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ORIGINAL CONTRIBUTION

Dietary glycaemic load and odds of depression in a group of institutionalized elderly people without antidepressant treatment

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Abstract
Background Depression is a very common disorder in elderly, especially in those institutionalized. Nutrition could play an important role in the onset and/or progression of depression, since the intake of carbohydrates with a high glycaemic index (GI) or diets with a high glycaemic load (GL) may increase the insulin-induced brain serotonin secretion.
Objective The aim of our study was to analyse the association between dietary GI and GL and the odds of suffering depression in institutionalized elderly people without antidepressant treatment.
Methods This cross-sectional study included 140 institutionalized elderly people from the Madrid region (Spain) (65–90 years of age) whose diets were recorded using a precise weighing method over seven consecutive days. Energy and nutrient intakes were recorded and the GI and GL calculated. The participants' affective capacity was assessed using the Geriatric Depression Scale (GDS). Subjects were grouped into non-depressed (GDS $\leq$ 5) and depressed (GDS $>$ 5). Since GDS scores and gender were statistically associated ($p < 0.01$), the data were grouped considering this association.
Results Dietary GI (51.09 $\pm$ 3.80) and GL (97.54 $\pm$ 13.46) were considered as medium. The dietary GL was significantly higher in the non-depressed (100.00 $\pm$ 12.13) compared with the depressed group (93.97 $\pm$ 14.04, $p < 0.01$). However, a similar GI was observed between non-depressed (51.50 $\pm$ 3.29) and depressed groups (50.52 $\pm$ 4.46). Additionally, participants with a dietary GL placed in the second and third tertiles had a 67.4 % and 65.3 %, respectively, less odds of suffering depression than those in the first tertile. GDS scores and dietary GL were inversely related; therefore, an increase in one unit in the dietary GL scale decreased the GDS score by 0.058 units.
Conclusions Glyaemic load is associated with a lower odd of depression.

Keywords Glycaemic load · Glycaemic index · Depression · GDS · Elderly

Abbreviations

BMI	Body mass index
GI	Glycaemic index
GL	Glycaemic load
BI	Barthel index
MMSE	Mini-Mental State Examination
CAMCOG	Cambridge Cognitive Examination
GDS	Geriatric Depression Scale
WHO	World Health Organization

Introduction

The depression prevalence in independent elderly population is between 5 and 20 %, and these figures may double in institutionalized individuals [1]. At the present time, depression has been acknowledged as an important public

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health problem, and it may become the second leading cause of disability worldwide in near future [2].

Genetic and biochemical factors, such as serotonin reductions, have been associated with the onset of depression [3]. It has also been suggested that nutrition could play an important role in the onset and development of depression [4]. However, the way that nutrition influences depression has not yet been elucidated.

Early research focused on the role played by carbohydrate intake on depression [5–8]. Recently, much attention has been focused on dietary glycaemic index (GI) and glycaemic load (GL) [9, 10]. The GI is an indicator of the quality of the dietary carbohydrate. Diets with high GI are associated with a greater fluctuations in blood glucose and insulin concentrations than those with low GI [11], and it could result in the release of tryptophan from protein, which is metabolized to serotonin in the brain [12, 13]. The GL reflects both the quality and quantity of carbohydrate and provides a summary measure of the relative glycaemic impact of a typical serving of that food [14]. Foods with a high GL elicit greater glycaemic and insulinaemic responses [5].

Depressed people usually tend to consume foods with higher GI and GL than non-depressed people [5, 6, 8, 15]. However, total food consumption may decrease, rather than excessive carbohydrate intake, due to the loss of appetite [8]. Therefore, the effects of depression on food consumption are not clear.

The brain is the most metabolically active organ in the body and uses glucose, almost exclusively, as its energy source, so the regulation of glucose levels is essential for brain function [16]. From the results of a study with rats, it was suggested that there is no protective mechanism to limit the amount of glucose entering into the brain [17] and that elevated glucose levels may promote brain lesions, such as ischaemic damage [16], which may be an indicator or a contributor to late life depression, as described by the vascular depression hypothesis [18, 19].

One of the most widely used treatment for depression is antidepressant drugs, which may also affect the carbohydrate intake. It has been observed that while selective serotonin reuptake inhibitors (SSIRs) reduce the intake of carbohydrates [6], tricyclic antidepressants increase carbohydrate intake [20], and these responses could mislead the interpretation of the association between depression and carbohydrate intake.

