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Dietary intake of n-3, n-6 fatty acids and fish: Relationship with hostility in young adults—the CARDIA study

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Background: Hostility has been shown to predict both the development and manifestation of coronary disease. Examining the inter-relation of dietary intake of fish and of polyunsaturated (n-3 and n-6) essential fatty acids with hostility may provide additional insights into the cardioprotective effect of dietary fish and polyunsaturated fatty acids.
Objective: To examine the association of dietary n-3, n-6 fatty acids and fish with level of hostility in a sample of 3581 urban white and black young adults.
Design: Cross-sectional observational study as part of an ongoing cohort study. A dietary assessment in 1992–1993 and measurement of hostility and other covariates in 1990–1991 were used in the analysis.
Results: The multivariate odds ratios of scoring in the upper quartile of hostility (adjusting for age, sex, race, field center, educational attainment, marital status, body mass index, smoking, alcohol consumption and physical activity) associated with one standard deviation increase in docosahexaenoic acid (DHA, 22:6) intake was 0.90 (95% CI = 0.82–0.98; $P = 0.02$). Consumption of any fish rich in n-3 fatty acids, compared to no consumption, was also independently associated with lower odds of high hostility (OR = 0.82; 95% CI = 0.69–0.97; $P = 0.02$).
Conclusions: These results suggest that high dietary intake of DHA and consumption of fish rich in n-3 fatty acids may be related to lower likelihood of high hostility in young adulthood. The association between dietary n-3 fatty acids and hostile personality merits further research.
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Keywords: dietary n-3 fatty acids; dietary n-6 fatty acids; fish consumption; hostility; young adults

Background

A growing body of literature supports a protective role of fish intake and of essential dietary long-chain polyunsaturated fatty acids in cardiovascular disease (Dolecek & Granditis, 1991; Ascherio *et al*, 1995; Daviglus *et al*, 1997; Hopper *et al*, 1999; Oomen *et al*, 2000; Rissanen *et al*, 2000; Hallgren *et al*, 2001; Iso *et al*, 2001; Yuan *et al*, 2001) including a reduction of the risk of sudden cardiac death (Siscovick *et al*, 1995; Albert *et al*, 1998). There are several potential mechanisms for this protection including antithrombotic (Kristensen *et al*, 1989; Prisco *et al*, 1995) and anti-arrhythmic effects (Marchioli *et al*, 2002), decreased heart rate variability (Christensen *et al*, 1997) and resting blood pressure (Knapp, 1989), decreased serum LDL cholesterol and triglyceride concentrations (Agren *et al*, 1996) and increased insulin sensitivity (Torjesen *et al*, 1997; Mori *et al*, 1999). Other plausible but less-explored mechanisms by which dietary fish or n-3 polyunsaturated fatty acids may be beneficial for cardiovascular health are favorable effects on endothelial function (Abeywardena & Head, 2001), anti-inflammatory effects (Madsen *et al*, 2001) as well as neuroendocrine influences including modulation of the hypothalamic–pituitary–adrenocortical axis activity (Wang *et al*, 1999).

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Essential polyunsaturated fatty acids are classified into two families, the n-3 and the n-6 families. The former contains an unsaturated bond at the third carbon, the later at the sixth carbon from the methyl end. The n-3 family includes α-linolenic acid (18:3), eicosapentaenoic acid (EPA, 20:5) and docosahexaenoic acid (DHA, 22:6). DHA is the major polyunsaturated fatty acid in the adult mammalian brain (Anderson *et al*, 1990; Green & Yavin, 1998; Innis, 2000) and is selectively concentrated at synaptic neuronal membranes (Innis, 2000). DHA and EPA are present in fatty fish (salmon, tuna, mackerel), although it can be obtained from n-3-enriched eggs (Lewis *et al*, 2000).

α-linolenic acid, which desaturates and elongates in humans to EPA and DHA, is found in green leafy vegetables, flaxseed, rapeseed, walnuts and vegetable oils, principally soybean and canola (Kris-Etherton *et al*, 2000).

