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Zhang, H orcid.org/0000-0002-9818-7904, Hardie, L and Cade, J (2020) Foods, nutrient intakes, and Mediterranean dietary pattern in midlife are not associated with reaction times: a longitudinal analysis of the UK Women's Cohort Study. British Journal of Nutrition. pp. 1-19. ISSN 0007-1145

https://doi.org/10.1017/s0007114520002287

Accepted manuscript

Foods, nutrient intakes, and Mediterranean dietary pattern in midlife are not associated with reaction times: a longitudinal analysis of the UK Women's Cohort Study

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Shortened title: Reaction times not related to diet in UKWCS

Keywords: Mediterranean diet, cooking methods, cognition, simple reaction time, choice reaction time

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This peer-reviewed article has been accepted for publication but not yet copyedited or typeset, and so may be subject to change during the production process. The article is considered published and may be cited using its DOI
10.1017/S0007114520002287
The British Journal of Nutrition is published by Cambridge University Press on behalf of The Nutrition Society

Abstract

Associations between dietary factors and general cognition in the elderly have been documented; however, little is known about reaction time ability in relation to midlife diet. This study aimed to investigate associations between reaction time and midlife dietary factors, specifically foods, nutrients, and Mediterranean diet (MeDi) pattern. The UK Women's Cohort Study UKWCS collected dietary information from middle-aged women (52 ± 9.4 years old) using a validated 217-item food frequency questionnaire in 1995-98. In 2010-11, a sub-group of 664 participants completed online reaction time ability tests including simple reaction time and choice reaction time, 503 participants were eligible for analysis. Participants were grouped into fast and slow groups by their median reaction time. The intake of particular foods, nutrients, adherence to the Mediterranean diet (MeDi) and cooking methods (roasting/baking, frying, and BBQ/grilling) were explored in relation to reaction times. We did not find any significant associations between reaction times and investigated foods, nutrients, or adherence to the MeDi in adjusted models. However, consumers of roasted/baked fish and fried vegetables were associated with slower simple reaction time (adjusted OR=1.46, 95% CI, 1.00 - 2.13, *P*=0.049; and adjusted OR=1.64, 95% CI, 1.12 - 2.39, *P*=0.010; respectively) compared with non-consumers of that particularly cooked food. Overall, our findings show no significant associations between midlife diet and reaction time ability 10-15 years later.

1. Introduction

The global population aged 60 years and over is projected to reach 2 billion by 2050 which will be around 22% of the people in the world [(1)]. Brain aging is associated with a decline in several cognitive functions, including memory, attention, speed of processing, and executive function [(2)]; changes that may result in mild incapacity even prior to the onset of dementia [(3)]. The speed of processing is an important domain of cognitive function and can be assessed by reaction time. Researchers have proposed that the speed of processing might be a fundamental component of individual differences in relation to cognitive aging [(4)]. Some studies have suggested that diet, a modifiable lifestyle factor, may play a key role in cognitive aging [(5)]; however, current evidence about associations of foods as well as their cooking methods, nutrient intakes, and dietary patterns with processing speed is limited.

Nutrients may influence the loss of cognitive function with aging [6]. Neuroprotective effects of polyunsaturated fatty acids (PUFAs) and several vitamins, especially antioxidant vitamins (including vitamin E), are supported by cell and animal experiments in vitro and in vivo, observational studies, and randomized control trials [7-9]. However, several clinical trials do not support the positive effects across all cognitive function measures [10-12]. A systematic review and meta-analysis of supplementation trials with ω-3 PUFAs from infancy to old age showed that beneficial effects on cognition might happen only in infants but not in children, adults or the elderly [13], indicating that effects of nutrients on cognitive function may vary by age groups.

Cooking methods play an important role in dietary intake by modifying taste, palatability and nutrient composition of foods during the cooking process. For example, frying can reduce unsaturated fatty acids and antioxidant vitamins due to oxidation, but has little impact on protein and mineral content, whereas dietary fibre of potatoes can be increased by frying because of the formation of resistant starch [14]. Cooking can also influence fat content and fatty acid composition in meat. Gerber et al. showed considerable fat loss in several meat cuts cooked by grilling, broiling or pan-frying without fat added, which affected the polyunsaturated/saturated fatty acids ratio [15]. In addition, some hazardous compounds can be produced as a by-product during the cooking process. When high-protein containing food such as meat and fish is heated to high temperatures, polycyclic aromatic hydrocarbons (PAHs) can be produced, particularly benzo[*a*]pyrene [16]. A cross-sectional study showed a 1% increase of urinary 1-hydroxypyrene (a biomarker of PAHs) resulted in approximately a 2% poorer performance on cognitive function in individuals aged 60 years and older [17]. With regard to carbohydrate-rich food heated to high temperatures, acrylamide can be produced, a known neurotoxin and carcinogen [18]. Currently, evidence regarding effects of acrylamide on cognitive function is limited, but a study among non-smoking elderly Chinese men found that dietary acrylamide exposure was associated with mild cognitive decline [19]. Both loss of nutrients and production of hazardous compounds can vary by cooking method, and at present very little information exists regarding the possible influence of cooking methods on cognitive function.