A study by Mwamburi et al. [9] found that depressed elderly people taking antidepressants drugs (most were on SSRIs) followed a lower GL diet than depressed subjects that were not taking antidepressants. This suggested that antidepressants may suppress GI intake independently of their effect on mood.

Taken into account all the above, and that most of the studies have examined the relationship between depression and the carbohydrate consumption in young people or homebound elderly [9], the aim of the present study was to analyse the association between dietary GI and GL and the odds of depression in institutionalized elderly people without antidepressant treatment.

Materials and methods

A group of institutionalized elderly people living in four different nursing homes in the Madrid region (Spain) took part in the study. These nursing homes were chosen from an initial randomly selected sample of fifteen. Six of the nursing homes refused to participate in the study, and three of them had a much reduced number of residents and did not fulfil the inclusion criteria. The four participating homes were randomly selected from the remaining six. All participants had similar characteristics, with acceptable physical and cognitive capacities. All data were collected by our research group (UCM-920030), from the Department of Nutrition of the Complutense University of Madrid, between April and May 2001.

Participants were excluded from the study if they suffered any condition that might affect the digestion, absorption or use of nutrients (e.g. cancer, cirrhosis, abnormal liver function, poor intestinal absorption). Additionally, those who showed an important cognitive decline (a Mini-Mental State Examination score of <23) were also excluded, as were those whose alcohol intakes provided 10 % or more of their daily energy.

Taking into account the exclusion criteria, the cognitive capacity and dietetic studies were assessed first and then the anthropometric, haematological and biochemical, functional and affective studies.

Initially, a group of 183 elderly people (aged 65–97 years) were selected to participate in the study, from which 43 individuals were excluded from the study as they were taking antidepressant drugs. Therefore, 51 men and 89 women took part in the study. 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 Human Research Review Committee of the Pharmacy Faculty, Complutense University of Madrid. All participants took part in the study voluntarily and gave written informed consent.

Anthropometric study

Weight and height were recorded using a Seca Alpha digital scale (range 0.1–150 kg) and a Harpenden digital stadiometer (range 70–205 cm), respectively. Body mass index (BMI; kg/m^2) was then calculated. All measurements were taken by trained personnel with subjects barefoot and

wearing minimal clothing, in accordance with World Health Organization (WHO) norms [21].

Dietary survey

All the food served in the nursing homes was prepared by the same catering company. The precise individual weighing method was used over 7 days to record the dietary intake of each subject and to determine the energy and nutrients intake. All foods served during each meal (breakfast, lunch, evening snack and evening meal) and the leftovers were weighed to calculate the exact amount of food consumed. All residents were offered two choices of starter, main course and desert during lunch and dinner. Therefore, the dietary survey reflected the individual preferences and possibly their lifetime dietary habits [22]. The food consumed outside the nursing home or at odd times was recorded using a food record [23]. All dietary data were recorded at the same time of the year and under similar conditions in all nursing homes.

Energy intake, nutrients, fibre, GI and GL of the ingested foods and drinks were then calculated using the nutritional analysis software DIAL [24], which uses the Food Composition Tables of the Department of Nutrition, Complutense University of Madrid [25]. In order to judge the quality of the diet, the real nutritional intake was compared with the nutritional goals for the Spanish population. To evaluate the adequacy of the subjects' nutrient consumptions, these were compared with the daily recommended intakes (RI) for the Spanish population, bearing in mind sex and age [26].

The dietary GI was calculated by multiplying the amount of available carbohydrates of each food item by the food's GI, and the sum of these products was then divided by the total carbohydrate intake. Glucose was used as the reference (GI for glucose = 100) [27, 28]. GL was then calculated as follows: GL = (total available carbohydrate intake × dietary GI)/100 [14].

Each subject's energy requirements were established using the equations proposed by the WHO [29], for the calculation of the basal metabolic rate and multiplying by an activity coefficient. In order to determine this activity coefficient, all participants completed an activity questionnaire (adapted from Dallosso et al. [30] for elderly persons) that recorded the time spent on different daily life activities (walking, eating, reading, etc.). An individual activity coefficient was then calculated for each person.

The results of the dietetic study were validated comparing energy intake with the theoretical expenditure. The discrepancy percentage between the energy expenditure and the sum of the measured and declared intakes was determined using the following formula [31, 32]:

$$(\text{Theoretical energy expenditure} - \text{Energy intake}) \times 100/\text{Theoretical energy expenditure}$$

A negative result indicates that the declared energy intake is greater than the theoretical energy expenditure (probable over-reporting), while a positive result indicates that a declared energy intake is lower than the theoretical (probable under-reporting) [23, 33].

