Published in final edited form as:
J Psychosom Res. 2013 February ; 74(2): 142–148. doi:10.1016/j.jpsychores.2012.11.002.

Intake of Mediterranean foods associated with positive affect and low negative affect

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Abstract

Objective—To examine associations between consumption of foods typical of Mediterranean versus Western diets with positive and negative affect. Nutrients influence mental states yet few studies have examined whether foods protective or deleterious for cardiovascular disease affect mood.

Methods—Participants were 9255 Adventist church attendees in North America who completed a validated food frequency questionnaire in 2002–6. Scores for affect were obtained from the Positive and Negative Affect Schedule questionnaire in 2006–7. Multiple linear regression models controlled for age, gender, ethnicity, BMI, education, sleep, sleep squared (to account for high or low amounts), exercise, total caloric intake, alcohol and time between the questionnaires.

Results—Intake of vegetables (β=0.124 [95% CI 0.101, 0.147]), fruit (β=0.066 [95% CI 0.046, 0.085]), olive oil (β=0.070 [95% CI 0.029, 0.111]), nuts (β=0.054 [95% CI 0.026, 0.082]), and legumes (β=0.055 [95% CI 0.032, 0.077]) were associated with positive affect while sweets/desserts (β=−0.066 [95% CI −0.086, −0.046]), soda (β=−0.025 [95% CI −0.037, −0.013]) and fast food frequency (β=−0.046 [95% CI −0.062, −0.030]) were inversely associated with positive affect. Intake of sweets/desserts (β=0.058 [95% CI 0.037, 0.078]) and fast food frequency (β=0.052 [95% CI 0.036, 0.068]) were associated with negative affect while intake of vegetables (β=−0.076 [95% CI −0.099, −0.052]), fruit (β=−0.033 [95% CI −0.053, −0.014]) and nuts (β=−0.088 [95% CI −0.116, −0.060]) were inversely associated with negative affect. Gender interacted with red meat intake (P<.001) and fast food frequency (P<.001) such that these foods were associated with negative affect in females only.

Conclusions—Foods typical of Mediterranean diets were associated with positive affect as well as lower negative affect while Western foods were associated with low positive affect in general and negative affect in women.

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Conflict of interest: No conflicts of interest. All authors will complete the Unified Competing Interest form at http://www.icmje.org/coi_disclosure.pdf and declare that they have no competing interests to report.

Keywords

Affect; Dietary behaviors; Mediterranean; Mental health; Western

Introduction

One in 17 Americans experience a serious mental illness in their lifetime while currently, only about 17% of United States adults are reported to be in an optimal state of mental health [1]. Associations between diet and mental illness have been reported, particularly with depression and anxiety [2–5]. However, little is known about the associations of dietary patterns and mental well-being [6,7].

Affect describes both the positive and negative facets of subjective well-being and has been shown to be independent of mental illness [8]. Positive affect has been associated with health outcomes including reduced cardiovascular disease risk [6]. Many of the dietary patterns associated with protection against cardiovascular disease may also be associated with mental health. Examples include prudent and Mediterranean dietary patterns characterized by a variety of fresh fruit and vegetables, certain dairy products, olive oil, fish and whole grains as well as vegetarian diets [4,9–12]. These dietary patterns are associated with improved mood states, improved self-reported functional health and quality of life and less depression in some studies [13–16]. Western dietary patterns characterized by intake of such foods as solid fats and refined sugars [3,17] and lack of omega-3 fatty acids have in contrast been associated with increased depression and negative mood states [18,19]. Recent research has increasingly focused on the role played by positive affect in health, not solely the detrimental effects of negative affect [6]. While the notion that foods reduce the risk of developing mental disease has been suggested [20], few studies have examined the relation between foods that may be protective against mental disease and promote positive affect.

In the current paper, we examined associations of consumption of foods typical of the Mediterranean diet and of Western diets with positive and negative affect. This was an observational analysis of a largely healthy cohort of Seventh-day Adventist church goers. This population spans a wide range of geographical locations and educational levels, has limited alcohol intake and is largely non-smoking [21], both potential confounders of associations of food and affect. Most importantly, this population follows a range of dietary patterns from vegan to non-vegetarian, as vegetarian diets have been historically encouraged by the church [22], providing ample opportunity to study diets and health outcomes.

Methods

Participants and design

Two sets of archival data were examined using an observational 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 included approximately 96,000 subjects over 30 years of age who filled out a 50 page mailed questionnaire regarding their medical histories, lifestyle and dietary intakes. In 2006–7, the outcome variable (affect) was assessed in the Psychosocial Manifestations of Religion Sub-Study (PsyMRS), a sub-population of the AHS-2 study [21,23], which aimed to study connections between religion and health. Of 20,000 randomly sampled AHS-2 participants 10,988 responded to the 20-page PsyMRS questionnaire. The PsyMRS questionnaire included questions on mental health and religion [23]. Recruitment methodologies of subjects in both studies are described in previous literature [21,23].

All respondents that completed both AHS-2 and PsyMRS surveys were eligible for the present analyses (N=10,988). Excluded in this study were subjects not well represented including those less than 35 years of age (N=132), ethnicities other than Black or White (N= 700), non-Seventh Day Adventists (N=363), and current smokers (N=87), and subjects with an estimated energy intake <500 kcal/day or >4500 kcal/day or incomplete dietary data (N=451) leaving 9255.

Dietary assessments

Dietary intake was assessed by a self-administered food frequency questionnaire (FFQ), which contains a list of over 200 food items including fruit, vegetables, legumes, grains, oils, dairy, fish, eggs and beverages, and commercially prepared products. This FFQ was designed to specifically assess dietary intake among a population where a large proportion is vegetarian. Respondents were asked about their intake of foods during the past year. Frequency categories range from *never or rarely*, 1–3 *times per month*, X *times per week* (where X was 1, 2 to 4, or 5 to 6) or *Y time per day* (where Y was 1, 2 to 3, or 4+). Portion sizes include *standard* (amount was dependent upon food item), 1/2 or less or 1 1/2 or more. The FFQ was previously validated against six 24-hour dietary recalls for intake of nutrients [24] and selected foods/food groups [25]. These studies showed that de-attenuated validity correlations in Whites for vegetables, fruits, dairy, all legumes and nuts, fish, red meats and soda were 0.66, 0.68, 0.86, 0.58, 0.53, 0.76, and 0.58, respectively. In Blacks, these were 0.41, 0.52, 0.82, 0.47, 0.57, 0.72 and 0.48, respectively.

