive function groups (SPMSQ = 0: 43.86%; SPMSQ > 0: 43.80%) in terms of the percentage of their members who took supplements.

The subjects who incurred no errors in the SPMSQ test were found to have greater consumptions of cereals, eggs, fats, and oils (Table 2). Tables 3, 4, and 5 show the intake of nutrients with respect to the SPMSQ results. They also had greater intakes of carbohydrates, fats, polyunsaturated fatty acids (PUFAs), and cholesterol (Table 3). Taking into account energy density, these subjects continued to show a greater intake of PUFAs, and showed a greater intake of vitamin E (Table 4).

There was no association between educational level of participants in the study and the number of mistakes incurred ($r = 0.0212$; $p = 0.8015$).

Energy consumption was also greater among the subjects with no errors in the SPMSQ test (1,875 ± 348.18 kcal/day compared to 1,753 ± 270.52 kcal/day in >0 errors group; $p < 0.05$). ANCOVA showed

Table 3 Intake of macronutrients and fibre with respect to SPMSQ score and age ($X \pm SD$)

	SPMSQ = 0		SPMSQ > 0		
	Age (years) < P_{50}	Age (years) ≥ P_{50}	Age (years) < P_{50}	Age (years) ≥ P_{50}	
Proteins					
Intake (g/day)	71.01 ± 14.30	70.02 ± 12.89	67.63 ± 12.68	67.98 ± 10.67	–
Density (g/1,000 kcal)	38.00 ± 4.75	37.58 ± 3.69	39.35 ± 4.76	38.56 ± 4.61	–
Carbohydrates					
Intake (g/day)	206.18 ± 36.05	217.45 ± 38.73	197.26 ± 33.45	200.68 ± 29.86	a
Density (g/1,000 kcal)	110.93 ± 13.08	117.07 ± 14.09	114.83 ± 11.26	113.62 ± 9.97	–
Lipids					
Intake (g/day)	87.09 ± 25.51	85.08 ± 22.82	77.10 ± 17.51	79.45 ± 16.37	a
Density (g/1,000 kcal)	45.74 ± 6.31	44.97 ± 6.10	44.43 ± 5.00	44.65 ± 5.29	–
SFAs					
Intake (g/day)	24.98 ± 6.77	24.83 ± 6.07	22.87 ± 4.91	23.92 ± 4.84	–
Density (g/1,000 kcal)	13.19 ± 2.19	13.18 ± 1.90	13.27 ± 1.79	13.48 ± 1.81	–
MUFAs					
Intake (g/day)	39.03 ± 13.93	36.37 ± 12.29	35.51 ± 9.72	35.20 ± 10.06	–
Density (g/1,000 kcal)	20.44 ± 4.47	19.10 ± 4.50	20.43 ± 3.57	19.66 ± 3.96	–
PUFAs					
Intake (g/day)	13.73 ± 4.95	14.19 ± 5.24	11.14 ± 3.63	11.37 ± 3.90	a
Density (g/1,000 kcal)	7.23 ± 2.07	7.44 ± 2.03	6.38 ± 1.51	6.42 ± 2.00	a
Cholesterol					
Intake (mg/day)	280.90 ± 92.09	255.76 ± 74.22	246.46 ± 61.61	240.86 ± 57.28	a
Density (mg/1.000 kcal)	148.28 ± 33.92	135.50 ± 24.86	143.50 ± 29.04	136.12 ± 26.64	b
Fibre					
Intake (g/day)	15.87 ± 5.01	15.09 ± 4.43	15.63 ± 4.33	15.34 ± 4.94	–
Density (g/1,000 kcal)	8.52 ± 2.44	8.05 ± 2.00	9.13 ± 2.34	8.70 ± 2.60	–