The n-6 family includes linoleic acid (18:2) and arachidonic acid (20:4). Unlike the n-3 fatty acids, the role of dietary n-6 polyunsaturated fatty acids in the pathogenesis of atherosclerosis is equivocal. Some animal studies have shown that n-6-enriched diets result in decreased atherosclerosis (George *et al*, 2000) and several epidemiological studies have found that linoleic acid in the adipose tissue is inversely related to the risk of coronary heart disease (Wood *et al*, 1987; Tavendale *et al*, 1992). However, other reports indicate that n-6 fatty acids may decrease HDL concentration (Hodson *et al*, 2001), increase oxidative stress (Hanaoka *et al*, 2002) and thus potentially enhance atherosclerosis.

Hostility, along with other psychosocial factors like depression, anxiety and chronic life stress, has been shown to be associated with heightened sympathetic tone (Suarez *et al*, 1998) and with increased risk of clinical (Koskenvuo *et al*, 1988; Barefoot *et al*, 1995; Everson *et al*, 1997) and subclinical (Iribarren *et al*, 2000) cardiovascular disease. This evidence is reinforced by behavioral interventions to reduce hostility demonstrating benefit over and above usual medical care among patients with evidence of myocardial ischemia (Williams & Littman, 1996; Blumenthal *et al*, 1997).

The inter-relation between dietary fish intake, and n-3 and n-6 fatty acid consumption and cardiovascular disease on the one hand and between hostility and cardiovascular disease on the other, coupled with the known physiological importance of n-3 fatty acids in neurodevelopment (Carlson & Neuringer, 1999), raise the possibility that at least part of the beneficial effect of dietary fish intake or n-3 fatty acid consumption on cardiovascular disease may be mediated through amelioration of hostility. In this paper, we examine the association between dietary fish intake and consumption of n-3 and n-6 fatty acids with hostility among a large sample of US urban young adults. Since there is evidence that not only the individual consumption but also the balance of consumption of n-3 and n-6 fatty acids may be important (Gudbjarnason *et al*, 1991; Simopoulos, 1999), we also examined the ratio of all n-6 to all n-3 fatty acids. The central hypothesis is that hostility scores would be lower in CARDIA subjects with greater intake of n-3 and n-6 fatty acids and greater intake of fish rich in n-3 fatty acids.

Participants and methods

Cohort description and procedures

CARDIA is a longitudinal investigation of heart disease risk factors and subclinical coronary disease in a population of black and white men and women who were aged 18–30 y at baseline in 1985–86. Participants were recruited by random-digit dialing in Birmingham, Alabama; Chicago, IL; and Minneapolis, MN (where door-to-door recruitment was also used in areas with low telephone subscription), and at random from the membership files of the Kaiser Permanente Medical Care Program in Oakland, CA. The sampling scheme ensured a cohort evenly balanced by race (black *vs* white), sex, age (18–24 *vs* 25–30) and educational attainment (high school or less *vs* more than high school). More details of study design, recruitment and procedures have been published before (Hughes *et al*, 1987; Friedman *et al*, 1988). The baseline examination ($n = 5115$) was completed in 1985–86. Subsequent re-examinations have taken place at years 2 (1987–1988), 5 (1990–1991), 7 (1992–1993), 10 (1995–1996) and 15 (2000–2001), with high retention rates (86% at year 5, 79% at year 10 and 73% at year 15).