Functional capacity study

The Barthel Index (BI) was used to measure performance in daily living activities [34]. The BI consisted of 10 questions that provide a measure of an individual's daily activities, focusing on their mobility and level of dependency. The questionnaire includes questions about feeding, bathing, dressing, toilet use, bed to wheel-chair transfers, level mobility and going up-/downstairs. The activities have certain points allocated; being 0 the lowest level of independency and 10 or 15 the highest level of independency. The sum of the scores indicates the level of dependency of the participants, so 0 point means totally dependent and 100 points means independent.

Cognitive capacity tests

The study of the cognitive capacity was performed using two different tests. One of the tests was the Mini-Mental State Examination (MMSE) [35], validated and translated into Spanish by Lobo and Ezquerra [36]. This test explores cognitive areas such as orientation, word recall, attention and calculation, language abilities and visuospatial ability. MMSE ranges from 0 to 35, with scores $\geq$24 considered as normal.

In addition, the Cambridge Cognitive Examination (CAMCOG) [37] was used to assess the cognitive capacity (validated and translated into Spanish by Llinas et al. [38]). The CAMCOG incorporates items that are commonly used in neuropsychological assessment to examine cognitive behaviours (CAMDEX). This cognitive test includes assessments of the following domains: orientation, language, memory, attention, praxis, abstract thinking, perception and calculation. The maximum score is 107, and scores of 70 or higher are considered normal cognitive function.

Affective capacity study

The Yesavage's Geriatric Depression Scale (GDS) was used to assess the affective capacity [39], validated and translated into Spanish by Pérez et al. [40]. The GDS is a screening test to detect the presence of depression that includes 15 individual questions with scores ranging from 0

to 15. A score of 5 or less is considered as normal (no suffering depression).

All the tests were performed by an experienced geriatrician.

Statistical analysis

Descriptive data were expressed as mean and standard deviation (SD). Anthropometric, dietary and functional, cognitive and affective capacities data were analysed using analysis of the variance (two-way ANOVA). The dietary data were adjusted by energy intake using the residuals method of Willet [41]. GI and GL tertiles were calculated from the residuals. The Student's *t* test (or the Mann–Whitney test if the results were not normally distributed) was used to compare means. Comparisons between proportions were made using an approximation of the binomial distribution to the normal distribution, employing continuity correction. Also Pearson and Spearman correlation coefficients were calculated depending on the normality of the sample, to see whether there was a relationship between the variables.

The X^2 test was used to determine the differences between proportions. Relationships between variables were analysed using multiple linear regressions, including potential confounders such as sex, CAMCOG, BI, protein intake, GI and GL. These confounders were chosen considering their association with the GDS score. Logistic regression analysis was used to identify risk or protection factors, expressing the OR and the 95 % confidence interval (95 % CI). Test of linear trend across increasing tertiles was conducted by assessing the medians to each tertile; this variable was treated as continuous. All calculations were made using RSIGMA BABEL Software (Horus Hardware; Madrid, Spain) and SPSS Inc., version 19.0. The level of significance was set at $p < 0.05$.

Results

The mean age of the sample was 82.31 ± 7.01 years, and no sex-related difference was seen at the age of the participants in the study. The mean GDS score was 5.18 ± 3.48, with 42.1 % of the participants with scores higher than 5. Within the group of depressed individuals, 49.2 % had mild depression (GDS 5–8), 41 % had moderate depression (GDS 9–11), and 9.8 % had severe depression (GDS ≥ 12). The GDS data revealed a higher percentage of depressed women (50.5 %) compared to men (27.8 %) ($p < 0.05$). This association was not found between GDS score and age. The anthropometric variables were similar in depressed and non-depressed individuals. However, the non-depressed group had a higher BI and CAMCOG scores, which meant that they had a better functional and cognitive capacity, respectively (Table 1).

With respect to the diet, the energy contribution to the energy expenditure was similar in both groups.