In relation to dietary patterns, accumulating studies suggest that higher adherence to the Mediterranean diet (MeDi) may be associated with better cognitive performance [20, 21]. Nevertheless, a recent systematic review suggested that there was a high level of heterogeneity among 32 articles studying associations between adherence to the MeDi, cognitive function and dementia, with almost half reporting the MeDi was not associated with cognitive function or dementia [22], indicating that the protective effect of the MeDi on cognitive function remains inconsistent.

This longitudinal observational study aimed to investigate associations between midlife dietary factors, specifically foods, nutrients, and Mediterranean diet (MeDi) pattern, with reaction time ability 10-15 years later. Potential associations between cooking methods and reaction time ability were also explored. In the present study, consumption of unsaturated fatty acids and fish, vitamins and vegetables, as well as adherence to the MeDi were hypothesized to be positively associated with reaction time ability; whereas consumption of saturated fatty acids and meat was assumed to be negatively linked to reaction time ability.

2. Methods

2.1 Study design and participants

The UK Women's Cohort Study (UKWCS) [23] was initiated in 1995 to explore potential associations between diet and chronic disease and recruited 35,372 women aged 52 years (SD: 9.4) (1995 to 1998). At recruitment, the baseline survey collected food frequency questionnaires (FFQs), lifestyle as well as demographic and anthropometric information.

Sample size to investigate the impact of diet on reaction ability in the UKWCS, was estimated using the mean choice reaction time (CRT). A sample size of 530 women was computed from the estimation of the mean CRT using comparison of one mean to a reference value with the two-sided significance level of 0.05, marginal error of 15 milliseconds (ms), and power of 0.8. This estimation was calculated using a reference mean CRT of 628 ms (SD: 123 ms) from a British study in which SRT and CRT were tested using the Deary-Liewald reaction time task for residents aged between 61 and 80 in the City of Edinburgh [24]. There were no previous studies of diet and reaction time on which to base a sample size calculation.

In 2010/11, a subset of 664 women was involved in our pre-designed online reaction-time tests. Among them, 510 women had complete dietary records and cognitive testing results. Exclusion criteria were applied among individuals with unlikely fast reaction times (SRT<200ms; CRT<250ms) prior to analyses as these were likely to represent accidental screen presses which were adapted from previous studies [25]. We excluded participants if their reported energy intake was outside 1% of the population distribution (<500 kcal/day or 25 MJ/day and >6,000 kcal/day or 0.2 MJ/day) following previous studies [26]. We also excluded participants with stroke history because stroke could significantly impair cognitive function including the reaction time ability [27].

Ethical approval was granted from National Research Ethics Service (NRES) Committee for Yorkshire & the Humber – Leeds East (Ref: 15/YH/0027) at the cohort's initiation in 1993; now covered by Health Research Authority REC Reference: 17/YH/0144.

2.2 Reaction ability tests

The web-based cognitive measurement tasks (www.uk-wcs.co.uk) test participants' reaction ability including simple reaction time and choice reaction time described previously [24, 28]. The simple reaction time (SRT) task required participants to respond to a letter "Y" appearing on a screen by pressing the "Y" key on the keyboard as soon as it appeared for 20 trials. The choice reaction time (CRT) task required participants to respond to one of four numbers (5, 6, 7 or 8) appearing randomly on a screen by pressing the corresponding number on the keyboard as soon as it appeared for 40 trials. The mean values of reaction times were analysed as the outcome to reflect participants' cognitive ability. Each reaction time was grouped into two categories according to their median values, where the slow group was defined as less than the median and the fast group equal to or above the median. The median was used here to reduce the impact of outliers and skewed data.

2.3 Dietary measurement

Dietary information at baseline was obtained from self-administered FFQs with 217 British food items, which was based on the FFQ used in the UK for the European Prospective Investigation into Cancer and Nutrition (EPIC) study [29]. The baseline FFQ was compared against 4-day weighed food diaries and a second FFQ collected at the same time as the diary, on 283 women 3 years after baseline. Whilst accepting that each tool type is measuring different aspects of diet, correlations between the two dietary assessment methods were comparable to those found in other studies; for example, the correlation coefficients between the FFQ and the 4-day weighed food diaries were 0.39 for carbohydrate, 0.35 for fat, 0.43 for calcium and 0.62 for vitamin C [30, 31]. Classification of food groups and derivation of nutrient intakes were detailed in previous studies [32, 33]. Nutrients provided by supplements were not included in the nutritional analysis. The cooking methods of several common foods including meat, fish, vegetables, and potatoes, have been investigated by asking 'How often do you eat foods cooked by the following methods?' The specific cooking methods included roasting/baking, frying, and BBQ/grilling, and the consumption frequencies ranged from never to more than once a day containing 8 categories. Participants with the frequencies of never and less than once a month were treated as non-consumers of specific cooked food item, while others with the frequencies of once a month or more were considered as consumers of that food item. The consumption frequency of each cooking method was treated as a dichotomous variable: non-consumers and consumers. This was included in the regression models with non-consumers as the reference group.