Each participant completed at year 7 a diet history questionnaire, which utilized food models and measuring cups and spoons, to help estimate portion sizes (McDonald *et al*, 1991; Liu *et al*, 1994). The month prior to each clinic visit was used as a frame of reference for estimating usual intake. Daily nutrient intakes were estimated (without consideration of n-3 fatty acid supplements) by translating the precoded CARDIA diet history using the database developed by the Nutrition Coordinating Center at the University of Minnesota. The intake of n-3 and n-6 fatty acids and alcohol were expressed as nutrient density (kcal/1000 kcal/day). We applied minimum and maximum cutoffs of total energy to account for under-reporting or over-reporting below and above levels compatible with normal lifestyle (500–6000 kcal in women and 500–8000 kcal in men) (Goldberg *et al*, 1991). Intake of total fish and of fish rich in n-3 fatty acids (ie, salmon, mackerel, trout, herring, eel and cod) was coded as average eating occasions/week. The mean number of eating occasions/week was used in the analysis. Quality control data pertaining to the CARDIA diet history questionnaire have been published elsewhere (Hilner *et al*, 1992).

The rest of the covariates of interest in this study, including hostility, were measured at year 5. Hostility is a personality and character trait with attitudinal (cynicism and mistrust of others), emotional (anger) and behavioral (overt and repressed aggression) components, and was measured using the Cook–Medley Scale (Cook & Medley, 1995) with scores ranging from 0 to 50 (low to high).

Body weight was measured in light clothing to the nearest 0.2 lb using a standard balance beam scale, and height was measured to the nearest 0.5 cm using a metal ruler mounted on the wall. Body mass index was calculated as weight/height^2 (kg/m^2). Habitual physical activity was measured by the Baecke questionnaire, which yields three scores corresponding to three domains: leisure time, sports and work (Baecke *et al*, 1982). Test–retest reliability of these three scores has been shown to be adequate (Baecke *et al*, 1982). Tobacco use was ascertained with interviewer-administered questionnaires detailing each participant's smoking history. Education attainment, marital and employment statuses were ascertained by self-report.

Statistical methods

Since several of the dietary variables were not normally distributed (n-3 and n-6 fatty acids, alcohol intake, total fish and n-3 fish intake), the rank-order Spearman's correlation coefficient was employed to assess unadjusted associations among continuous variables. Both linear and nonlinear trends were investigated by plotting intake of n-3 and n-6 fatty acids, and fish consumption against hostility scores and by fitting linear and quadratic regression models.

Multiple logistic regression was used to estimate the independent likelihood of scoring in the sex and race-specific upper quartile of hostility as a function of a (sex- and race-specific) 1 standard deviation increase in each of the nutrient densities of interest. For the analysis of dietary intake of all types of fish and of fish rich in n-3 fatty acids, we used the following categories (according to average eating occasions/week): 0, >0 but less than 2, and ≥ 2; and 0, >0 but less than 1, and ≥ 1, respectively. These categories were chosen because the 2000 American Heart Association dietary recommendations included consumption of fish at least twice per week (Krauss *et al*, 2001). Covariates included age, sex, race, field center (Birmingham, Chicago, Oakland, relative to Minneapolis), body mass index, the three Baecke indices of physical activity (leisure time, sports and work), cigarette smoking status (never, former, current), educational attainment (elementary, junior high or high school, at least some college and graduate school), marital status (single, married, separated/divorced and widowed) and employment status (employed, unemployed). To assess differential associations between the dietary variables and hostility by sex or race, multiplicative tests for interaction were performed while adjusting for covariates. No statistically significant interactions were found (all $P > 0.11$); thus the results of the logistic regression analysis are presented combining sex and race groups.

The number of CARDIA participants with complete data on hostility at year 5 and dietary variables at year 7 were 672 black men, 967 black women, 925 white men and 1017 white women.

Results

Descriptive statistics among cohort participants are given in Table 1. Except for consumption of all types of fish as a continuous variable, there was significant heterogeneity across sex/race categories in all study variables. The mean hostility score was higher in black men, followed by black women, white men and white women. Total energy intake was highest in black men, followed by white men, black women and white women. Intake of both linoleic and α-linolenic acid was highest in black women, lowest in white women and intermediate among men. Dietary intake of arachidonic acid was highest in black men and lowest in white women; intake of EPA and DHA was higher in black than in white subjects. The ratio of n-6 to n-3 fatty acid consumption was slightly lower in white women. Alcohol intake was higher among men than women, and higher in white women than in black women. While there were no differences in the intake of all types of fish across sex–race groups, intake of fish rich in n-3 fatty acids was higher in black than in white subjects.