The consumption of foods typical of Mediterranean or Western diets was assessed a priori based on hypothesized associations between foods and mental state. Mediterranean foods included non-starchy fresh vegetables, fresh fruit, certain dairy products, olive oil, nuts, fish, and legumes (excluding soy). Soy was excluded due to the wide range of processed and unprocessed foods that may include soy among people following vegetarian diets. Western foods included red meats, processed meats, sweets/desserts, soda, and fast foods. Associations between grain intakes and disease may depend on whether the grains are refined or whole, and also on the type of grain protein [26], and, thus, we did not aim to study these relationships and did not include grains. Furthermore, butter was not considered as butter may have positive or negative health effects [27] while fatty acid patterns were considered separately (submitted). Because the Mediterranean diet may include whole fat milk and yogurt, fatty dairy products were not separated from low fat products. Poultry was not analyzed because it may be part of both Mediterranean and Western diets.

Each food group was a composite of individual food items in the FFQ. Table 1 describes the food items used to classify the dietary food groups. Food intakes with the exception of fast foods were calculated using the product-sum method [28]. Thus, $I=\Sigma (F\times A\times S)$ where I = intake, F = weighted frequency, A = weighted amount and S = standard weight of a standard serving size in grams. Amount of food was coded into three options including standard serving size, 50% of the standard serving size and 150% of the standard serving size for each individual dietary variable. Missing values for amount of foods were coded as the standard serving size only if frequency was marked and amount was missing. If frequency was missing and amount of diet variable was missing, this diet variable was coded as zero. If frequency was missing and amount was marked, the diet variable was still coded as zero. Total energy intake was calculated using nutrient composition based from the NDS-R 2008 database (The Nutrition Coordinating Center), information from manufacturers, and the Caribbean Food and Nutrition Institute. Food intake was energy-adjusted using the residual method [28].

Assessment of affect

Positive and negative affect was measured by a short form of the Positive and Negative Affect Schedule (PANAS) [29]. The PANAS has been validated in a cross-sectional and correlational analysis [30]. This 10-item scale includes five items on positive emotion: inspired, alert, excited, enthusiastic, and determined and five items on negative emotion: afraid, upset, nervous, scared and distressed. The items are assessed on a 5-point rating scale ranging from *very slightly or not at all* to *extremely,* based on the statement "This set of questions consists of a number of words and phrases that describe different feelings and emotions. Mark a bubble to show to what extent you have felt this way during the past year." High internal reliability was indicated by Cronbach's α's which were 0.85 and 0.87 for positive and negative affect, respectively.

Control variables were chosen a priori based on expected confounders of relations between diet and affect. These included age, gender, ethnicity, BMI, educational level, frequency of vigorous physical activity, alcohol intake, sleep, sleep squared (to account for risks of high or low amounts), total energy intake and time between two questionnaires. Ethnicity was self-defined. BMI was calculated from a current height and weight. Educational level was represented by highest level attained: grade school, some high school, high school diploma, trade school diploma, some college, Associate degree, Bachelors degree, Masters degree, or Doctoral degree. Frequency of vigorous physical activity was assessed by the question "How many times per week do you usually engage in regular vigorous activities, such as brisk walking, jogging, bicycling, etc., long enough or with enough intensity to work up a sweat, get your heart thumping or get out of breath?" This questionnaire is shown to be validated and reliable in Black and White Adventists [31,32]. Alcohol intake was queried by an affirmative response to 'I still drink alcoholic beverages'. Participants categorized the number of hours of sleep at night as <6, 7–8 and ≥9. Because low and high amounts of sleep may be associated with poor health [33], a quadratic relationship was investigated between sleep and affect. Time between the two questionnaires was calculated as the return date of the PsyMRS questionnaire minus the return date of the AHS-2 questionnaire in years.

Statistical analysis

Missing values constituted less than 3% of the cases for all variables. Because multiple imputation produces the least biased estimates and lowest loss of power and allows the use of auxiliary variables to further reduce bias and increase power [34], SPSS version 20 multiple imputation routines were used on 147 variables. All variables used in any analysis were included. To reduce bias and increase power a variety of auxiliary variables not used in any analysis were included in the multiple imputations [34]. Examples of such variables were marital status, church involvement, congregational warmth, sleep difficulty, perceived stress, optimism, satisfaction with life, and gratitude. Regarding scales (such as the PANAS) including the separate scale items rather than the total scale score produces a power advantage so we did imputation with the items and calculated the scale scores after imputation [35]. Imputation of too few multiple data sets results in a loss of power [36] so we imputed 40 data sets and calculated all analyses across all 40 sets.

Descriptive statistics were reported for all measures and data are reported as mean and standard deviation. Independent sample *t*-tests and Chi-square tests were utilized to examine the differences between genders. The regressions of positive and negative affect on dietary variables were analyzed separately for males and females to detect possible interactions between gender and diet. The confidence intervals of the regressions of positive and negative affect on dietary variables in both males and females were examined to determine if they overlapped. If the confidence intervals did not overlap or overlapped slightly, interaction effects were tested directly by including a product term for each dietary variable

and gender in the regression of affect on dietary variable and gender. A Bonferroni adjustment was applied to the interactions tested (24–for each of positive and negative affect with 12 foods) thus interactions of $P<.002$ were considered statistically significant.

After controlling for age, gender, ethnicity, BMI, educational level, frequency of vigorous physical activity, total energy intake, alcohol intake, sleep, sleep squared, and time between two questionnaires, positive and negative affect were regressed on each of the dietary variables. Because of the multiplicity of statistical tests (gender, positive and negative affect, and 12 food groups equating to 2×2×12=48 tests), a Bonferroni adjustment of the cut-off P-value for statistical significance was determined at $P<.001$. All data were analyzed using SPSS version 20.0.

