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Original Research

# *Trans* fatty acid intake is related to emotional affect in the Adventist Health Study-2

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ABSTRACT

*Trans* fatty acids in Western diets increase health risks, and have been associated with the risk of depression. We hypothesized that intakes of *trans* fatty acids (primarily from margarines and baked goods) were inversely associated with positive affect and positively associated with negative affect in a longitudinal study. Church attendees residing in North America completed a food frequency questionnaire in 2002-6 as part of the Adventist Health Study-2. A subset in which we excluded participants with established cardiovascular disease (n = 8,771) completed the Positive and Negative Affect Schedule (PANAS) in 2006-7. The associations between dietary intakes of fatty acids to positive and negative affect were tested with linear regression analysis controlling for age, gender, ethnicity, education, body mass index, exercise, sleep, sleep squared, Mediterranean diet, total energy intake and alcohol. Intakes of *trans* fatty acids were inversely associated with positive affect ($\beta$ = -0.06, $B$ = -0.27 [95% CI -0.37, -0.17], $p < .001$) and positively associated with negative affect ($\beta$ = 0.05, $B$ = 0.21 [95% CI 0.11, 0.31], $p < .001$). In comparison, we found no association between n-3 polyunsatured fatty acids (PUFA) intakes with affect. The n-6:n-3 PUFA ratio was inversely associated with positive affect ($\beta$ = -0.03, $B$ = -0.34 [95% CI -0.58, -0.10], $p$ = 0.006). The findings suggest that a lower dietary *trans* fatty acid intake has beneficial effects on emotional affect while the n-6: n-3 ratio is detrimental to positive affect.



## 1. Introduction

Dietary fats are found in three forms: (a) saturated, (b) monounsaturated, (c) polyunsaturated including the essential fatty acids and two major n-3 dietary fatty acids from marine sources, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In the last 50 years, American diets have replaced n-3 polyunsaturated fatty acids from marine and plant sources with n-6 polyunsaturated fatty acids (PUFA) found in common vegetable oils, desserts, dressings, meats, and chips [1].

Currently, in Western diets, the ratio of n-6:n-3 PUFA ranges from approximately 20-30:1 instead of the ratio of 1-2:1 observed in people eating more traditional and less processed diets [2]. An increased amount of n-6 PUFA may lead to

*Abbreviations:* AHS-2, Adventist Health Study-2; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; FDA, Federal Drug Administration; PANAS, Positive and Negative Affect Schedule; PsyMRS, Psychosocial Manifestations of Religion Sub-Study; PUFA, Polyunsaturated Fatty Acids.

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cardiovascular and mental health problems [2,3]. In addition, biological pathways supporting the relationship between fatty acid metabolism and mental health have been identified. The two long-chain n-3 PUFA, EPA and DHA, decrease the production of the inflammatory eicosanoids derived from n-6 PUFA, including arachidonic acid, by competing with or inhibiting pro-inflammatory cytokines [1]. Individuals with mental disorders show an increase in inflammatory eicosanoids derived from arachidonic acid metabolism [4,5]. Treatment with n-3 PUFA may play a role in the treatment of depressive disorders [6]. Recently evidence from a Mendelian randomization study weakly supported the association between EPA and perinatal onset depression giving further credence to the notion of causality [7]. Diets with higher n-6:n-3 PUFA ratios have been observed to enhance the risk for depression [8,9]. Recently among US adults, a higher n-3:n-6 ratio was associated with longitudinal slower increases in depressive symptoms [10].

*Trans* fatty acids are a type of unsaturated fatty acids formed by the hydrogenation of vegetable oils and found mainly in industrial products [11]. In 2006, the Federal Drug Administration (FDA) required that food labels list *trans* fats, and in 2013 the FDA determined that partially hydrogenated oils are not generally recognized as safe for use in food. In June 2015, food companies were advised to eliminate the *trans* fat in food products within the next three years. From 1991 to 2008 *trans* fat was the only type of dietary fat to decrease in the Framingham study population [12] while *trans* fat intake among American consumers in general declined from 4.6 grams per day in 2003 to about 1 gram per day in 2012. These changes have been based on growing evidence that *trans* fatty acids adversely affect cardiovascular health [13] and increase serum cholesterol levels [14]. Experimental evidence has demonstrated that intakes of *trans* fatty acids are pro-inflammatory [15]. Pro-inflammatory eicosanoids and downstream cytokines can adversely influence mental health [16,17]. A longitudinal study in Spain found a detrimental relationship between *trans* fatty acid intake and depression risk [18]. Furthermore, the Whitehall II Study found that *trans* fat intake was associated with recurrent depressive symptoms in women [19].