Black women, on average, had the highest body mass index and white women the lowest. The proportion of current smokers and the prevalence of unemployment were higher, whereas educational attainment and the proportion of married people were lower in black compared to white subjects. Leisure time, sports and work-related activity was highest in white women, white men and black men, respectively.

In bivariate analysis, total energy was consistently and positively correlated with hostility across sex–race groups, with correlation coefficients ranging from 0.19 in black men to 0.07 in white women (Table 2). α-Linolenic acid was negatively correlated with hostility among black men. Dietary intake of EPA (among black subjects) as well as DHA, linoleic acid, all n-6 fatty acids and of fish rich in n-3 fatty acids (among black men) also had an inverse correlation with the level of hostility. On the other hand, the ratio of n-6 to n-3 fatty acids was uncorrelated with hostility across sex–race groups. Alcohol intake was significantly and positively correlated with hostility in black but not in white subjects.

Dietary intake of fish rich in n-3 fatty acids (expressed in eating occasions/week) was positively correlated with EPA and DHA intake, respectively, consistently across sex–race groups, with correlations ranging from 0.60 for DHA intake among white men to 0.70 for EPA intake among black men (data not shown). Conversely, it was negatively correlated with the ratio of n-6 to n-3 fatty acids (ranging from −0.08 in black men to −0.24 in white men).

Table 3 summarizes the results of the multiple logistic regression analysis. High hostility, the dependent variable, was defined as scoring above the 75th percentile of the Cook–Medley scale in each sex and race group. Total energy and alcohol consumption were significantly and positively associated with high hostility (P-trend $= 0.0001$ and 0.02, respectively): a 1 s.d. increase in total energy was associated

Table 1 Descriptive cohort characteristics, by sex and race groups

	Black men (n=672)	*Black women (n=967)*	*White men (n=925)*	*White women (n=1017)*	P*
		Mean (s.d.) or %			
Age (y)	29.4 (3.7)	29.6 (3.8)	30.5 (3.3)	30.6 (3.4)	0.0001
Cook–Medley hostility score	20.9 (8.1)	18.5 (7.6)	15.3 (7.0)	13.4 (6.5)	0.0001
Total energy (kcal)†	3,664 (1,590)	2,496 (1,098)	3,178 (1,171)	2,243 (797)	0.0001
α-linolenic acid (kcal/1000 kcal)	6.53 (2.38)	6.60 (2.22)	6.13 (2.02)	5.88 (2.16)	0.0001
EPA (kcal/1000 kcal)	0.17 (0.26)	0.17 (0.22)	0.14 (0.20)	0.15 (0.17)	0.0006
DHA (kcal/1000 kcal)	0.33 (0.34)	0.34 (0.31)	0.25 (0.30)	0.25 (0.22)	0.0001
All n-3 fatty acids (kcal/1000 kcal)	7.03 (2.48)	7.11 (2.30)	6.53 (2.11)	6.28 (2.20)	0.0001
Linoleic acid (kcal/1000 kcal)	67.8 (22.0)	69.7 (23.8)	64.1 (21.3)	59.2 (20.3)	0.0001
Arachidonic acid (kcal/1000 kcal)	0.72 (0.28)	0.67 (0.27)	0.53 (0.22)	0.49 (0.22)	0.0001
All n-6 fatty acids (kcal/1000 kcal)	68.5 (22.0)	70.3 (23.9)	64.6 (21.3)	59.7 (20.3)	0.0001
Ratio n-6/n-3 fatty acids	10.1 (2.9)	10.3 (3.7)	10.2 (2.9)	9.8 (3.0)	0.01
Alcohol (kcal/1000 kcal)	29.8 (46.0)	15.6 (32.2)	30.0 (38.4)	22.1 (34.5)	0.0001
All fish (eating occasions/week)	1.4 (1.3)	1.4 (1.2)	1.5 (1.3)	1.4 (1.1)	0.39
0	5	3	3	5	0.03
>0 but <2	72	76	72	73	
⩾2	23	21	25	22	
n-3 fish (eating occasions/week)	0.6 (0.9)	0.6 (0.8)	0.5 (0.7)	0.4 (0.6)	0.0001
0	31	33	37	40	0.001
>0 but <1	46	50	49	49	
⩾1	23	17	14	11	
Body mass index (kg/m^2)	26.7 (5.3)	28.1 (7.3)	25.5 (4.0)	24.3 (5.2)	0.0001
Leisure time activity index	2.5 (0.7)	2.5 (0.7)	2.6 (0.7)	2.8 (0.6)	0.0001
Sports activity index	3.0 (0.8)	2.4 (0.7)	3.1 (0.8)	2.9 (0.8)	0.0001
Work activity index	2.8 (0.9)	2.4 (0.9)	2.6 (0.8)	2.5 (0.8)	0.0001
Cigarette smoking					0.001
Never	57	60	61	55	
Former	8	9	16	23	
Current	35	31	23	22	
Education level					0.001
Elem., Jr high or high school	44	37	20	20	
At least some college or college	49	58	56	56	
Graduate school	7	5	24	24	
Marital status					0.001
Single	52	48	48	40	
Married	35	32	45	50	
Separated/divorced	12	19	6	9	
Widowed	0.5	1	0.1	0.5	
Unemployed	24	21	11	14	0.001