Results

The analytic population for this study consisted of 9255 subjects who completed the AHS-2 and the PsyMRS, encompassing 6234 females and 3021 males. The study sample showed a greater percentage of females than males and a higher percentage of White respondents than Black (Table 2). Females were significantly younger than males and had a significantly higher BMI than males. Mean BMIs in both genders are categorized as overweight. The vast majority of the sample did not use alcohol. The average time elapsing between the baseline measurement and the outcome measurement was approximately 2 years. Scores for positive affect did not differ between emales and males. Scores for negative affect were significantly higher in females than males.

Food intakes

The mean intakes of foods were generally higher in males than females, as expected (Table 3). Approximately half of the sample reported never or rarely consuming fast food; males reported a higher frequency of fast food frequency and higher intakes of nuts, red meat, processed meats, sweets/desserts and soda per day compared to females. Females reported a higher intake of fresh vegetables compared to males.

Regression of affect on food intakes

In the total population, intake of fresh vegetables, fresh fruit, olive oil, nuts, and legumes intakes were associated with positive affect while intake of sweets/dessert and soda as well as fast food frequency were inversely associated with positive affect. Intake of sweets/desserts and fast food frequency were positively associated with negative affect while intake of fresh vegetables, fresh fruit, and nuts were inversely associated with negative affect (see Tables 4 and 5).

The results for gender specific regressions are also shown in Tables 4 and 5. Significant interactions were found for gender with red meat and fast food frequency ($P<.001$). Consumption of these foods was associated with negative affect in females only (red meat, β −0.044, $P<.001$ and fast food, β −0.058, $P<.001$).

Discussion

Our overall results show that positive affect is associated with intake of fresh vegetables, fresh fruit, olive oil and legumes but inversely associated with intake of sweets/desserts and soda as well as fast food frequency. By comparison, intake of fresh vegetables, fresh fruit, and nuts was inversely associated with negative affect while the intake of red meat and sweets/desserts as well as fast food frequency was associated with negative affect. Overall, the association of reported food intakes with negative affect was more pronounced in females than males. As this is an observational study, the findings do not indicate causality.

Foods typical of a Mediterranean diet that protect against cardiovascular disease, compared to Western diet patterns may affect mood, or mood may affect choice of foods. The findings underscore the importance of both positive and negative affect in food choices or vice versa.

The participants of our study were representative of a partly vegetarian and healthy eating population due to their religion [21]. Some of the most important confounders were considered in this analysis in regards to the relationship between dietary intake and mental state including gender, BMI, and total energy intake. Smoking and alcohol are important determinants of food choices [37–39]. As the population consisted of church-goers, belonging to a denomination that strongly discourages adherents from using tobacco, smokers were few, and excluded, isolating the relationship between food choices and affect from smoking. Alcohol intake was low in this population, as expected, with only 5–6% reporting current use.

The effects of food on health rather than isolated nutrients have received increasing attention in recent studies [40–45]. Using factor analysis, foods may be analyzed separately or grouped into dietary patterns, such as Western or prudent and Mediterranean [2,17,44]. Western dietary patterns are characterized by high intakes of processed meats, red meat, animal and processed fats, high-fat dairy products, eggs, and refined grains, while prudent diets characteristically include high intakes of vegetables, fruit, legumes, whole-grains and fish [44]. The Mediterranean dietary pattern has been associated with fewer depressive symptoms [4,10], while Western-type patterns have been associated with negative mental health states [2,3]. Specifically, the dose relationship of trans fatty acids in Western diets and depression is notable [46].

We sought to explore associations of specific foods associated with Western or Mediterranean patterns, to illuminate whether these associations were similar for negative or positive affect, or whether positive or negative affect each had their own determinants. The results indicate that vegetables, fruit and nuts determined both higher positive affect and lower negative affect while sweets/desserts determined lower positive affect and higher negative affect. Olive oil and legumes determined higher positive affect only, while fast food frequency and soda were inversely associated with positive affect only. Thus, it appears that negative and positive affect share major dietary determinants, while other determinants may be specific to the type of affect. These differences require further study, as the current results are hypothesis-generating.

Significant differences were found among men and women. Men generally consumed higher amounts of foods including nuts, red meats, processed meats, sweets/desserts, sodas and fast foods yet women consumed higher amounts of vegetables. In the large EPIC-Norfolk study [14] women likewise reported higher vegetable as well as fruit intakes compared with men. In one study [47] in older adults, men had less nutritional knowledge and lacked awareness of the links between healthy dietary behaviors and prevention of disease compared to women. We did not find a difference in fruit intakes between genders, perhaps due to health consciousness of the population.

The associations between intakes of certain foods (red meat and fast foods) and negative affect appeared only in women. The red meat intake among the females in the present study averaged 3.8 g per day with a large standard deviation (SD=11.8). Despite the low mean consumption, increased red meat was associated with higher scores of negative affect. In support of these findings, in a recent randomized controlled trial, Beezehold and Johnston [48] restricted meat, fish, and poultry among a mostly female sample and found significant associations between the reductions of meat and improvement of several domains of mood. In contrast, Jacka and colleagues [49] recently reported that Australian women who ate <28

g of meat per day were more likely to have a diagnosis of an anxiety or depressive disorder compared to women who ate 28–57 g of meat per day. These contrasting results may be possibly explained by the difference in meat products between U.S. and Australia. Cattle in Australia are largely grass-fed beef therefore beef products may have higher omega-3 fatty acids compared to U.S. meats [50]. Omega-3 fatty acids have been previously associated with decreased prevalence of depressive disorders [18].

Our study is the first to our knowledge that associates fast food frequency and negative affect in women. Fast foods are high in added sugars, processed meats and vegetable oils. High glycemic foods that include foods more common to a Western diet and fast food products such as refined carbohydrates and added sugars have been associated with higher levels of inflammatory markers in women [51]. Processed meats and vegetable oils are high in long-chain omega-6 fatty acids, which are potentially pro-inflammatory [52–54]. Western diets, characterized by high omega-6:omega-3 ratios may enhance the risk for depression [18,46,55,56]. Higher omega-6:omega-3 ratios have been observed in depressed subjects compared with non-depressed subjects [57–59]. Likewise, in the current study, increased intakes of sweets/ desserts were associated with low positive and high negative affect. Intakes of fast foods, refined sugars, sweets and desserts have previously been associated with mental disorders [3,19,60]. Konttinen and colleagues [61] found that depressive symptoms were related to emotional eating [62,63]. Emotional eaters may have increased intakes of sweet foods. We were unable to test if the association of sweets/desserts with affect was independent of disordered eating, as we did not have data regarding eating behavior.

