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ORIGINAL PAPER

Oily Fish Intake and Cognitive Performance in Community-Dwelling Older Adults: The Atahualpa Project

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Abstract Due to their high content of omega-3 polyunsaturated fatty acids, oily fish consumption is likely associated with a better cognitive performance. However, information on this association is controversial, with some studies showing a positive effect while others showing no association. We aimed to assess the effects of oily fish consumption on cognitive performance in a population of frequent fish consumers living in rural coastal Ecuador. Atahualpa residents aged ≥60 years were identified during a door-to-door survey and evaluated by the use of the Montreal Cognitive Assessment (MoCA). Oily fish servings per week were calculated in all participants. We estimated whether fish intake correlated with MoCA scores in generalized multivariate linear models adjusted for demographics, cardiovascular risk factors, edentulism and symptoms of depression. Out of 330 eligible persons, 307 (93 %) were enrolled. Mean MoCA scores were 19 ± 4.8 points, and mean oily fish consumption was 8.6 ± 5.3 servings per week. In multivariate analyses, MoCA scores were related to fish servings (β 0.097, 95 % CI 0.005–0.188, $p = 0.038$). Locally weighted scatterplot smoothing showed an inflection point in the total MoCA score curve at four fish servings per week. However, predictive margins of the MoCA score were similar across groups below and above this point, suggesting a direct linear relationship between oily fish intake and cognitive performance. Simple preventive measures, such as modifying dietary habits might be of value to reduce the rate of cognitive decline in community-dwelling older adults living in underserved populations.

Keywords Oily fish · Omega-3 · Cognitive performance · Montreal Cognitive Assessment · Population-based study · Ecuador

Introduction

Omega-3 polyunsaturated fatty acids (ω-3 PUFAs) are essential components of neural membrane phospholipids and may improve cognition by favoring different aspects of neuronal functioning [1, 2]. Therefore, oily fish consumption—being the most common dietary source of ω-3 PUFAs—might be associated with a better cognitive performance and with a decreased rate of progression from normal aging to mild cognitive impairment or dementia. However, the literature on this subject is inconclusive, with some studies showing a positive effect [3–6], while others showing no association [7–9]. Same controversial results have been noticed in studies addressing the effect of fish oils supplements on cognitive function [10–15]. These contradictory results are most likely related to differences in study designs, outcome definitions, or in the characteristics of participants.

The prevalence of mild cognitive impairment and dementia is growing at an alarming rate among older adults

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living in rural communities of many low- and middle-income countries [16]. Epidemiologic surveys assessing regional-specific modifiable risk factors are required to develop cost-effective strategies directed at reducing the burden of these new epidemics, and will lead to more informed decisions on the prioritization of existing resources which, in most of these regions, are already limited. In this view, simple preventive measures, such as modifying dietary habits, may result in profound changes in the mental health of underserved populations. This study aims to assess the relationship between dietary oily fish intake and cognitive performance in a population of frequent fish consumers living in rural coastal Ecuador.

Methods

Population Studied

The population of Atahualpa (2478 residents according to the 2012 census) mostly belongs to the Ecuadorian native/Mestizo ethnic group, and the living characteristics of its inhabitants are homogeneous, as described elsewhere [17]. Most men work as carpenters and most women are home keepers. The diet of villagers is rich in fish and carbohydrates but limited in meat and dairy products; there are no fast-food restaurants in the village, and most people eat at home. Due to both high costs and lack of awareness of their importance, dietary intake of non-marine sources of ω-3 PUFAs (olive oil, chia seeds, walnuts, flaxseeds) or the use of fish oils supplements, is nonexistent in the village. The village is relatively isolated and closed. Inhabitants do not migrate and many of them have never visited large urban centers.

Study Design

The Institutional Review Board of Hospital-Clínica Kennedy, Guayaquil, Ecuador (FWA 00006867) approved the study. All Atahualpa residents aged ≥60 years identified during door-to-door surveys were invited to participate. Those who signed the informed consent were interviewed with field instruments directed to assess the cognitive performance and the amount of dietary oily fish intake, as well as the cardiovascular health (CVH) status, the presence of symptoms of depression, and the number of remained teeth. Individuals unable to complete the test for cognitive assessment due to aphasia or severe visual or hearing impairment were not included.

Assessment of Fish Consumption

Our personnel visited the local fish market to identify and weight edible parts of frequently available fish species. With the aid of community leaders, we created a list with commonly consumed oily fish (>5 % fat), which due to lower prices, are preferred by Atahualpa residents. These included Pacific Bumperfish (*Chloroscombrus orqueta*), Pacific Mackerel (*Scomber japonicus*), Shortjaw Leatherjacket (*Oligoplites refulgens*), Pacific Thread Herring (*Opisthonema libertate*) and Sardine (*Sardine pilcardus*). According to the US department of Agriculture and the US Department of Health and Human Services (http://www.health.gov/DietaryGuidelines/) and other authoritative reviews [18, 19], these are among the fishes with the highest content of ω-3 PUFAs.