Table 1 Anthropometric, dietary and functional, cognitive and affective capacities data

	Men		Women	
	Non-depressed (GDS ≤ 5)	Depressed (GDS > 5)	Non-depressed (GDS ≤ 5)	Depressed (GDS > 5)
n	36	15	43	46
Age (years)	81.31 ± 7.81	81.40 ± 8.86	81.95 ± 7.86	84.62 ± 5.69
Weight (kg) **S**	69.56 ± 12.87	70.08 ± 13.68	63.95 ± 15.52	63.05 ± 16.06
Height (cm) **S**	157.56 ± 6.44	157.17 ± 3.94	146.19 ± 6.10	147.37 ± 4.67
BMI (kg/m^2)	28.09 ± 5.35	28.83 ± 5.71	29.96 ± 7.12	28.98 ± 7.07
Energy (kcal/day) **S**	1,896 ± 290.9	1,933 ± 286.1	1,841 ± 283.4	1,737 ± 311.2
Proteins (g/day)	65.75 ± 9.12	66.07 ± 7.98	65.78 ± 8.43	66.26 ± 8.22
Lipids (g/day) **G**	81.47 ± 9.99	84.46 ± 9.91	79.02 ± 8.84	85.72 ± 9.75
Carbohydrates (g/day) **G**	191.22 ± 21.35	180.99 ± 17.80	196.37 ± 17.14	185.92 ± 18.73
GI **S**	52.72 ± 2.91	51.18 ± 2.79	50.45 ± 3.27	50.32 ± 4.87
GL **G**	100.65 ± 13.59	92.44 ± 12.22	99.45 ± 10.87	94.44 ± 14.64
BI **G**	92.89 ± 13.79	82.93 ± 23.37	87.14 ± 21.37	79.62 ± 21.86
MMSE **S**, **I**	27.19 ± 3.37	27.89 ± 4.23	27.77 ± 4.24	24.33 ± 4.23***
CAMCOG **S**, **G**	75.29 ± 9.90	73.30 ± 13.17	72.63 ± 11.02	65.60 ± 11.60
GDS **S**, **G**, **I**	2.44 ± 1.75	9.80 ± 2.43***	2.84 ± 1.63	8.00 ± 2.05***

BI Barthel Index, *MMSE* Mini-Mental State Examination, *CAMCOG* Cambridge Cognitive Examination, *GDS* Geriatric Depression Scale

Two-way ANOVA analysis: S: differences according to sex; G: differences according to GDS score; I: interaction between sex and GDS score

Differences between depressed and non-depressed within the same sex group (Student's *t* test): *** $p < 0.001$

Table 2 Association between dietary data and depression (GDS > 5) (data adjusted by sex)

	Model 1 OR (95 % IC)	Model 2 OR (95 % IC)
Protein (g/day)		
Reference (T1)	1	1
T2	1.300 (0.547–3.077)	1.632 (0.617–4.316)
T3	1.350 (0.561–3.247)	1.847 (0.699–4.881)
p for trend	0.511	0.307
Carbohydrate (g/day)		
Reference (T1)	1	1
T2	0.594 (0.250–1.413)	0.696 (0.240–2.016)
T3	0.235 (0.092–0.599)	0.626 (0.152–2.582)
p for trend	0.002	0.270
Lipid (g/day)		
Reference (T1)	1	1
T2	1.617 (0.671–3.900)	1.064 (0.395–2.867)
T3	2.640 (1.075–6.469)	0.550 (0.132–2.293)
p for trend	0.030	0.955
GI		
Reference (T1)	1	
T2	0.519 (0.221–1.222)	
T3	0.657 (0.278–1.550)	
p for trend	0.236	
GL		
Reference (T1)	1	
T2	0.326 (0.133–0.796)	
T3	0.347 (0.141–0.855)	
p for trend	0.002	

GI glycaemic index, *GL* glycaemic load, *T1* first tertile, *T2* second tertile, *T3* third tertile

[1] Model 1 adjusted for sex

[2] Model 2: Model 1 + protein, lipid and carbohydrate intake as appropriate

If the confidence interval does not include 1.00, the results are statistically significant

Furthermore, those with a caloric profile close to the theoretical ideal had lower odds of depression (Table 2).

According to Brand-Miller et al. [42] and Monro and Shaw [43] criteria, the dietary GI (51.09 ± 3.80) and GL (97.54 ± 13.46) were considered as medium. Significant differences were observed in the dietary GL between non-depressed (100.00 ± 12.13) and depressed (93.97 ± 14.04) groups ($p < 0.01$), but not in the GI (non-depressed: 51.50 ± 3.29; depressed: 50.52 ± 4.46; NS). Subjects with a dietary GL in the second (T2: 91.7–102.8) and third tertiles (T3: ≥102.8) had a 67.4 and 65.3 %, respectively, less odds of suffering depression than those in the first tertile (T1: <91.7) (Table 2). A negative correlation between dietary GL and lipid intake ($r = -0.696$; $p < 0.001$) was observed. Carbohydrate intake and GL were positively related ($r = 0.878$; $p < 0.001$).