Consumption of fresh vegetables was associated with higher scores of positive affect. At least one randomized controlled trial reported that a 10-day intervention of Mediterranean eating improved mood states in women [11]. Our findings provide a mirror image of observations in other cross-sectional studies reporting less negative affect and decreased cognitive decline in adherents of vegetarian or Mediterranean diets [3,13,64,65]. Likewise, Samieri and colleagues [64] reported that women with higher consumption of fruit and vegetables reported less depressive symptoms. However, their outcome may be a result of self-reported bias as respondents were asked to self-report a perceived present state of health rather than a validated measure of affect, such as the PANAS. Furthermore, their analysis was solely based on intake frequency, which may not reflect portion size or adjust for total energy intakes. Jacka and colleagues [2] reported that diets including vegetables and fruits were associated with lower odds for depression and anxiety compared to diets containing foods typical of western diets. Data on the association of positive affect with fruit and vegetables intakes seem to be lacking.

Lower negative affect was associated with increased nut consumption while higher positive affect was associated with increased nut consumption. Nuts are beneficial for a range of metabolic and cardiovascular conditions through their content of essential fatty acids [66,67]. Essential fatty acids, including omega-3 fatty acids intakes reduce inflammatory states indicating a possible positive correlation between consumption of polyunsaturated fatty acids from nuts and optimal mental health [18,68]. Similar results have been reported in cross-sectional analyses as the increased consumption of nuts were associated with reduced mental health disorders such as depression and improved self-perceived mental health in both genders [4,40]. Further analysis is needed to investigate the association in affective states.

Limitations

Our limitations include the complex nature of diet where certain foods tend to be consumed together. We did not test a specific dietary pattern, but chose foods a priori that are

characteristic of Mediterranean or Western patterns. A principle component or factorial analyses could have been appropriate, but we wished to study the association of specific foods.

A causal relationship of food predicting later mood states is not implied. Positive or negative affect may be related to adherence to healthy or unhealthy dietary patterns. Specifically, poor mental health may lead to an increment in consumption of fast foods or sweets. However, in the current study the assessment of diet preceded assessment of affect by a mean of 2 years, making reverse causality less likely, however, this remains a possibility. Only 4.8% of subjects completed both questionnaires within a time period of less than 1 year (data not shown). Dietary habits tend to be stable in older populations, and show high reproducibility within 1 year [69], thus, the dietary patterns at baseline were likely to also have been present at the time of the mood assessment. We were able to control for biological correlates including ethnicity, BMI, total energy intakes, sleep, alcohol intake, and physical activity, all of which were associated with food choices and affect (data not shown). Other data were not available, including information on biological measurements. At the baseline measurement, we lacked data regarding mental disease. Such data may be used to exclude subjects with depression, who may be most likely to change their dietary pattern after a diagnosis of depression, i.e. eat more sweets to ameliorate depressive symptoms [70]. Our population represents a Seventh-day Adventist population where healthy eating and spiritual lifestyles are emphasized which limits the ability to generalize to a population where such are lacking. Our population also includes only Whites and Blacks, limiting our ability to generalize to other races and/or ethnicities. There were substantially more women than men in this study, resulting in higher power among female subjects, possibly explaining the findings of some significant associations in women and not in men. PANAS was chosen as the instrument to assess mood. Previous research supports the utility of the PANAS in large-scale normative data [30]. Furthermore, the presence of internal consistency within the PANAS has been shown in the general adult population as well as adequate reliability [30]. Critiques of PANAS, suggest inconsistencies due to recall bias, influence of current mood states, and the variables of affective state in everyday lives [71,72].

Conclusions

Our results suggest an association of foods typical of Western diets such as red meat and frequent consumption of fast food with negative affect in females only and foods typical of Mediterranean diets such as fresh vegetables, fresh fruit, olive oil, nuts, and legumes with positive affect in males and females.

Acknowledgments

Source of funding This research was supported by grants from the National Institute on Aging (Biopsychosocial Religion and Health Study, 1R01AG026348) and the National Cancer Institute for the parent study (Adventist Health Study 2, 5R01 CA094594).

We thank the participants in the Adventist Health Study-2.

References

1. U.S. Department of Health and Human Services. Mental health: A report of the Surgeon General. Rockville, MD: U.S. Department of Health and Human Services; Substance Abuse and Mental Health Services Administration, Center for Mental Health Services, National Institutes of Health, National Institute of Mental Health; 1999.