During door-to-door surveys, participants were requested to quantify their consumption of fish included in the previously created list and to recall any additional consumed species that were not listed. Then, the number of servings per week was calculated by dividing the average intake of each fish by 140 g (the weight of a serving size). We also inquired about the way fish is prepared and only included in the analysis those served broiled, baked or cooked as a soup (oily fish is rarely fried by Atahualpa residents).

Cognitive Performance

Cognition was assessed by the use of the Spanish version of the MoCA test (www.mocatest.org, © Z. Nasreddine MD, version 07 November 2004). The MoCA evaluates major cognitive domains: visuospatial-executive (trail making B task, 3-dimentional cube copy, and clock drawing) for a maximum of five points; naming (unfamiliar animals) for a maximum of three points; language (sentence repetition, and a phonemic fluency task) for a maximum of three points; short-term memory (delayed recall or words) for a maximum of five points; abstraction (verbal abstraction) for a maximum of two points; attention and calculation (digits forward and backward, target detection using tapping, serial 7's subtraction) for a maximum of six points; and orientation (time and space) for a maximum of six points [20]. Maximum MoCA score is 30 points, with an additional point given to persons with ≤12 years of education. We did not used a cutoff score for defining cognitive impairment, but the continuous MoCA score to avoid problems related to poor reliability of specific cutoffs in less well-educated populations [21, 22]. In addition, we only relied on the total MoCA score and not in domain-specific subscores due to their limited predictive validity when compared against other neuropsychological tests [23].

Covariates Investigated

Besides demographics and cardiovascular risk factors, severe edentulism and symptoms of depression were

chosen as confounding variables because they have shown to modify cognition in Atahualpa residents [24, 25]. Education was not used as a covariate because of collinearity, since the MoCA assigns one extra point for those with low levels of instruction (almost 90 % of participants). Cardiovascular risk factors were assessed by the use of the seven metrics proposed by the American Heart Association [26], including smoking status, body mass index, physical activity, diet, blood pressure, fasting glucose, and total cholesterol blood levels. As previously detailed, each metric was categorized as ideal, intermediate or poor, and the cardiovascular health status was classified as poor if at least one metric was in the poor range [27]. Severe edentulism was defined in individuals having <10 remaining teeth [24] and symptoms of depression were assessed by the depression axis of the depression-anxiety-stress-21 scale, a reliable field instrument that measures dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest/involvement, anhedonia, and inertia [25].

Statistical Analyses

All analyses are performed using STATA version 14 (College Station, TX). In the univariate analysis, continuous variables were compared by linear models and categorical variables by x^2 or Fisher exact test as appropriate. We examined the association between total MoCA scores and oily fish servings per week in a generalized multivariate linear model adjusted for demographics, cardiovascular risk factors, severe edentulism and symptoms of depression. Using locally weighted scatterplot smoothing, we assessed a potential non-linearity in the relationship.

Results

The MOCA were performed in 330 (86 %) out of 385 individuals aged ≥60 years enrolled in the Atahualpa Project. The remaining persons either declined to participate (n = 29) or were unable to complete the full version of the test (n = 26) due to aphasia or severe visual or hearing impairment. Information on dietary oily fish intake was possible in 307 (93 %) out of the 330 individuals who had cognitive assessment. The remaining 23 had died, moved out the village or declined further collaboration between the practice of the MoCA and the fish survey.

Mean age of participants was 69.4 ± 7.8 years, 170 (55 %) were women, 226 (74 %) had a poor CVH status, 149 (49 %) had severe edentulism, and 35 (11 %) had symptoms of depression. Mean oily fish consumption was 8.6 ± 5.3 servings per week (range 0–28), and total MoCA scores were 19 ± 4.8 points, including the extra point given to 294 individuals due to low levels of education.

Table 1 Univariate analysis showing differences in the total MoCA score across relevant confounders in 307 Atahualpa residents aged ≥60 years

Variable	Total MoCA score, Mean ± SD	*p* value
Age (median)		
≤67 years (n = 156)	20.4 ± 4.4	0.001
>67 years (n = 151)	17.6 ± 5.1	
Sex		
Men (n = 137)	19.8 ± 4.6	0.010
Women (n = 170)	18.4 ± 4.8	
Cardiovascular health status		
Intermediate/ideal (n = 81)	20.3 ± 4.4	0.006
Poor (n = 226)	18.6 ± 4.8	
Severe edentulism		
≥10 remaining teeth (n = 158)	19.8 ± 4.5	0.003
<10 remaining teeth (n = 149)	18.2 ± 5	
Symptoms of depression		
Symptoms absent (n = 272)	19.4 ± 4.5	0.001
Symptoms present (n = 35)	16.3 ± 6	