The CARDIA Study, 1990–1991.
*For contrasting sex/race groups using ANOVA for continuous variables and χ^2 tests for proportions.
†All dietary variables are from the year 7 exam (1992–1993).

with 1.25 times higher odds of high hostility, whereas a 1 s.d. increase in alcohol was associated with 1.09 times higher odds of high hostility. There was a significant inverse trend of high hostility with increasing intake of DHA (P-trend = 0.02): a 1 s.d. increase in DHA intake was associated with 0.90 times lower odds of high hostility. Any consumption and more than zero but less than one eating occasions of fish rich in n-3 fatty acids, compared to no consumption, was significantly associated with 0.82 and 0.81 times lower odds of high hostility, respectively. One or more eating occasions of fish rich in n-3 fatty acids was associated with nonsignificant 0.83 times lower odds of high hostility. We also conducted additional logistic regression models adjusting simultaneously for EPA and DHA. The odds of high hostility remained low for DHA (0.50) and became high for EPA (1.58). However, there were significant collinearity, so we do not show these analyses in our table.

In a multivariate model with simultaneous entry of any consumption of fish rich in n-3 fatty acids and dietary intake of DHA as a continuous variable (food-group analysis adjusted for a specific nutrient variable), the odds ratio (OR) associated with any consumption of n-3 fish was 0.86 (95% CI = 0.72–1.03). Thus, part of the inverse association

Table 2 Rank-order Spearman's correlations between hostility and selected dietary variables

	Black men (n=672)	Black women (n=967)	White men (n=925)	White women (n=1017)	All (n=3581)
Dietary variables					
Total energy (kcal)	0.19***	0.15***	0.13***	0.07*	0.14***
α-linolenic acid (kcal/1000 kcal)	−0.08*	−0.01	0.02	−0.04	−0.02
EPA (kcal/1000 kcal)	−0.09*	−0.09**	−0.01	−0.05	−0.06**
DHA (kcal/1000 kcal)	−0.08*	−0.06	−0.02	−0.03	−0.04
All n-3 fatty acids (kcal/1000 kcal)	−0.08*	−0.02	0.02	−0.05	−0.02
Linoleic acid (kcal/1000 kcal)	−0.09*	−0.02	−0.03	−0.05	−0.05*
Arachidonic acid (kcal/1000 kcal)	0.02	0.05	0.05	0.07*	0.05**
All n-6 fatty acids (kcal/1000 kcal)	−0.09*	−0.02	−0.03	−0.05	−0.04*
Ratio n-6/n-3 fatty acids	−0.00	−0.01	−0.04	0.00	−0.01
Alcohol (kcal/1000 kcal)	0.07*	0.13***	0.03	−0.04	0.04**
All types of fish (eating occasions/week)	−0.06	−0.06	−0.05	0.00	−0.03*
n-3 Fish (eating occasions/week)	−0.10**	−0.04	−0.05	−0.02	−0.04**