2. Jacka F, Mykletun A, Berk M, Bjelland I, Tell G. The association between habitual diety quality and the common mental disorders in community-dwelling adults: the Hordaland Health Study. Psychosom Med. 2011; 73:483–90. [PubMed: 21715296]
3. Jacka F, Pasco J, Mykletun A, Williams L, Hodge A, O'Reilly S, et al. Association of Western and traditional diets with depression and anxiety in women. Am J Psychiatry. 2010; 167:305–11. http://dx.doi.org/10.1176/appi.ajp.2009.09060881. [PubMed: 20048020]
4. Sanchez-Villegas A, Delgado-Rodriguez M, Alonso A, Schlatter J, Lahortiga F, Majem LS, et al. Assocation of the mediterranean dietary pattern with the incidence of depression: the Seguimiento University de Navarra/University of Navarra follow-up (SUN) cohort. Arch Gen Psychiatry. 2009; 66:1090–8. [PubMed: 19805699]
5. Akbaraly TN, Brunner EJ, Ferrie JE, Marmot MG, Kivimaki M, Singh-Manoux A. Dietary pattern and depressive symptoms in middle age. Br J Psychiatr. 2009; 195:408–13.
6. Steptoe A, Dockray S, Wardle J. Positive affect and psychobiological processes relevant to health. J Pers. 2009; 77:1747–65. [PubMed: 19796062]
7. Grant N, Wardle J, Steptoe A. The relationship between life satisfaction & health behavior: a cross-cultural analysis of young adults. Int J Behav Med. 2009; 16:259–68. http://dx.doi.org/10.1007/s12529-009-9032-x. [PubMed: 19319695]
8. Diener E, Oishi S, Lucas RE. Personality, culture, and subjective well-being: emotional and cognitive evaluations of life. Annu Rev Psychol. 2003; 54:403–25. http://dx.doi.org/10.1146/annurev.psych.54.101601.145056. [PubMed: 12172000]
9. Hu FB, Rimm E, Smith-Warner SA, et al. Reproducibility and validity of dietary patterns assessed with a food frequency questionnaire. Am J Clin Nutr. 1999; 69:243–9. [PubMed: 9989687]
10. Sánchez-Villegas A, Henríquez P, Bes-Rastrollo M, Doreste J. Mediterranean diet and depression. Public Health Nutr. 2006; 9:1104–9. [PubMed: 17378948]
11. McMillan L, Owen L, Kras M, Scholey A. Behavioural effects of a 10-day Mediterranean diet. Results from a pilot study evaluating mood and cognitive performance Appetite. 2011; 56:143–7. http://dx.doi.org/10.1016/j.appet.2010.11.149.
12. Muñoz MA, Fíto M, Marrugat J, Covas MI, Schröder H. Adherence to the Mediterranean diet is associated with better mental and physical health. Br J Nutr. 2009; 101:1–7.
13. Beezhold B, Johnston C, Daigle D. Vegetarian diets are associated with healthy mood states: a cross-sectional study in Seventh Day Adventist adults. Nutr J. 2010; 9:26. [PubMed: 20515497]
14. Myint P, Welch A, Bingham S, Surtees P, Wainwright N, Luben R, et al. Fruit and vegetable consumption and self-reported functional health in men and women in the European Prospective Investigation into Cancer-Norfolk (EPIC-Norfolk): a population-based cross-sectional study. Public Health Nutr. 2007; 10:34–41. [PubMed: 17212840]
15. Steptoe A, Perikins-Porres L, Hiton Rink E, Cappucio F. Quality of life and self-related health in relation to changes in fruit and vegetables intakes and in plasma vitamin C and E in a randomized trial of behavioral and nutrition education counseling. Br J Nutr. 2004; 92:177–84. [PubMed: 15231001]
16. Hibbeln JR. Fish consumption and major depression. Lancet. 1998; 351:1213. [PubMed: 9643729]
17. Slattery ML, Boucher KM, Caan BJ, Potter JD, Ma KN. Eating patterns and risk of colon cancer. Am J Epidemiol. 1998; 148:4–16. [PubMed: 9663397]
18. Freeman M. Omega-3 fatty acids in major depressive disorder. J Clin Psychiatry. 2009; 701:7–11. [PubMed: 19909687]
19. Peet M. International variation in outcome of schizophrenia and prevalance of depression in relation to national dietary practices. J Psychiatr. 2004; 184:404–8. http://dx.doi.org/10.1192/bjp.184.5.404.
20. Richman LS, Kubzansky L, Maselko J, Kawachi I, Choo P, Bauer M. Positive emotion and health: going beyond the negative. Health Psychol. 2005; 24:422–9. [PubMed: 16045378]
21. Butler TL, Fraser GE, Beeson WL, Knutsen SF, Herring RP, Chan J, et al. Cohort profile: the Adventist Health Study-2 (AHS-2). Int J Epidemiol. 2008; 37:260–5. [PubMed: 17726038]
22. Fraser, G. Diet, life expentancy, and chronic disease Studies of Seventh-day Adventists and other vegetarians. New York: Oxford University Press; 2003.

23. Lee JW, Morton KR, Walters J, Bellinger DL, Butler TL, Wilson C, et al. Cohort profile: the biopsychosocial religion and health study (BRHS). Int J Epidemiol. 2009; 38:1470–8. http://dx.doi.org/10.1093/ije/dyn244. [PubMed: 19052114]
24. Jaceldo-Siegl K, Knutsen SF, Sabate J, Beeson WL, Chan J, Herring RP, et al. Validation of nutrient intake using an FFQ and repeated 24 h recalls in black and white subjects of the Adventist Health Study-2 (AHS-2). Public Health Nutr. 2010; 13:812–9. http://dx.doi.org/10.1017/S1368980009992072. [PubMed: 19968897]
25. Jaceldo-Siegl K, Fan J, Sabate J, Knutsen SF, Haddad E, Beeson WL, et al. Race-specific validation of food intake obtained from a comprehensive food frequency questionnaire: AHS-2. Public Health Nutr. 2011; 14:1988–97. [PubMed: 21557864]
26. Kalaydjian A, Eaton W, Cascella N, Fasano A. The gluten connection: the association between schizophrenia and celiac disease. Acta Psychiatr Scand. 2006; 113:82–90. http://dx.doi.org/10.1111/j.1600-0447.2005.00687.x. [PubMed: 16423158]
27. Tvrzicka E, Lefkothea-Stella K, Stankova B, Zak A. Fatty acids as biocompounds: their role in human metabolism, health & disease – a review. Part 1 Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2011; 155:117–30. http://dx.doi.org/10.5507//bp.2011.038.
28. Willet, W. Food frequency methods. In: Willett, W., editor. Nutritional epidemiology. 2nd. New York: Oxford University Press; 1998. p. 273-301.
29. Mackinnon A, Jorm AF, Christensen H, Korten AE, Jacomb PA, Rodgers B. A short form of the positive and negative affect schedule: evaluation of factorial validity and invariance across demographic variables in a community sample. Pers Indiv Differ. 1999; 27:405–16.
30. Crawford J, Henry J. The positive and negative affect schedule (PANAS): construct validity, measurement properties, and normative data in a large non-clinical sample. Br J Clin Psychol. 2004; 43:245–65. [PubMed: 15333231]
31. Singh P, Fraser G, Knutsen S, Lindsted D, Bennet H. Validity of a physical activity questionnaire among African-American Seventh-day Adventists. Med Sci Sports Exerc. 2000; 33:468–75. [PubMed: 11252076]
32. Singh P, Tonstad S, Abbey D, Fraser G. Validity of selected physical activity questions in white Seventh-day Adventists and non-Adventists. Med Sci Sports Exer. 1996; 28:1026–37.
33. Akiko T, Yoshiyuki O. Self-reported sleep duration as a predictor of all-cause mortality Results from the JACC study, Japan Sleep. 2004; 27:51–4.
34. Graham JW. Missing data analysis: making it work in the real world. Annu Rev Psychol. 2009; 60:549–76. [PubMed: 18652544]
35. Gottschall AC, West SG, Enders CK. A comparison of item-level and scale-level multiple imputation for questionnaire batteries. Multivar Behav Res. 2012; 47:1–25. http://dx.doi.org/10.1080/00273171.2012.640589.
36. Graham JW, Olchowski AE, Gilreath TD. How many imputations are really needed? – some practical clarifications of multiple imputation theory. Prev Sci. 2007; 8:206–13. http://dx.doi.org/10.1007/s11121-007-0070-9 (Article). [PubMed: 17549635]
37. Tonstad S, Gørbitz C, Sivertsen M, Ose L. Underreporting of dietary intake by smoking and nonsmoking subjects counseled for hypercholesterolemia. J Intern Med. 1999; 245:337–44. [PubMed: 10356595]
38. Yeomans MR. Alcohol, appetite and energy balance: is alcohol intake a risk factor for obesity? Physiol Behav. 2010; 100:82–9. [PubMed: 20096714]
39. Forsander OA. Hypothesis: factors involved in mechanisms regulating food intake affect alcohol consumption. Alcohol Alcohol. 1998; 64:279–85.
40. Trichopoulou A. Traditional mediterranean diet and longevity in the elderly: a review. Public Health Nutr. 2004; 7:943–7. [PubMed: 15482622]
41. Tucker K. Commentary: dietary patterns in transition can inform health risk, but detailed assessments are needed to guide recommendations. Int J Epidemiol. 2007; 36:610–1. [PubMed: 17533165]
42. Kant AK, Graubard BI, Schatzkin A. Dietary patterns predict mortality in a national cohort: the national health interview surveys, 1987 and 1992. J Nutr. 2004; 134:1793–9. [PubMed: 15226471]