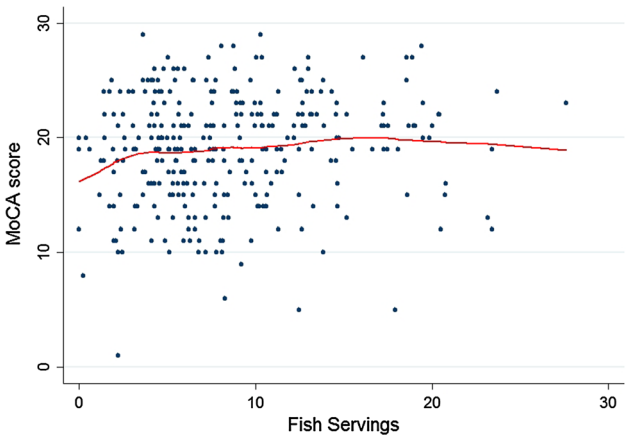

Fig. 1 Locally weighted scatterplot smoothing of the Montreal Cognitive Assessment score and number of servings of oily fish per week in 307 Atahualpa residents aged ≥60 years, showing a direct linear relationship between both parameters

Total MoCA scores significantly differed by age (dichotomized according to the median age of the population), sex, CVH status, edentulism and symptoms of depression in univariate analyses (Table 1).

In the generalized multivariate linear model adjusted for relevant confounders, the total MoCA score was significantly related to the number of fish servings per week (β 0.097, 95 % CI 0.005–0.188, $p = 0.038$). Locally weighted scatterplot smoothing of total MoCA scores and fish intake showed an inflection point at four servings per week (Fig. 1). However, predictive margins of the MoCA score

were similar across groups below and above this point, showing that the previously constructed linear model was better to assess this correlation.

Discussion

This population-based study, conducted in frequent fish consumers aged ≥60 years living in rural coastal Ecuador, showed a linear (dose-dependent) relationship between dietary oily fish intake and cognitive performance. The association remained significant after adjustment for several non-nutritional variables (age, sex, cardiovascular risk factors, severe edentulism and symptoms of depression) with a proven association with cognitive performance.

Marine ω-3 PUFAs are recommended as a part of a healthy diet [18, 28]. Besides their well-known cardioprotective effects, several studies have investigated a possible influence of ω-3 PUFAs intake in the nervous system. The rationale for this research has been supported by human and experimental research showing—among other facts—that these nutrients constitute more than one-third of neural membrane phospholipids, and can enhance dendritic arborization, increase the levels of brain-derived neurotrophic factor and up-regulate synaptic plasticity [29–31]. According to several studies using optimized voxel-based morphometry on high resolution MRI, the effect of ω-3 PUFAs on cognitive performance is through preservation of brain areas involved in the intrinsic mechanisms of memory, such as the anterior cingulate cortex, the amygdala, and the hippocampus [13–15]. It has also been stated that the effects of ω-3 PUFAs in the nervous system might be mediated by their anti-inflammatory and anti-thrombotic properties, due to reduction of vascular risk factors associated with cognitive decline [32].

Studies assessing a possible relationship between ω-3 PUFAs intake and cognitive performance are by no means uniform [3–15]. Some studies have focused on the effects of oily fish intake while others have studied the effects of fish oils administration. In addition, neuro-psychological tests used to assess cognition have varied from one study to another, and the results might not be comparable. With few exceptions, population-based studies evaluating the effects of long-term fish intake in frequent fish consumers yielded positive results, and studies assessing the effect of short-term fish oils administration have been negative. These are predictable findings, since it should not be expected that ω-3 PUFAs intake for a few weeks or months would improve cognition or prevent cognitive decline. In addition, it seems that de novo ω-3 PUFAs intake would not be effective once severe cognitive decline has occurred.

It has also been reported a better cognitive performance in persons adhering to the so-called Mediterranean diet, which contains fish [33, 34]. However, these studies might not be comparable since this diet is also rich in other sources of ω-3 PUFAs [35]. Moreover, many people—at least those living in developed countries—who adhere to a Mediterranean diet, also opt for a healthier life style and the results may have been biased even after correcting for confounding variables [36]. In contrast, people living in coastal rural areas of low- and middle-income countries do not choose to eat fish as a part of a healthier life style, but as the most accessible (and probably the only) option to get energy from food.

The cross-sectional design of the present study does not allow for assessing causality. In addition, blood omega-3 levels were not determined and we cannot be sure whether ω-3 PUFAs or other nutrients present in oily fish—such as vitamin D [37]—accounted for the observed effects of oily fish intake on cognitive performance. However, these potential limitations are counterbalanced by the population-based design with unbiased selection of participants, the use of reliable field instruments to assess cognitive performance and potential confounders, and the protocol used to calculate the amount of oily fish ingested per person. Further longitudinal studies in Atahualpa as well as in other underserved communities are warranted to determine whether oily fish intake prevents the occurrence of cognitive decline or dementia in the long-term follow-up.

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Compliance with Ethical Standards

Conflict of interest Nothing to disclose.

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