SPMSQ Short Portable Mental State Questionnaire

'a' differences with respect to SPMSQ score, 'b' differences with respect to age

correlations between food consumption or nutrient intake and the number of errors incurred in the SPMSQ test (even after adjusting for energy intake and educational level). The number of errors incurred fell as the intake of cereals ($r^2 = 0.4006$; $p < 0.001$), eggs ($r^2 = 0.1653$; $p < 0.001$), oils ($r^2 = 0.3738$; $p < 0.001$), (Fig. 1), vegetables ($r^2 = 0.2287$; $p < 0.001$) (Fig. 2), fish ($r^2 = 0.1384$; $p < 0.001$), proteins ($r^2 = 0.5899$; $p < 0.001$), lipids ($r^2 = 0.7609$; $p < 0.001$), monounsaturated fatty acids (MUFAs) ($r^2 = 0.5847$; $p < 0.001$), PUFAs ($r^2 = 0.3993$; $p < 0.001$), fibre ($r^2 = 0.1698$; $p < 0.001$), thiamine ($r^2 = 0.3180$; $p < 0.001$), niacin ($r^2 = 0.3943$; $p < 0.001$), pyridoxine ($r^2 = 0.3182$; $p < 0.001$), folic acid ($r^2 = 0.1635$; $p < 0.001$), vitamin C ($r^2 = 0.1555$; $p < 0.001$), vitamin D ($r^2 = 0.1809$; $p < 0.001$), vitamin E ($r^2 = 0.2243$; $p < 0.001$) (Fig. 2), iron ($r^2 = 0.4575$; $p < 0.001$), phosphorus ($r^2 = 0.4998$; $p < 0.001$), magnesium ($r^2 = 0.4456$; $p < 0.001$), and zinc ($r^2 = 0.3739$; $p < 0.001$) increased. In contrast, the intake of meat ($r^2 = 0.1086$; $p < 0.001$) and saturated fatty acids (SFAs) ($r^2 = 0.6506$; $p < 0.001$) correlated with a greater number of errors incurred.

Discussion

The cognitive capacity of the subjects was similar to that reported by other authors [24].

The subjects of the older group incurred more errors in the SPMSQ test than the younger group ($r = 0.203$; $p < 0.01$). This agrees with the findings of other authors [4, 25–27].

No differences were found between age and cognitive function groups in terms of the total number of grams of food consumed (Table 2). This differs to that reported by Requejo et al. [4] and Ortega et al. [7]. The subjects who fell into the group with no errors in the SPMSQ test consumed greater amounts of cereals, eggs, and oils. After adjusting for energy intake and educational level, a negative association was found between the SPMSQ score and

Table 4 Intake of vitamins with respect to SPMSQ score and age ($X \pm$ SD)

	SPMSQ = 0		SPMSQ > 0		
	Age (years) < P_{50}	Age (years) ≥ P_{50}	Age (years) < P_{50}	Age (years) ≥ P_{50}	
Thiamine					
Intake (mg/day)	1.11 ± 0.28	1.12 ± 0.25	1.10 ± 0.24	1.09 ± 0.25	–
Density (mg/1,000 kcal)	0.59 ± 0.11	0.60 ± 0.11	0.64 ± 0.10	0.62 ± 0.14	–
Riboflavin					
Intake (mg/day)	1.39 ± 0.35	1.46 ± 0.24	1.32 ± 0.25	1.42 ± 0.25	b
Density (mg/1,000 kcal)	0.74 ± 0.14	0.80 ± 0.16	0.77 ± 0.12	0.81 ± 0.14	b
Niacin					
Intake (mg/day)	25.40 ± 6.00	24.72 ± 5.34	24.41 ± 5.43	23.63 ± 4.72	–
Density(mg/1000 kcal)	13.57 ± 2.25	13.28 ± 2.02	14.22 ± 2.54	13.40 ± 2.26	–
Pyridoxine					
Intake (mg/day)	1.45 ± 0.34	1.44 ± 0.33	1.43 ± 0.28	1.40 ± 0.29	–
Density (mg/1,000 kcal)	0.78 ± 0.14	0.78 ± 0.16	0.84 ± 0.13	0.80 ± 0.15	–
Folates					
Intake (μg/day)	176.83 ± 66.74	173.88 ± 46.30	160.39 ± 39.81	165.83 ± 48.11	–
Density (μg/1,000 kcal)	94.22 ± 31.04	93.60 ± 22.91	93.98 ± 22.00	94.60 ± 28.32	–
Cyanocobalamine					
Intake (μg/day)	4.27 ± 1.72	3.92 ± 1.22	3.41 ± 1.77	3.98 ± 1.70	–
Density (μg/1,000 kcal)	2.29 ± 0.89	2.12 ± 0.64	1.97 ± 0.89	2.24 ± 0.88	–
Vitamin C					
Intake (mg/day)	121.23 ± 37.71	125.93 ± 41.13	103.36 ± 36.99	107.48 ± 43.86	a
Density (mg/1,000 kcal)	65.40 ± 21.26	68.03 ± 22.09	60.02 ± 19.04	60.67 ± 23.04	–
Vitamin A					
Intake (mg/day)	808.81 ± 293.09	815.58 ± 216.30	685.15 ± 212.74	837.13 ± 340.16	–
Density (mg/1,000 kcal)	425.34 ± 119.91	443.03 ± 138.12	403.71 ± 139.27	469.95 ± 165.74	–
Vitamin E					
Intake (mg/day)	10.04 ± 4.42	10.64 ± 4.69	7.46 ± 2.69	8.43 ± 3.47	a
Density (mg/1,000 kcal)	5.30 ± 2.16	5.61 ± 1.89	4.29 ± 1.24	4.81 ± 1.97	a
Vitamin D					
Intake (mg/day)	3.57 ± 3.09	3.31 ± 1.90	2.12 ± 1.59	3.01 ± 2.56	a
Density (mg/1,000 kcal)	1.82 ± 1.37	1.75 ± 0.98	1.21 ± 0.82	1.65 ± 1.24	–