43. Newby P, Tucker K. Emperically derived eating patterns using factor or cluster analysis, a review. Nutr Rev. 2004; 62:177–203. [PubMed: 15212319]
44. Hu F. Dietary pattern analysis; a new direction in nutritional epidemiology. Curr Opin Lipidol. 2002; 13:3–9. [PubMed: 11790957]
45. Jacques P, Tucker K. Are dietary patterns useful for understanding the role of diet in chronic disease. Am J Clin Nutr. 2001; 73:1–2. [PubMed: 11124739]
46. Sánchez-Villegas A, Verberne L, Delrala J, Ruiz-Canela M, Toledo E, Serra-Majem L, et al. Dietary fat and the risk of depression: the SUN project. PLoS One. 2011; 60:e16268. http://dx.doi.org/10.1371/journal.pone.0016268. [PubMed: 21298116]
47. Baker A, Wardle J. Sex differences in fruit and vegetable intake in older adults. Appetite. 2003; 40:269–75. [PubMed: 12798784]
48. Beezhold B, Johnston C. Restriction of meat, fish, and poultry in omnivores improves mood: a pilot randomized controlled trial. Nutr J. 2012; 11:9. [PubMed: 22333737]
49. Jacka F, Pasco J, Williams L, Mann N, Hodge A, Brazionis L, et al. Red meat consumption and mood and anxiety disorders. Psychother Psychosom. 2012; 81:196–8. http://dx.doi.org/10.1159/000334910. [PubMed: 22433903]
50. Daley C, Abbott A, Doyle P, Nader G, Larson S. A review of fatty acid profiles and antioxidant content in grass fed beer and grain fed beef. Nutr J. 2010; 10:10. [PubMed: 20219103]
51. Liu S, Manson JE, Buring JE, Stamper MJ, Willett WC, Ridker PM. Relation between a diet with a high glycemic load and plasma concentrations of high sensitivity C-reactive protein in middleaged women. Am J Clin Nutr. 2002; 75:492–8. [PubMed: 11864854]
52. Kiecolt-Glaser JK. Stress, food, and inflammation: psychoneuroimmunology and nutrition at the cutting edge. Psychosom Med. 2010; 72:365–9. http://dx.doi.org/10.1097/PSY.0b013e3181dbf489. [PubMed: 20410248]
53. Farooqui A, Harrocs L, Farroqui T. Modulation of inflammation in brain: a matter of fact. J Neurochem. 2007; 101:577–99. [PubMed: 17257165]
54. Song C, Wang H. Cytokines mediated inflammation and decreased neurogenesis in animal models of depression. Prog Neuropsychopharmacol. 2011; 35:760–8.
55. Kiecolt-Glaser JK, Belury MA, Porter K, Beversdorf D, Lemeshow S, Glaser R. Depressive symptoms, omega-6:omega-3 fatty acids, and inflammation in older adults. Psychosom Med. 2007; 69:217–24. [PubMed: 17401057]
56. Maes M, Smith R, Christophe A, Cosyns P, Desnyder R, Metlzer H. Fatty acid composition in major depression: decreased omega 3 fractions in cholesteryl esters and increase C20:4 omega 6/C20:5 omega 3 ratio in cholesteryl esters and phospholipids. J Affect Disord. 1996; 38:35–46. [PubMed: 8735157]
57. Frasure-Smith N, Lesperance F, Julien P. Major depression is associated with lower omega-3 fatty acid levels in patients with recent acute coronary syndromes. Biol Psychiatry. 2004; 55:891–6. [PubMed: 15110732]
58. Jacka FN, Pasco JA, Williams LJ, Meyers BJ, Diggers R, Berk M. Dietary intake of fish and PUFA, and clinical depressive and anxiety disorders in women. Br J Nutr. 2012; 10:1–8.
59. Hallahan B, Garland M. Essential fatty acids and mental health. Br J Psychiatry. 2005; 186:275. [PubMed: 15802681]
60. Dog TL. The role of nutrition in mental health. Altern Ther Health Med. 2010; 16:42–6. [PubMed: 20232617]
61. Konttinen H, Mannisto S, Sarlio-Lahteenkorva S, Silventoinen K, Haukkala A. Emotional eating, depressive symptoms and self-reported food consumption: a population-based study. Appetite. 2010; 54:473–9. [PubMed: 20138944]
62. Macht M. How emotions affect eating: a five-way model. Appetite. 2008; 50:1–11. [PubMed: 17707947]
63. Oliver G, Wardle E, Gibson E. Stress and food choice: a laboratory study. Psychosom Med. 2000; 62:853–65. [PubMed: 11139006]
64. Samieri C, Jutand M, Feart C, Capuron L, Letenneur L, Barberger-Gateau P. Dietary patterns derived by hybrid clustering method in older people: association with cognition, mood, and self-reated health. J Am Diet Assoc. 2008; 108:1461–71. [PubMed: 18755318]