To quantify adherence to the Mediterranean diet (MeDi), a variable of MeDi score was created based on the 217-item FFQ. The MeDi score was derived from a modified 10-point version of the MeDi [34, 35] covering 10 food/nutrient components consumed in grams per day. Of the 10 components, 6 traditionally consumed in the MeDi (vegetables, legumes, fruits and nuts, cereals, fish, and fatty acid ratio of monounsaturated plus polyunsaturated fatty acids to saturated fatty acids, namely MUFA+PUFA: SFA), considered beneficial were assigned 1 if consumed at or above the median. Another 3 foods (meat, poultry, and dairy) considered detrimental were given a score of 1 for consumption below the median. For alcohol, a score of 1 was given to women who had intakes of between 5 and 25 g per day. Details are given in Supplementary Table 1. Thus, the total MeDi score ranges from a minimal adherence score of 0 to a maximal adherence score of 10, with higher scores indicating greater dietary adherence. Further the total MeDi score was divided into three groups: scores 0–3 (Low adherence), 4–6 (Moderate adherence), and 7–10 (High adherence).

2.4 Covariate assessment

Baseline socio-demographic information such as age, ethnicity, educational level, marital status, was undertaken by self-report. Body mass index (BMI) was calculated from self-reported height and weight by formula of "weight/height^2 (kg/m2)". Sleep duration (hours/day) was the weighted mean value calculated from self-reported sleep durations of weekdays and weekends. Socio-economic status (SES) was derived from the United Kingdom National Statistics-Socio-Economic Classification (NS-SEC), where participants are classified into three categories (routine/manual, intermediate, or managerial/professional) [36]. Due to overlapping properties among socioeconomic indicators (education, social class, income, or employment) [37], only SES was used as the adjustment factor in this study. Physical activity was assessed as self-reported time spent on activities vigorous enough to cause sweating or a faster heartbeat (hours/day).

A directed acyclic graph (DAG) was constructed using the online DAGitty tool (http://www.dagitty.net) to determine the minimally sufficient set of confounding adjustments for the exposure–outcome relationship [38]. Potential confounding variables including age, ethnicity (white, Asian, African, and others), SES, BMI, physical activity, sleep duration, smoking status (current, former, and non-smoker), alcohol consumption (g/day), and marital status (married or living as married, separated or divorced, single or widowed) were considered in the DAG. Actual or likely relationships between variables were based on a priori knowledge from the literature, and the minimally sufficient adjustment set was age, ethnicity, marital status, physical activity, SES, sleep duration, BMI, smoking status, and alcohol consumption (Supplementary Figure 1).

2.5 Statistical analysis

Characteristics such as demographics and dietary consumption were summarized. For continuous variables, the mean and standard deviation (SD) were displayed with Student's t-test for difference, while categorical variable characteristics were presented as percentages (%) with the chi-square test for difference. Nutrient intakes were adjusted for total energy using the nutrient density method [39] (for protein, carbohydrates, and fat, the percentage of total energy derived from each one; for other nutrients, the ratio of selected nutrient intake to per 1000 kcal (4186 kJ) of total energy intake). Each energy-adjusted intake of foods and nutrients was entered in a multiple logistic regression model with total energy intake as a covariate using the multivariate nutrient density method recommended by Willett et al [39]. Due to skewed distributions, the two reaction time variables were dichotomously categorized taking the median values as cut points; the fast groups (reaction time less than the median) were treated as the reference group, while the slow groups (reaction time equal to or above the median) were treated as the case group. Logistic regression models were conducted to identify potential associations between dietary intake, cooking methods and reaction ability. All analyses were conducted using Stata version 16.1 (StataCorp LLC, College Station, Texas). Values of $P < 0.05$ were considered to be statistically significant.

3. Results

Of 510 women with complete records, 1 participant with an unlikely fast choice reaction time (64 ms), 2 individuals with extremely high energy intake (6293 kcal/day that is 26 MJ/day, and 7780 kcal/day that is 33 MJ/day), and 4 participants with self-reported stroke history were excluded. Therefore, 503 women were considered eligible for analysis (Figure 1).