SPMSQ Short Portable Mental State Questionnaire

'a' differences with respect to SPMSQ score; 'b' differences with respect to age

the consumption of vegetables and fish. These findings suggest that the subjects who incurred fewest errors in the SPMSQ test made better food choices or had better food habits.

The relationship between better cognitive capacity and the consumption of more cereals and vegetables might explain the inverse relationship seen between number of errors incurred in the SPMSQ test and the intake of fibre, folic acid, pyridoxine, and vitamin C. Some authors have suggested that an adequate intake of folic acid, and vitamin B_6 and B_{12} is essential for the adequate functioning of the brain since these nutrients are involved in homocysteine metabolism [28, 29].

A negative association was also seen between the number of errors incurred on the SPMSQ test and the consumption of fats and oils. This might help to explain the relationship seen between better cognitive capacity and the intake of vitamin E, a fat soluble vitamin (Table 4). Some authors suggest antioxidant vitamins, such as vitamins C and E attenuate the effects of free radicals in the brain, thus preventing, or at least slowing down, cognitive decline [1]. The present results agree with those of Aparicio et al. [8], Fillenbaum et al. [30], and Wolters et al. [31] who report an association between cognitive capacity and the intake of vitamins C and/or E. Some authors, however, report no such association [32–35].

Table 5 Intake of minerals with respect to SPMSQ score and age ($X \pm$ SD)

	SPMSQ = 0		SPMSQ > 0		
	Age (years) < P_{50}	Age (years) ≥ P_{50}	Age (years) < P_{50}	Age (years) ≥ P_{50}	
Calcium					
Intake (mg/day)	771.32 ± 206.44	804.39 ± 129.34	716.30 ± 178.06	792.11 ± 157.46	a
Density (mg/1,000 kcal)	410.86 ± 88.33	440.54 ± 99.68	419.89 ± 102.26	450.69 ± 87.50	a
Iron					
Intake (mg/day)	10.05 ± 2.20	9.76 ± 1.95	9.39 ± 1.99	9.64 ± 1.85	–
Density (mg/1,000 kcal)	5.37 ± 0.82	5.24 ± 0.70	5.46 ± 0.84	5.47 ± 0.91	–
Phosphorus					
Intake (mg/day)	1048.08 ± 224.57	994.74 ± 167.02	972.02 ± 183.93	979.07 ± 172.16	–
Density (mg/1,000 kcal)	561.09 ± 83.41	534.39 ± 45.97	568.00 ± 87.43	554.56 ± 77.37	–
Magnesium					
Intake (mg/day)	253.09 ± 61.04	247.02 ± 41.06	239.21 ± 41.43	244.10 ± 41.26	–
Density (mg/1,000 kcal)	135.15 ± 24.12	133.29 ± 17.04	139.92 ± 19.87	138.50 ± 19.29	–
Zinc					
Intake (mg/day)	7.99 ± 1.84	7.89 ± 1.55	7.51 ± 1.45	7.55 ± 1.40	–
Density (mg/1,000 kcal)	4.28 ± 0.69	4.24 ± 0.66	4.37 ± 0.61	4.31 ± 0.86	–