65. Sofi F, Cesari F, Abbate R, Gensin G, Cassini A. Adherence to Mediterranean diet & health status: a meta analysis. BMJ. 2008; 337:a1344. http://dx.doi.org/10.1136/bmj:a1344. [PubMed: 18786971]

66. O'Neil C, Keast D, Niclas T, Fulgoni V. Nut consumption is associated with decreased health risk factors for cardiovascular disease and metabolic syndrome in U.S. adults: NHANES 1999–2004. J Am Coll Nutr. 2011; 30:502–10. [PubMed: 22331685]

67. Kris-Etherton PM, Zhao G, Binkoski AE, Coval SM, Etherton TD. The effects of nuts on coronary heart disease risk. Nutr Rev. 2001; 59:103–11. [PubMed: 11368503]

68. Boissonneault, GA. Dietary fat, immunity, and inflammatory disease. In: Chow, CK., editor. Fatty acids in foods and their health implications. New York: Marcel Dekker; p. 2000p. 777-807.

69. Khani B, Ye W, Terry P, Wolk A. Reproducibility & validity of major dietary patterns among Swedish women assessed with a food frequency questionnaire. J Nutr. 2004; 134:1541–5. [PubMed: 15173426]

70. Hepworth R, Mogg K, Brignell C, Bradley B. Negative mood increases selective attention to food cues and subjective appetite. Appetite. 2010; 54:134–42. [PubMed: 19815043]

71. Kahneman D, Krueger A. Developements in the measurement of subjective well-being. J Econ Perspect. 2006; 20:3–4.

72. Shiffman S, Stone A, Hufford M. Ecological momentary assessment. Annu Rev Clin Psychol. 2008; 4:1–32. [PubMed: 18509902]

Table 1

Sixty-nine items from the FFQ used for classification of food types in Mediterranean and Western diet patterns

Mediterranean			
Fresh vegetables (13)	Dark green lettuce		Onions
	Iceberg lettuce		Avocados
	Tomatoes		Broccoli
	Peppers, carrots		Cauliflower
	Cabbage, brussels sprouts		Spinach
	Kale, collards, mustard greens		Peas
Fresh fruits (19)	Grapes in season and out of season		Persimmons in season
	Plum in season and out of season		Apples
	Apricot in season		Oranges
	Cantaloupe in season and out of season		Grapefruits
	Strawberry in season and out of season		Bananas
	Blueberry in season and out of season		Fruit salad, fresh
	Cherry in season and out of season		
Dairy (6)	Milk, whole or 2%		Low fat yogurt
	Low fat milk, 1% or skim		Regular yogurt
	Low fat cheese (mozzarella, ricotta)		Cottage cheese
Olive oil (2)	Salad dressings		
	Added to breads, foods (aside from salads		
Nuts (6)	Seeds (sunflower, pumpkin, sesame)		Walnuts
	Mixed nuts		Almonds
	Peanuts		Cashews
Fish (5)	White fish (cod, salt-fish, sole, haddock catfish) or halibut, snapper,		
	Salmon		Tuna salad
Canned tuna		Tuna casserole	
Legumes (5)	Navy, red kidney, other red beans Lentils, split peas		Pinto, black Lima, white
	Chick peas (garbanzos), black-eyed		
Western			
Red meat (2)	Hamburger, ground beef (in casserole, meatballs)		
	Beef or lamb as main dish (steak, roast, stew, pot pies)		
Processed meats (3)	Processed beef, lamb (sausage, salami, bologna)		
	Processed chicken or turkey (turkey bologna, turkey, ham)		
	Pork (bacon, sausage, ham, chops, ribs, lunch-meat)		
Fast food (1)	How often do you eat out: fast food/takeout		
Sweets and desserts (11)	Doughnuts, cake	Pastries	Sweet pies
	cookies, store-bought	cookies, homemade	ice cream, ice milk
		Cinnamon rolls	Milkshakes
		Frozen yogurt	
Soda (4)	Regular coke, Pepsi or other, caffeine free		
	Regular coke, Pepsi or other, with caffeine		

Mediterranean	
	Diet coke, Pepsi or other, caffeine free
	Diet coke, Pepsi or other, with caffeine

Table 2

Descriptive characteristics of study sample n=9255 by gender in 6234 females and 3021 males. Values are mean (SD) or percentages

		Female	Male
		67.3%	**32.6%**
Age, years[a]		61.7 (13.3)	62.9 (13.1)
Ethnicity[a]			
	Black	25.5%	8.7%
	White	42.0%	23.9%
Body mass index, kg/m^2[a]		27.4 (6.4)	26.6 (4.8)
Education[a]			
	High school or less	14.8%	17.8%
	Trade school to associates	43.8%	35.0%
	Bachelor's degree	24.9%	26.9%
	Graduate degree or higher	16.5%	20.3%
Sleep	6 h or less	32.5%	32.4%
	7–8 h	61.6%	62.5%
	9 or more hours	5.9%	5.1%
Frequency of vigorous activity[a]	Never	21.1%	12.7%
	Less than once/week	15.7%	15.5%
	1–2 times per week	17.8%	22.8%
	3 times per week	18.4%	17.7%
	4 times per week	9.6%	10.9%
	5+ times per week	17.4%	20.4%
Current alcohol intake	No use	95.0%	93.8%
	Current use	5.0%	6.2%
Total energy intake, kcal/day[a]		1843.5 (724.6)	1991.6 (749.6)
Time, years		1.9 (0.65)	1.8 (0.69)
Positive affect[b]		3.5 (0.71)	3.5 (0.70)
Negative affect[a,b]		1.8 (0.74)	1.6 (0.63)

[a] *P*-value<.001 for continuous variables *t*-test and categorical variables chi-squared test.