Elders with a dietary GI in the second (T2: 50.2–52.5) or third tertile (T3: >52.5) did not show less odds of depression than those in the first tertile (T1: <50.2) (Table 2). Moreover, no differences in GDS score (T1: 6.00 ± 3.07; T2: 4.90 ± 3.89; T3: 4.48 ± 3.13; NS) or percentage of depressed individuals (T1: 53.2 %; T2: 35.6 %; T3: 37.3 %; NS) were observed between groups.

Otherwise, elders allocated in the higher dietary GL tertile had lower GDS scores (Table 3) and therefore better affective capacity. Also, an inverse association between GDS score and dietary GL was observed, so that an increase in one unit in the dietary GL scale decreased the GDS score by 0.058 (Table 4).

Discussion

The prevalence of depression of the present study was similar to the values reported by Burrows et al. [1]. Additionally, there was a higher prevalence of depression in women compared to men, in agreement with several studies [44–48].

Nutrition may play an important role in the onset and/or evolution of affective disorders [4]. Appetite loss and therefore an energy intake decrease have been related to depression [12]. However, the present study found similar energy intakes between non-depressed and depressed individuals (Table 2), similar to results found by Oishi et al. [49].

Several studies have observed unbalanced diets in depressed individuals, typically high intakes of lipids and proteins and low intakes of carbohydrates [50–52]. The present study also presented unbalanced diets in the depressed individuals, with a higher intake of lipids and proteins (Table 2). Scaglioni et al. [53] and Venn and Green [54] indicated that a high intake of lipids and proteins and a poor intake of carbohydrates could reduce the GL of the diet. This justifies the low GL observed in the depressed group (Table 2). It has been suggested that depression could lead to a loss of the feeding control, with increases in the consumption of certain foods, such as foods high in fat [55], or a reduction in the carbohydrate intake. However, some authors have observed that depressed individuals obtain a high percentage of their daily energy from carbohydrates, especially those carbohydrates with high GI and GL [5, 6].

In agreement with other studies performed in Western populations [56–58], the dietary GI and GL mean values of the current study were qualified as medium GI and GL for both groups (depressed and non-depressed), taking into account a GI value between 51 and 69 (for glucose) [42]

Table 3 Dietary data and GDS score with respect to dietary GL

	T1		T2		T3	
	Men	Women	Men	Women	Men	Women
Energy (kcal/day) **S**	1,993 ± 302.02	1,798 ± 293.91	1,867 ± 206.32	1,733 ± 321.43	1,867 ± 323.43	1,844 ± 284.37
Contr. energy to RI (%) **S**	102.28 ± 14.19	103.55 ± 18.23	98.94 ± 12.75	103.60 ± 17.79	95.04 ± 16.69	106.83 ± 15.07
Under-reporting (%) **S**	−2.28 ± 14.19	−3.55 ± 18.23	1.06 ± 12.75	−3.60 ± 17.79	4.96 ± 16.69	−6.83 ± 15.07
Proteins (g/day)	66.05 ± 8.26	65.74 ± 8.24	63.56 ± 8.85	66.58 ± 8.22	67.47 ± 8.85	65.60 ± 8.39
TEP (%)	14.87 ± 1.99	15.08 ± 2.32	14.81 ± 1.66	14.92 ± 1.79	14.62 ± 1.89	14.06 ± 1.48
Lipids (g/day) §	90.28 ± 9.81	89.42 ± 10.09	81.25 ± 7.79	83.40 ± 5.21	75.71 ± 7.94	74.41 ± 7.51
TEL (%) §	44.60 ± 4.31	43.54 ± 5.08	39.95 ± 3.87	40.21 ± 3.40	37.12 ± 4.22	36.54 ± 3.41
Carbohydrates (g/day) §	167.86 ± 13.60	173.43 ± 13.49	186.57 ± 7.73	190.60 ± 6.99	208.18 ± 18.89	210.02 ± 12.48
TEC (%) S, §	36.54 ± 2.83	38.10 ± 3.37	40.66 ± 1.65	42.31 ± 2.46	45.67 ± 5.00	45.90 ± 2.77
Fibre (g/day)	18.32 ± 4.30	19.48 ± 4.61	17.51 ± 4.00	17.92 ± 3.36	19.45 ± 4.09	18.57 ± 2.70
Fibre contr. to RI (%)	67.33 ± 20.18	79.40 ± 21.74	67.87 ± 17.33	76.90 ± 21.64	76.68 ± 20.10	73.66 ± 16.10
GI S, §	49.71 ± 2.36	47.66 ± 5.08	52.32 ± 2.02	51.03 ± 2.25	54.05 ± 2.39	52.84 ± 2.30
GL §	82.78 ± 8.21	83.07 ± 7.53	97.29 ± 3.11	97.86 ± 3.14	112.15 ± 8.81	110.84 ± 7.74
GDS §	5.47 ± 4.29	6.39 ± 2.79	5.00 ± 3.85	5.07 ± 3.08	3.05 ± 2.53	5.04 ± 3.64
% GDS > 5	40	68.8	35.3	40	9.5	42.9**