The concept of subjective well-being is used to describe a domain of mental health beyond the absence of symptoms of depression and distress to also include the presence of happiness and life satisfaction [20]. Negative affective states, such as depression, anxiety and psychological distress have long been associated with disease [21]. Studies have associated positive well-being with reduced mortality [21]. Prudent dietary patterns are associated with a lower likelihood of negative mood states [4,22–25]. In contrast, Western dietary patterns associate with negative mood states [26–28]. The relation between *trans* fatty acid consumption and affective state has not been much studied. This relation is of interest given the potential role of diets in targeting fatty acids in the brain [29].

Given the findings from observational studies associating *trans* fatty acids with depression [18,19], we hypothesized that intakes of *trans* fatty acids (primarily from margarines and baked goods) were inversely associated with positive affect and positively associated with negative affect in an analysis of a largely healthy cohort of Seventh-day Adventists followed longitudinally. This population spanned a wide range of geographical locations, educational levels, has limited alcohol intake, and includes both genders [30]. Most importantly, this almost exclusively non-smoking population followed a range of dietary patterns from vegan to non-vegetarian. Our research objectives were to examine 1) the relation of *trans* fatty acids intakes longitudinally to positive affect and 2) the relation of *trans* fatty acids longitudinally to negative affect. We also studied associations of n-3 PUFA intakes and the n-6:n-3 PUFA ratio to affect. We hypothesized that these nutrients would be associated with affect.

## 2. Methods and materials

### 2.1. *Setting and study population*

Two sets of archival data were examined using an observational longitudinal study design. The predictor (dietary) variables were assessed in 2002-6 among participants in the Adventist Health Study-2 (AHS-2) cohort. In brief, the AHS-2 cohort [30] included approximately 96,000 subjects who were over 30 years of age who filled out a 50 page mailed questionnaire regarding their medical histories, lifestyle and dietary intakes. Between 2006-7, the outcome variable (affect) was assessed from the sub-study of AHS-2, the Biopsychosocial Religion and Health Study which included the Psychosocial Manifestations of Religion Sub-Study (PsyMRS) questionnaire [31]. The PsyMRS aimed to study connections between religion and health and randomly sampled approximately 21,000 AHS-2 participants of which 10,988 responded to the 20-page PsyMRS questionnaire. The PsyMRS questionnaire included questions on religion, spirituality and mental health. Recruitment methodologies of subjects in both studies are described in previous literature [30,31].

All respondents that completed both AHS-2 and PsyMRS surveys were eligible for analyses ($N$ = 10,988). Because of low numbers in these subgroups, subjects less than 35 years of age ($N$ = 132), ethnicities other than Black or White ($N$ = 700), non-Seventh Day Adventists ($N$ = 363), current smokers ($N$ = 87), subjects with body mass index (BMI) <15 kg/m$^2$ ($N$ = 43), subjects with an estimated energy intake <500 kcal/day or >4,500 kcal/day or incomplete dietary data ($N$ = 585), error in questionnaire dates ($N$ =5), and subjects with established cardiovascular disease, including heart attack, stroke, transient ischemic attack or heart failure ($N$ =302) were excluded, leaving 8,771 participants. The Institutional Review Board of Loma Linda University approved both the AHS-2 and PsyMRS studies.

### 2.2. *Dietary assessments*

Dietary intake was assessed by a self-administered food frequency questionnaire (FFQ), which contains a list of over 200 food items including fruits, vegetables, legumes, grains, oils, dairy, fish, eggs and beverages, and commercially prepared products such as dietary supplements, dry cereals, meat substitutes, and soy milk. This FFQ was designed to specifically assess dietary intake among a population where a