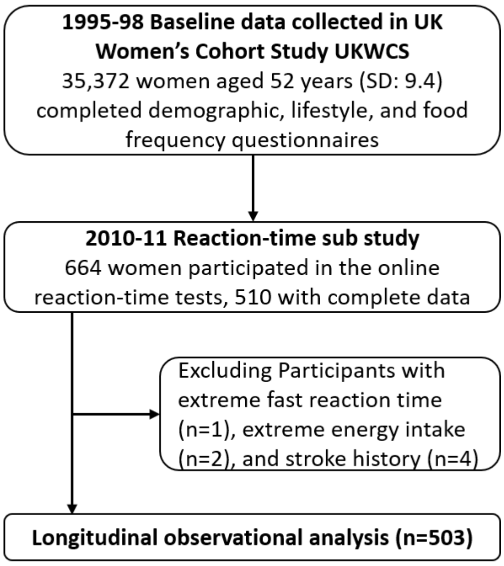

Figure 1 Flowchart of reaction-time study data collection and exclusion criteria

The characteristics of women who participated in the reaction-time sub-study are summarized in Table 1. Participants who took part in reaction time tests had a mean age of 62 years old (SD: 6.6). Simple reaction time and choice reaction time were categorized into the 'fast group' and the 'slow group'. Women in slow groups were significantly older and had lower educational levels than women in fast groups (64 vs 61 years old for both SRT and CRT; 35% vs 40% university degree for SRT; 34% vs 41% university degree for CRT). Among the women, 97% were white, 83% were married or living as married, 74% had a higher level of social economic status (Professional or managerial), 67% were non-smokers. The participants had a mean BMI of 23.5 kg/m^2, a mean sleep duration of 7.6 hours, and 0.25 hours per day of vigorous activities. With regard to alcohol consumption, 60% of the women drank less than once a day but more than once a month, while 20% consumed alcohol once a day or more and for the remaining 20% consumption was once a month or less.

There was no significant difference in daily consumption of energy-adjusted total meat, total fish, vegetables, and total energy intake, as well as energy-adjusted nutrients intake between fast groups and slow groups for both SRT and CRT (Table 2). In addition, multivariate logistic regressions showed that associations between these dietary exposures and reaction times were not statistically significant (Table 3).

As shown in Table 4, consumers of roasted/baked fish were 46% more likely to be in the slow SRT group (adjusted OR = 1.46, 95% CI: 1.00, 2.13). Consumers of fried vegetables were 64% more likely to be in the slow SRT group (adjusted OR = 1.64, 95% CI: 1.12, 2.39) with adjustment for confounding factors. However, the consumption of fish or vegetables cooked by any of these three methods did not change the risk of being in slow CRT groups. In addition, neither meat nor potato consumption cooked by any of these three methods changed the likelihood of being in slow groups for both SRT and CRT.

Adherence to Mediterranean diet (MeDi) and its association with reaction ability are summarized in Table 5. Most women included in this analysis had moderate adherence to the MeDi (53%) and the percentages of adherence among fast groups and slow groups for SRT and CRT were similar. Logistic regression results showed that SRT or CRT was not associated with adherence to the MeDi both in unadjusted and adjusted models.

4. Discussion

The prevalence of dementia in the general population aged 60 and over is 5-8% and this figure is expected to rise in coming decades [(40)]. There is an emerging awareness that women may disproportionately bear the burden of dementia almost globally compared with men [(41)]. Age is a strong risk factor for dementia and cognitive decline, and the average life expectancy worldwide is greater for women than men which makes dementia an important concern for women [(42)]. There are also sex-specific biological mechanisms that could possibly result in increased susceptibility of women to Alzheimer's dementia [(43)]. The present longitudinal observational analysis was conducted in a female-only cohort study; allowing exploration of dietary exposures and subsequent reaction ability in women for the first time.

Our results showed that consumption of meat, fish, vegetables and nutrient intakes in middle-aged women were not associated with reaction ability 10-15 years later. Compared with low adherence to the MeDi, moderate and high adherence did not influence the risk of being in the slow reaction-time groups. A similar longitudinal observational analysis however, suggested that adherence to the MeDi assessed 22 years previously was positively associated with cognitive function in the Health Professionals Follow-up Study, a prospective cohort study initiated in 1986 among 51,529 US men aged 40–75 years [(44)]. Although some evidence shows that there is a protective effect of the MeDi against cognitive decline, most studies focus on memory and attention which tends to be assessed by the mini-mental state examination (MMSE) [(45, 46)]. Few studies have been done on the associations between the MeDi and reaction time ability. A cross-sectional study involving 93 participants in Australia showed that the MeDi score did not differ significantly between the faster reaction time group and the slower reaction time group [(47)], consistent with our results.

Although in this study cooking methods of meat did not show effects on reaction times, the roasted/baked fish appeared to increase the risk of having a slow simple reaction time with adjustment for confounding factors. However, since both non-consumers and consumers of roasted/baked fish were likely meddled with those who may also have selected different cooking methods for fish, confounding bias might have occurred with this association and some caution should be exercised when interpreting these significant results. Oily fish is high in unsaturated fatty acids which could be reduced during the long-lasting and high-temperature cooking process required for roasting/baking. Unsaturated fatty acids such as n-3 fatty acids are associated with better global cognition [(9)]. Therefore, oxidation of unsaturated fatty acids could be the potential reason that roasted/baked fish increased the risk of having a slow simple reaction time. In addition, fried vegetables were also associated with a slower simple reaction time. This could be due to acrylamide produced in carbohydrate-rich food during frying, another high-temperature cooking process [(18, 19)]. However, fried potatoes, a carbohydrate-rich food, did not show a similar negative association with reaction times. Potential mechanisms why only roasted/baked fish and fried vegetables had detrimental effects on simple reaction time are unclear and similar studies are limited; more evidence needs be provided from other populations including cooking methods.