SPMSQ Short Portable Mental State Questionnaire

'a' differences with respect to SPMSQ score

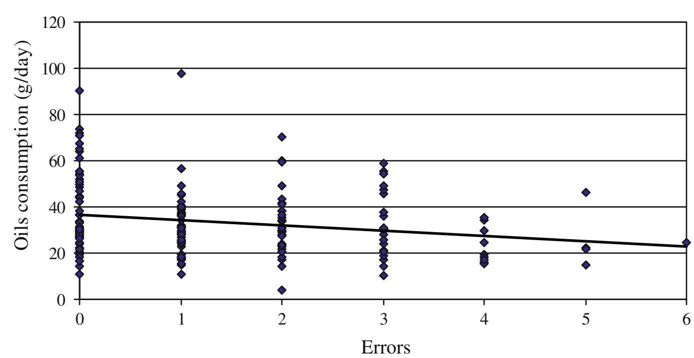

Fig. 1 Consumption of oils (g/day) in relation to the number of errors incurred in the SPMSQ ($r^2 = 0.3738$; $p < 0.001$)

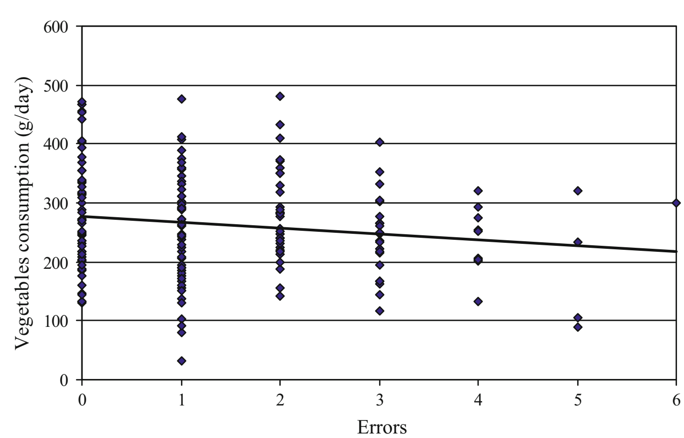

Fig. 2 Consumption of vegetables (g/day) in relation to the number of errors incurred in the SPMSQ ($r^2 = 0.2287$; $p < 0.001$)

The subjects with no errors in the SPMSQ test had a greater intake of cholesterol (Table 3); in contrast, most studies report an inverse association between cognitive capacity and cholesterol intake [4, 36, 37]. However, when cholesterol intake was examined in terms of dietary density, the association with SPMSQ score disappeared. This may be explained in that the present subjects had an intake adequate of cholesterol (<300 mg/day)—lower than that reported in the other studies. Thus, while a high intake of cholesterol may be associated with cognitive decline, an adequate intake may not be.

An association was also found between cognitive capacity score and the consumption of fish and oils. With respect to fish consumption, these results agree with those of other authors [4, 38–40]. The main type of oil used in food preparation for the present residential homes was sunflower oil, which, along with ingestion of fish, might provide for a greater intake of PUFAs (Table 3). These fatty acids include linoleic and linolenic acid, which are essential for cell function by acting as precursors for the synthesis of arachidonic and eicosapentanoic acids, respectively—molecules involved in the maintenance of brain cell integrity. Some studies have shown that an elevated PUFA (n-3) concentration can influence neuron membrane and affect neurotransmission [41]. Indeed, in the present work an association was found between PUFA n-3 intake and cognitive capacity ($r^2 = 0.1984$; $p < 0.001$). Some authors have proposed that a high intake of SFAs increases the risk of cognitive decline [42]. In the present work an association was seen between having a lower cognitive capacity and a greater consumption of SFAs, which agrees with the results of other authors [40, 43].

The subjects who incurred no errors on the SPMSQ test had a greater intake of eggs (Table 2). Their scores might be explained by the numerous beneficial nutrients that eggs contain, including choline, the precursor of acetylcholine. Several authors have suggested that a lack of acetylcholine caused by a dietary deficiency of choline, or dysfunctioning acetylcholine neurotransmission, might contribute to the cognitive decline observed in Alzheimer's disease [42, 43]. In the present work, after adjusting for energy intake and educational level, a negative association was seen between the number of errors incurred in the SPMSQ test and choline intake ($r^2 = 0.3031$; $p < 0.001$).

Conclusion

The subjects without errors in the SPMSQ generally followed a more adequate diet—even though all the subjects were offered the same menu options. This would seem to indicate that they made better food choices or had better food habits. Their greater consumption of cereals, vegetables, eggs, and fish would certainly supply essential nutrients that might facilitate the maintenance of cognitive capacity.

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Conflict of interest statement The authors declare that they have no conflict of interest.

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