[b] Affect scales range from 1 to 5, 1 being very slightly or not at all and 5 being extremely.

Table 3

Mean food group intakes of study sample in 6234 females and 3021 males. Values are mean (SD) or percentages

		Female	Male
Mediterranean			
Fresh vegetables, g/day[a]		139.8 (107.3)	127.4 (96.5)
Fresh fruits, g/day		170.7 (201.9)	168.3 (179.3)
Dairy, g/day		54.5 (86.0)	52.1 (80.7)
Olive oil, g/day		4.3 (7.67)	3.8 (8.6)
Nuts, g/day[a]		13.6 (18.9)	15.3 (21.6)
Fish, g/day		7.2 (15.7)	7.6 (15.3)
Legumes, g/day		24.4 (36.3)	23.6 (35.7)
Western			
Red meat, g/day[a]		3.8 (11.8)	5.3 (15.3)
Processed meats, g/day[a]		0.5 (2.6)	0.8 (3.3)
Sweets/desserts, g/day[a]		24.3 (39.3)	31.1 (48.6)
Soda, g/day[a]		61.2 (179.4)	88.9 (270.5)
Fast food frequency[a]	Never or rarely	49.1%	44.1%
	1–3 times per month	32.2%	33.3%
	Once per week	10.1%	11.5%
	2+ per week	8.6%	11.1%

[a] *P*-value<.001 for difference between genders (continuous variables tested with an unpaired *t*-test and categorical variables with the chi-squared test).

Table 4

Regressions of positive affect on each energy-adjusted food intakes for full sample (n=9255), females (n=6234), and males (n=3021)

	Full sample				Females				Males			
	95% C.I.				95% C.I.				95% C.I.			
	Beta	Lower	Upper	*P*	Beta	Lower	Upper	*P*	Beta	Lower	Upper	*P*
Mediterranean												
Fresh vegetables	0.124	0.101	0.147	<.001	0.139	0.110	0.167	<.001	0.093	0.053	0.133	<.001
Fresh fruits	0.066	0.046	0.085	<.001	0.072	0.048	0.096	<.001	0.053	0.021	0.085	.001
Dairy	−0.011	−0.025	0.002	.103	−0.022	−0.039	−0.005	.013	0.008	−0.015	0.032	.489
Olive oil	0.070	0.029	0.111	.001	0.082	0.032	0.132	.001	0.046	−0.025	0.117	.207
Nuts	0.054	0.026	0.082	<.001	0.045	0.009	0.081	.016	0.083	0.036	0.130	.001
Fish	0.034	0.004	0.064	.026	0.013	−0.024	0.051	.487	0.067	0.017	0.117	.008
Legumes	0.055	0.032	0.077	<.001	0.059	0.030	0.088	<.001	0.054	0.015	0.093	.007
Western												
Red meat	−0.048	−0.083	−0.013	.008	−0.072	−0.117	−0.026	.002	−0.027	−0.083	0.030	.359
Processed meats	−0.122	−0.227	−0.018	.021	−0.176	−0.316	−0.036	.014	−0.083	−0.240	0.074	.298
Sweets and desserts	−0.066	−0.086	−0.046	<.001	−0.073	−0.099	−0.047	<.001	−0.054	−0.087	−0.020	.002
Soda	−0.025	−0.037	−0.013	<.001	−0.027	−0.042	−0.012	<.001	−0.046	−0.007	−0.010	.008
Fast food frequency	−0.046	−0.062	−0.030	<.001	−0.055	−0.075	−0.035	<.001	−0.034	−0.060	−0.008	.011

Standardized betas were controlled for age, gender (full sample), ethnicity, BMI, education, frequency of physical vigorous activity, sleep hours, sleep hours squared, time, total energy intake and alcohol.

Table 5

Regressions of negative affect on each energy-adjusted food intakes for full sample (N=9255), females (n=6234), and males (n=3021)

	Full sample				Female				Male			
	95% C.I.				95% C.I.				95% C.I.			
	Beta	**Lower**	**Upper**	***P***	**Beta**	**Lower**	**Upper**	***P***	**Beta**	**Lower**	**Upper**	***P***
Mediterranean												
Fresh vegetables	−0.076	−0.099	−0.052	<.001	−0.091	−0.121	−0.061	<.001	−0.046	−0.082	−0.010	.013
Fresh fruits	−0.033	−0.053	−0.014	.001	−0.040	−0.065	−0.015	.002	−0.021	−0.051	0.009	.167
Dairy	0.007	−0.007	0.021	.323	0.016	−0.002	0.034	.085	−0.011	−0.032	0.010	.323
Olive oil	−0.043	−0.084	−0.002	.040	−0.070	−0.122	−0.018	.008	0.017	−0.047	0.082	.594
Nuts	−0.088	−0.116	−0.060	<.001	−0.101	−0.138	−0.065	<.001	−0.060	−0.102	−0.017	.006
Fish	0.016	−0.015	0.048	.301	0.029	−0.011	0.068	.152	−0.019	−0.065	0.027	.413
Legumes	−0.028	−0.051	−0.005	.017	−0.033	−0.062	−0.004	.026	−0.015	−0.051	0.020	.391
Western												
Red meat[a]	0.036	0.000	0.072	.051	0.085	0.038	0.133	<.001	−0.026	−0.078	0.026	.325
Processed meats	0.112	0.007	0.217	.037	0.197	0.049	0.345	.009	0.032	−0.111	0.174	.665
Sweets/desserts	0.058	0.037	0.078	<.001	0.073	0.046	0.100	<.001	0.032	0.002	0.062	.035
Soda	0.015	0.003	0.027	.013	0.026	0.010	0.041	.001	0.001	−0.017	0.019	.920
Fast food frequency[a]	0.052	0.036	0.068	<001	0.079	0.058	0.100	<.001	0.007	−0.016	0.031	.556

Standardized betas were controlled for age, gender (full sample), ethnicity, BMI, education, frequency of physical vigorous activity, sleep hours, sleep hours squared, time, total energy intake and alcohol.

[a]Significant effects for gender were seen with dietary variable and negative affect.