Strengths of this study include its novelty to explore effects of cooking methods on cognitive function, the longitudinal design, and a fully adjusted regression model. The exploration of frequencies of cooking methods is novel in relation to health-related outcomes, and has not been conducted in other studies to date. There is a possibility that these frequencies might be under- or over-reported. These potential measurement errors could reduce the power to detect real associations between dietary exposures and reaction ability; therefore, results should be interpreted with caution. Moreover, as an observational study causality cannot be established and potential confounding bias is always a possibility.

Our study is also limited that we did not include any assessment of nutritional supplement use resulting in underestimation of nutrient intakes; we have also not taken into account other diet quality indices apart from the Mediterranean diet in our analyses. It may be that combinations of nutrients and foods is more comprehensive than individual nutrients in relation to reaction times. In addition, most studies on the prevalence of dementia focus on people aged over 65 years; for those aged 45–64, the prevalence is relatively low at 98 per 100,000 [(48)]. The mean age of women who took part in the reaction time tests may be not old enough to show changes of reaction ability.

Overall, our study indicates no associations between reaction ability and consumption of total meat, fish, vegetables, energy-adjusted nutrient intakes, and Mediterranean diet. However, there was a suggestion that foods cooked by specific methods may be related to reaction ability. This needs further exploration in additional studies.

Acknowledgements

We thank the participants of the UK Women's Cohort Study for the provision of the data, the cohort team members who contributed to data collection, Mr. Gareth Hagger-Johnson for carrying out reaction time tests, and Mr. Neil Hancock for his contributions to data management and technical assistance for the cohort.

Financial Support

HZ received funding from the China Council Scholarship (CSC ID: 201806010423). The UK Women's Cohort was supported by funding from the World Cancer Research Fund (to JEC). The funders of CSC and the World Cancer Research Fund had no role in the design, analysis or writing of this article.

The authors declare that this work had no commercial or not-for-profit sectors involved.

Conflict of interest

None

Authorship

All authors were involved in the study conception and design. HZ contributed to the data analysis and wrote the manuscript. All authors did interpretation of findings, editing and approving the final manuscript.

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Table 1 Demographic characteristics of participants between fast groups and slow groups for simple and choice reaction times

		Simple Reaction Time			Choice Reaction Time			Total
		Fast group (N=252)	Slow group (N=251)	*P*	Fast group (N=252)	Slow group (N=251)	*P*	(N=503)
Age (years)	Mean (SD)	61 (5.9)	64 (7.1)	<0.001	61 (5.7)	64 (7.2)	<0.001	62 (6.6)
Ethnicity (%)	white	98.4	96.4	0.114	98.4	96.4	0.200	97.4
	Asian	0.4	0.0		0.0	0.4		0.2
	other	1.2	3.6		1.6	3.2		2.4
Educational Level (%)	No qualifications	2.8	9.9	0.009	3.2	9.6	0.023	6.3
	O-level or equivalent	30.6	28.6		29.2	29.9		29.6
	A-level or equivalent	26.6	27.0		26.9	26.7		26.8
	University degree	40.0	34.5		40.7	33.9		37.3
Marital status (%)	Married or living as married	85.7	81.0	0.341	87.0	79.7	0.083	83.3
	Separated or divorced	6.0	8.3		5.1	9.2		7.1
	Single or widowed	8.3	10.7		7.9	11.2		9.5
Socio-economic status (SES) (%)	Routine and manual	4.4	4.4	0.109	4.0	4.8	0.876	4.4
	Intermediate	17.4	25.0		21.7	20.7		21.2
	Professional and managerial	78.2	70.6		74.3	74.5		74.4
Daily exercise (h)	Mean (SD)	0.24 (0.4)	0.27 (0.4)	0.386	0.23 (0.3)	0.28 (0.5)	0.153	0.25 (0.4)
BMI (kg/m^2)	Mean (SD)	23.5 (3.8)	23.5 (3.3)	0.976	23.5 (3.6)	23.6 (3.6)	0.777	23.5 (3.6)
Sleep duration (h)	Mean (SD)	7.6 (0.9)	7.6 (0.9)	0.535	7.7 (0.9)	7.5 (0.9)	0.070	7.6 (0.9)
Smoking status (%)	Never	68.6	66.3	0.817	66.4	68.5	0.708	67.5
	Former	26.2	28.6		28.9	25.9		27.4
	Current	5.2	5.1		4.7	5.6		5.1
Alcohol (%)	Once a month or less	20.6	19.9	0.843	16.2	24.3	0.043	20.2
	Less than daily	60.7	59.5		61.3	59.0		60.1
	Once a day or more	18.7	20.6		22.5	16.7		19.7

Table 2 Profiles of main foods and nutrients intake comparing women with fast and slow reaction time SFAs, saturated fatty acids; PUFAs, polyunsaturated fatty acids; MUFAs, monounsaturated fatty acids.