The CARDIA study, 1990–1991.
All dietary variables were measured at year 7 (1992–93).
*$P<0.05$; **$P<0.01$; ***$P<0.001$.
EPA, eicosapentanoic acid; DHA, docosahexanoic acid.
The correlation coefficients for the total sample combined are adjusted for sex and race.

Table 3 Multivariate-adjusted odds ratios (95% confidence intervals) of scoring in the upper quartile of the Cook–Medley hostility scale at year 5 (1990–91) associated with a standard deviation increase in caloric intake, calorie-adjusted n-3 and n-6 fatty acids, alcohol and fish intake at year 7

	Odds ratio (95% CI)	P	
Dietary variables			
Total energy (kcal)	**1.25 (1.15–1.35)**	**0.0001**	
α-linolenic acid (kcal/1000 kcal)	0.97 (0.89–1.05)	0.43	
EPA (kcal/1000 kcal)	0.93 (0.85–1.01)	0.09	
DHA (kcal/1000 kcal)	**0.90 (0.82–0.98)**	**0.02**	
All n-3 fatty acids (kcal/1000 kcal)	0.95 (0.87–1.03)	0.22	
Linoleic acid (kcal/1000 kcal)	0.94 (0.86–1.02)	0.11	
Arachidonic acid (kcal/1000 kcal)	1.05 (0.97–1.14)	0.25	
All n-6 fatty acids (kcal/1000 kcal)	0.94 (0.86–1.02)	0.11	
Ratio n-6/n-3 fatty acids	0.99 (0.92–1.08)	0.93	
Alcohol (kcal/1000 kcal)	**1.09 (1.01–1.18)**	**0.02**	
Fish consumption variables			
	>0 but <2	**≥2**	>0
All types of fish (eating occasions/week)	0.94 (0.64–1.40)	1.06 (0.70–1.62)	0.97 (0.65–1.43)
	>0 but <1	≥1	>**0**
n-3 Fish (eating occasions/week)	**0.81 (0.68–0.97)**	0.83 (0.65–1.07)	**0.82 (0.69–0.97)**

The CARDIA study.
*Age, sex, race, field center, education level, marital status, employment status, smoking status, alcohol consumption, body mass index, leisure time activity index, sports activity index and work activity index.
The odds ratios for consumption of all types of fish or n-3 fish are relative to zero eating occasions/week.
EPA: eicosapentanoic acid; DHA: docosahexanoic acid.

between consumption of n-3 fish and hostility was explained by the DHA content. The unadjusted association between hostility scores and consumption of fish rich in n-3 fatty acids, by sex–race groups, is depicted in Figure 1.

In the multivariate logistic regression analysis (with consumption of fish rich in n-3 fatty acids in the model), eight other variables were significantly related to high hostility. Four variables were positively related: Chicago field center (OR = 1.35, 95% CI = 1.06–1.71), unemployment status (OR = 1.55, 95% CI = 1.26–1.90), current smoking (OR = 1.36, 95% CI = 1.12–1.65) and the upper quartile of body mass index (OR = 1.29, 95% CI = 1.04–1.62); and three variables were inversely related: college education (OR = 0.60, 95% CI = 0.49–0.72), graduate school education (OR = 0.40, 95% CI = 0.29–0.55) and being married (OR = 0.71, 95% CI = 0.59–0.86).