RI recommended intake, *TEP* total energy from proteins, *TEL* total energy from lipids, *TEC* total energy from carbohydrates, *GI* glycaemic index, *GL* glycaemic load, *T1* first tertile, *T2* second tertile, *T3* third tertile

S differences according to sex, § differences according to GL, ** $p < 0.01$

Table 4 Results of a multiple regression analysis with GDS score as dependent variable and sex, BI, CAMCOG, proteins intake, GI and GL as independent variables

	β (95 % IC)	Error	p for the variable	R^2
Sex	0.410 (−0.758 to 1.577)	0.590	0.489	0.185
BI	−0.035 (−0.063 to −0.007)	0.014	0.014	
CAMCOG	−0.065 (−0.113 to −0.016)	0.024	0.009	
Proteins (g/day)	0.013 (−0.053 to 0.078)	0.033	0.701	
GL	−0.058 (−0.099 to −0.018)	0.021	0.005	
Sex	0.254 (−0.961 to 1.469)	0.614	0.680	0.155
BI	−0.035 (−0.063 to −0.006)	0.014	0.016	
CAMCOG	−0.064 (−0.113 to −0.015)	0.025	0.011	
GI	−0.135 (−0.283 to 0.011)	0.074	0.069	

BI Barthel Index, *CAMCOG* Cambridge Cognitive Examination, *GI* glycaemic index, *GL* glycaemic load

β Constant or intercept

and a GL value between 80 and 119 [43], which are lower than in Asian populations [10, 59].

The pathogenesis of depression can be related to several factors and experiences through life, such as disease, bipolar disorders and old age. Additionally, depression may be also related to certain nutritional habits that can influence the synthesis of serotonin [3]. Serotonin is a neurotransmitter related to mood, and its presence is reduced during depression [60]. It has been indicated that rich carbohydrates diets are related to an increase in serum insulin concentration, which enhances tryptophan uptake in the brain and its conversion to serotonin [50]. Hence, diets rich in carbohydrates, especially high GI and GL foods, are expected to reduce the odds of depression [7, 59]. This hypothesis could explain why the prevalence of depression is lower in Asian countries compared with Western countries, because rice, a food with a high GI, is a staple of the Eastern diet [10, 13].

Although we can only speculate on the hypothesis mentioned above, since a limitation of our study is the lack of insulin concentration data, it has been found that those elders with a higher GL had a lower odd of suffering depression (Tables 2 and 3). Although all participants ingested similar diets (as they were fed in the nursing

home), interestingly non-depressed individuals consumed a higher amount of carbohydrates than those suffering from depression (Table 3).

Additionally, the present study indicated that depression was associated with reduced functional and cognitive capacities (Table 1). This could mean that the depressed elders, since they have a worse functional and mental capacities, made worse food choices, and this could affect their affective capacity. But differences in dietary GL found between non-depressed and depressed elders remained after adjusting by BI and CAMCOG score ($p = 0.023$).

Our study had some limitations, such as the low sample size. The cross-sectional design restricts our ability to evaluate the temporality of the observed association, and we could not determine whether a low dietary GL is a protective factor for depression or whether people without the disease followed a lower GL diet. Another limitation of our study is that depression was not adjusted by family history of depression, comorbidity and other medications. On the other hand, the precise weighing method for assessing the dietary intake is a positive characteristic of our study, and this is reflected in the low underestimation of diet.

Conclusions

The results of the present study indicate that there is an inverse association between the odds of depression and dietary GL, showing that, at least in this group of elders, depression is associated with the amount of carbohydrates consumed. Longitudinal studies and clinical trials are needed to evaluate whether changes in dietary GL could lead to a lower risk of depression in elders.

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

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