		Simple Reaction Time				**Choice Reaction Time**				**Total**
		Fast group (N=252)	Slow group (N=251)	Difference (95% CI)	*P*	Fast group (N=252)	Slow group (N=251)	Difference (95% CI)	*P*	(N=503)
Main foods: Mean (SD)										
Total meat	(g/day)	57 (67)	58 (58)	-0.5 (-11, 10)	0.933	60 (64)	55 (60)	5 (-6, 16)	0.354	58 (62)
Total fish	(g/day)	23 (23)	25 (21)	-2 (-6, 2)	0.272	25 (23)	23 (22)	2 (-2, 6)	0.357	24 (22)
Vegetables	(g/day)	307 (169)	312 (159)	-5, (-34, 24)	0.724	310 (164)	309 (164)	1 (-27, 30)	0.923	310 (164)
Nutrients intake: Mean (SD)										
Energy intake	(kcal/day)	2326 (614)	2343 (676)	-17 (-130, 96)	0.770	2375 (601)	2293 (685)	82 (-31, 195)	0.154	2334 (645)
	(MJ/day)	10 (3)	10 (3)	0 (-0.5, 0.5)	0.770	10 (3)	10 (3)	0 (-0, 1)	0.154	10 (3)
Protein	(g/day)	86 (27)	88 (26)	-2 (-6, 3)	0.446	89 (25)	85 (27)	3 (-1, 8)	0.174	87 (26)
	(%energy)	15 (3)	15 (3)	-0.3 (-0.8, 0.1)	0.175	15 (3)	15 (3)	0 (-0.5, 0.5)	0.981	15 (3)
Carbohydrate	(g/day)	311 (93)	309 (99)	3 (-14, 19)	0.759	314 (88)	306 (103)	7 (-9, 24)	0.380	310 (96)
	(%energy)	54 (7)	53 (7)	1 (-0.4, 2)	0.183	53 (7)	53 (7)	-0.2 (-2, 1)	0.703	53 (7)
Fat	(g/day)	84 (29)	87 (31)	-2 (-8, 3)	0.391	88 (30)	83 (30)	4 (-1, 10)	0.104	85 (30)
	(%energy)	32 (6)	33 (6)	-1 (-2, 0.5)	0.258	33 (6)	33 (6)	0.2 (-1, 1)	0.740	33 (6)
SFAs	(g/day)	29 (13)	30 (13)	-1 (-3, 1)	0.476	30 (13)	29 (13)	1 (-1, 3)	0.330	30 (13)
	(%energy)	11 (3)	11 (3)	-0.2 (-1, 0.4)	0.451	11 (3)	11 (3)	-0.1 (-1, 1)	0.853	11 (3)
PUFAs	(g/day)	16 (6)	17 (6)	-0.3 (-1, 1)	0.556	17 (6)	16 (6)	1 (0, 2)	0.029	16 (6)
	(%energy)	6 (2)	6 (2)	-0.1 (-0.4, 0.2)	0.514	6 (2)	6 (2)	0.1 (-0.2, 0.5)	0.357	6 (2)
MUFAs	(g/day)	28 (10)	28 (11)	-1 (-2, 1)	0.463	29 (10)	27 (10)	2 (-0.2, 3)	0.081	28 (10)
	(%energy)	11 (3)	11 (2)	-0.2 (-1, 0.3)	0.509	11 (2)	11 (3)	0.1 (-0.4, 0.5)	0.711	11 (3)
Vitamin C	(mg/k kcal)	74 (33)	73 (32)	1 (-5, 6)	0.822	72 (32)	75 (33)	-3 (-9, 2)	0.254	73 (33)
Vitamin B1	(ug/k kcal)	1281 (810)	1228 (634)	53 (-74, 180)	0.414	1294 (842)	1215 (588)	79 (-48, 206)	0.224	1255 (727)
Vitamin B2	(ug/k kcal)	1075 (289)	1100 (254)	-25 (-72, 23)	0.314	1086 (275)	1088 (271)	-3 (-50, 45)	0.918	1087 (273)
Vitamin B6	(ug/k kcal)	1176 (264)	1171 (223)	4 (-38, 47)	0.839	1172 (254)	1175 (235)	-4 (-46, 39)	0.871	1173 (244)
Vitamin B12	(ug/k kcal)	2 (1)	2 (1)	-0.1 (-0.3, 0.1)	0.154	2 (1)	2 (1)	0 (-0.2, 0.2)	0.908	2 (1)
Folate	(ug/k kcal)	170 (39)	172 (40)	-2 (-9, 5)	0.608	169 (41)	172 (37)	-3 (-10, 4)	0.366	171 (39)
Vitamin A	(ug/k kcal)	392 (179)	416 (188)	-23 (-55, 9)	0.156	392 (178)	416 (189)	-24 (-56, 8)	0.146	404 (184)
Vitamin D	(ug/k kcal)	1 (1)	1 (1)	0 (-0.1, 0.1)	0.763	1 (1)	1 (1)	0.1 (-0.1, 0.2)	0.351	1 (1)
Vitamin E	(ug/k kcal)	4135(1380)	4287(1266)	-152 (-384, 80)	0.199	4249(1244)	4173(1403)	77 (-156, 309)	0.517	4211(1325)
Calcium	(mg/k kcal)	486 (116)	505 (131)	-20 (-41, 2)	0.074	488 (114)	503 (132)	-14 (-36, 7)	0.196	496 (124)
Iron	(mg/k kcal)	8 (3)	8 (2)	0.3 (-0.2, 1)	0.238	8 (2)	8 (2)	-0.1 (-1, 0.3)	0.605	8 (2)
Zinc	(mg/k kcal)	5 (1)	5 (1)	-0.1 (-0.2, 0.1)	0.494	5 (1)	5 (1)	0 (-0.2, 0.2)	0.856	5 (1)