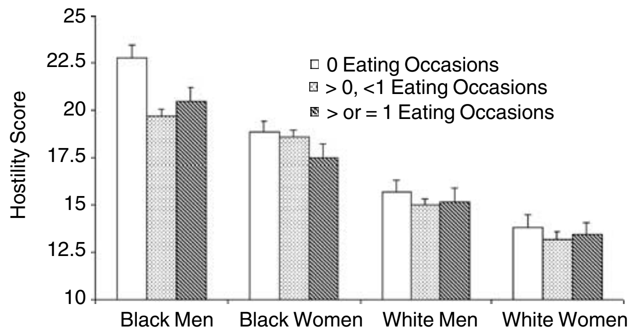

Figure 1 Cook–Medley hostility score according to eating occasions of fish rich in n-3 fatty fish and sex/race groups. The bars depict s.e.m.

Discussion

In this analysis among young adults, dietary intake of DHA was significantly associated with reduced likelihood of high hostility after adjusting for age, sex, race, field center, educational attainment, marital and employment statuses, physical activity, body mass index, smoking and alcohol consumption. Analysis of food groups revealed that any consumption of fish rich in n-3 fatty acids was also an independent, significant inverse predictor of high hostile personality. On the other hand, the other dietary n-3 fatty acids, the dietary n-6 fatty acids, and the overall balance of n-6 and n-3 essential fatty acid intake were not predictive of high hostility.

Another finding worth noting in our analysis were significant associations of total energy intake and alcohol consumption with high hostility level, not explained by confounding with physical activity. Higher work activity (but not leisure time or sports-related activity) was correlated significantly both with total energy (ranging from $r=0.04$ in white women to $r=0.18$ in white men) and with high hostility among men. A possible explanation of this association is that hostile persons may exaggerate intake.

In the analysis presented here, arachidonic acid was the only essential fatty acid showing a weak positive (although not statistically significant) association with hostility. Arachidonic acid is the precursor of thromboxane A_2, which has potential detrimental effects such as vasoconstriction and platelet aggregation (Horrobin, 1993).

Our results are consistent with the results of two prior placebo-controlled trials. In a trial among young adults in Japan, DHA supplementation with fish oil capsules prevented extra-aggression at times of mental stress (Hamazaki *et al*, 1996) and lowered resting plasma norepinephrine concentrations by 31% (Hamazaki *et al*, 2000). In another trial, a high fish diet intervention as part of a cholesterol-lowering program resulted in a reduction of aggressive hostility as measured by the Hopkins Symptom Checklist (SCL-90) (Weidner *et al*, 1992). In an observational study, subjects with a history of impulsive behaviors, plasma DHA were negatively correlated with serotonin and dopamine metabolites in cerebrospinal fluid, suggesting that the dietary intake of DHA may influence neurotransmitter concentrations (Hibbeln *et al*, 1998).

The present study has some limitations that should be taken into account when interpreting the findings. First, these are observational data and thus subject to residual confounding despite multivariate adjustment in the analysis. Second, the cross-sectional nature of the design does not rule out the possibility of effect–cause (ie, hostility measured at year 5 affecting diet at year 7); however, we believe that the likelihood of effect–cause bias is low since the participants were unaware of their hostility scores while reporting their habitual diet. Third, we also assumed that hostility was a stable trait personality variable from year 5 to year 7, which may not be so for all individuals. Finally, we did not have plasma phospholipid or adipose tissue measurements of n-3 or n-6 fatty acid status, although recent studies have demonstrated a good correlation between polyunsaturated fatty acids from the diet and in serum (Lands *et al*, 1992; Yli-Jama *et al*, 2001). Strengths of the study include the large sample size and the biracial composition of the cohort.

In summary, our findings are consistent with the hypothesis that high intake of DHA and of fish rich in n-3 fatty acids may be associated with lower hostility. The extent to which the protective effect of n-3 fatty acid intake on cardiovascular outcomes is mediated through reduction of hostility warrants further investigation.

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