Table 3 Associations of main foods and energy-adjusted nutrient intakes with reaction times SFAs, saturated fatty acids; PUFAs, polyunsaturated fatty acids; MUFAs, monounsaturated fatty acids.

		Simple Reaction Time OR (95%CI)			Choice Reaction Time OR (95%CI)		
		Unadjusted	Adjusted*	*P**	Unadjusted	Adjusted*	*P**
Main foods (OR, 95%CI)							
Total meat	per g/1000kcal	1.00 (0.93, 1.07)	0.98 (0.91, 1.06)	0.634	0.98 (0.91, 1.05)	0.99 (0.91, 1.07)	0.746
Total fish	per g/1000kcal	1.15 (0.95, 1.38)	1.11 (0.91, 1.34)	0.306	0.99 (0.82, 1.19)	0.96 (0.79, 1.17)	0.685
Vegetables	per g/1000kcal	1.01 (0.99, 1.04)	1.01 (0.98, 1.04)	0.458	1.01 (0.99, 1.04)	1.00 (0.98, 1.03)	0.742
Nutrient consumption (OR, 95%CI)							
Energy intake	per 1000kcal	1.04 (0.79, 1.37)	1.10 (0.83, 1.47)	0.501	0.82 (0.62, 1.08)	0.87 (0.65, 1.17)	0.360
Protein	per %energy	1.05 (0.98, 1.12)	1.04 (0.97, 1.12)	0.276	1.00 (0.94, 1.07)	0.99 (0.92, 1.06)	0.770
Carbohydrate	per %energy	0.98 (0.96, 1.01)	0.98 (0.95, 1.01)	0.130	1.00 (0.98, 1.03)	1.00 (0.97, 1.03)	0.801
Fat	per %energy	1.02 (0.99, 1.05)	1.02 (0.99, 1.05)	0.217	1.00 (0.97, 1.02)	1.01 (0.98, 1.04)	0.690
SFAs	per %energy	1.02 (0.97, 1.08)	1.02 (0.97, 1.08)	0.428	1.01 (0.95, 1.06)	1.03 (0.97, 1.09)	0.305
PUFAs	per %energy	1.03 (0.94, 1.14)	1.05 (0.95, 1.16)	0.374	0.95 (0.87, 1.05)	0.96 (0.87, 1.06)	0.443
MUFAs	per %energy	1.02 (0.96, 1.10)	1.03 (0.96, 1.11)	0.430	0.99 (0.92, 1.06)	1.01 (0.94, 1.08)	0.807
Vitamin C	per mg/1000kcal	1.00 (0.99, 1.00)	1.00 (0.99, 1.00)	0.741	1.00 (1.00, 1.01)	1.00 (0.99, 1.01)	0.842
Vitamin B1	per µg/1000kcal	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.819	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.300
Vitamin B2	per µg/1000kcal	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.294	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.773
Vitamin B6	per µg/1000kcal	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.845	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.549
Vitamin B12	per µg/1000kcal	1.12 (0.96, 1.31)	1.09 (0.92, 1.30)	0.304	0.99 (0.85, 1.16)	0.97 (0.82, 1.15)	0.728
Folate	per µg/1000kcal	1.00 (1.00, 1.01)	1.00 (1.00, 1.01)	0.460	1.00 (1.00, 1.01)	1.00 (1.00, 1.01)	0.826
Vitamin A	per µg/1000kcal	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.308	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.398
Vitamin D	per µg/1000kcal	1.04 (0.79, 1.37)	0.97 (0.73, 1.29)	0.832	0.88 (0.67, 1.15)	0.86 (0.64, 1.15)	0.310
Vitamin E	per µg/1000kcal	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0169	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.401
Calcium	per mg/1000kcal	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.111	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.489
Iron	per mg/1000kcal	0.96 (0.89, 1.03)	0.95 (0.88, 1.03)	0.225	1.02 (0.95, 1.10)	1.00 (0.93, 1.08)	0.966
Zinc	per mg/1000kcal	1.07 (0.89,1.28)	1.02 (0.84, 1.23)	0.876	1.02 (0.85, 1.22)	0.96 (0.79, 1.17)	0.693

* Adjusted for age, ethnicity, marital status, socioeconomic status, physical activity, body mass index, sleep duration, smoking status, alcohol consumption, and total energy intake

Table 4 Comparison of reaction times between consumers and non-consumers of specific foods cooked by roasting/baking, frying, and BBQ/grilling

	N of Consumers	**N of Non-consumers**	**Simple Reaction Time OR (95%CI)**			**Choice Reaction Time OR (95%CI)**		
			Unadjusted	Adjusted*	*P**	Unadjusted	Adjusted*	*P**
Roasted/Baked meat	292	211	1.11 (0.78, 1.59)	1.05 (0.68, 1.61)	0.824	0.89 (0.62, 1.26)	0.89 (0.57, 1.37)	0.586
Fried meat	123	380	1.22 (0.81, 1.83)	1.11 (0.71, 1.74)	0.637	0.94 (0.63, 1.42)	0.91 (0.58, 1.42)	0.669
BBQ'd/Grilled meat	273	230	0.99 (0.70, 1.41)	0.95 (0.63, 1.45)	0.819	1.03 (0.72, 1.46)	1.13 (0.74, 1.73)	0.570
Roasted/Baked fish	271	232	1.51 (1.06, 2.14)	1.46 (1.00, 2.13)	0.049	1.06 (0.75, 1.50)	0.99 (0.68, 1.45)	0.953
Fried fish	144	359	1.27 (0.86, 1.87)	1.12 (0.75, 1.69)	0.579	0.93 (0.63, 1.37)	0.85 (0.56, 1.29)	0.451
BBQ'd/Grilled fish	239	264	1.28 (0.90, 1.82)	1.35 (0.93, 1.96)	0.118	0.93 (0.66, 1.32)	0.97 (0.66, 1.41)	0.863
Roasted/Baked vegetables	338	165	1.21 (0.84, 1.76)	1.29 (0.87, 1.93)	0.205	1.17 (0.81, 1.70)	1.27 (0.85, 1.91)	0.240
Fried vegetables	206	297	1.55 (1.08, 2.21)	1.64 (1.12, 2.39)	0.010	0.88 (0.62, 1.26)	0.95 (0.65, 1.38)	0.787
BBQ'd/Grilled vegetables	216	287	0.88 (0.62, 1.26)	0.92 (0.63, 1.35)	0.680	0.83 (0.58, 1.18)	0.88 (0.60, 1.29)	0.505
Roasted/Baked potatoes	444	59	0.76 (0.44, 1.31)	0.87 (0.48, 1.57)	0.635	1.03 (0.60, 1.78)	1.37 (0.74, 2.51)	0.312
Fried potatoes	219	284	1.16 (0.82, 1.66)	1.16 (0.79, 1.69)	0.445	0.74 (0.52, 1.05)	0.76 (0.52, 1.11)	0.150
BBQ'd/Grilled potatoes	67	436	1.19 (0.71, 2.00)	1.21 (0.70, 2.08)	0.494	1.19 (0.71, 2.00)	1.18 (0.68, 2.04)	0.560

*Adjusted for age, ethnicity, marital status, socioeconomic status, physical activity, body mass index, sleep duration, smoking status, alcohol consumption, and total energy intake

Table 5 Adherence to Mediterranean diet and its associations with reaction times

		Mediterranean diet			Total
		Low adherence	Moderate adherence	High adherence	
N of Participants (%)		117 (23.2)	265 (52.7)	121 (24.1)	503 (100)
Simple reaction time					
	Fast group (N, %)	60 (23.8)	126 (50.0)	66 (26.2)	252 (100)
	Slow group (N, %)	57 (22.7)	139 (55.4)	55 (21.9)	251 (100)
Choice reaction time					
	Fast group (N, %)	54 (21.4)	138 (54.8)	60 (23.8)	252 (100)
	Slow group (N, %)	63 (25.1)	127 (50.6)	61 (24.3)	251 (100)
Odds Ratio (Slow group vs. Fast group)					***P* trend**†
Simple reaction time					
	Unadjusted	ref	1.16 (0.75, 1.79)	0.88 (0.53, 1.46)	0.944
	Adjusted*	ref	1.34 (0.83, 2.17)	0.94 (0.52, 1.70)	0.222
Choice reaction time					
	Unadjusted	ref	0.79 (0.51, 1.22)	0.87 (0.52, 1.45)	0.724
	Adjusted*	ref	0.83 (0.51, 1.35)	0.83 (0.45, 1.51)	0.739

* Adjusted age, ethnicity, marital status, socioeconomic status, physical activity, body mass index, sleep duration, smoking status, alcohol consumption, and total energy intake; † tests for linear trend of adherence to the Mediterranean diet in relation to reaction times.