Annals of Epidemiology 25 (2015) 398–405

Contents lists available at ScienceDirect

Annals of Epidemiology

journal homepage: www.annalsofepidemiology.org

Original article

Construct validation of the dietary inflammatory index among postmenopausal women

Fred K. Tabung PhD [a,b], Susan E. Steck PhD [a,b,c,*], Jiajia Zhang PhD [b], Yunsheng Ma PhD [d], Angela D. Liese PhD [b,c], Ilir Agalliu ScD [e], Melanie Hingle PhD [f], Lifang Hou PhD [g], Thomas G. Hurley MSPH [a], Li Jiao PhD [h], Lisa W. Martin MD [i], Amy E. Millen PhD [j], Hannah L. Park PhD [k], Milagros C. Rosal PhD [d], James M. Shikany PhD [l], Nitin Shivappa PhD [a,b], Judith K. Ockene PhD [d], James R. Hebert PhD [a,b,c]

[a] South Carolina Statewide Cancer Prevention and Control Program, University of South Carolina, Columbia
[b] Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia
[c] Center for Research in Nutrition and Health Disparities, University of South Carolina, Columbia
[d] Division of Preventive and Behavioral Medicine, University of Massachusetts Medical School, Boston
[e] Department of Epidemiology and Population Health, Albert Einstein College of Medicine, Bronx, NY
[f] Department of Nutritional Sciences, College of Agriculture and Life Sciences, The University of Arizona, Tucson
[g] Department of Preventive Medicine and the Robert H. Lurie Comprehensive Cancer Center, Feinberg School of Medicine, Northwestern University, Chicago, IL
[h] Department of Medicine, Baylor College of Medicine, Houston, TX
[i] Cardiology Division, School of Medicine and Health Sciences, George Washington University, Washington, DC
[j] Department of Epidemiology and Environmental Health, University at Buffalo, The State University of New York, Buffalo
[k] Department of Epidemiology, School of Medicine, University of California at Irvine, Irvine
[l] Division of Preventive Medicine, School of Medicine, University of Alabama at Birmingham, Birmingham

ARTICLE INFO

Article history:
Received 14 November 2014
Accepted 12 March 2015
Available online 19 March 2015

Keywords:
Dietary inflammatory index
Inflammatory biomarkers
Construct validation
Women's Health Initiative

ABSTRACT

Purpose: Many dietary factors have either proinflammatory or anti-inflammatory properties. We previously developed a dietary inflammatory index (DII) to assess the inflammatory potential of diet. In this study, we conducted a construct validation of the DII based on data from a food frequency questionnaire and three inflammatory biomarkers in a subsample of 2567 postmenopausal women in the Women's Health Initiative Observational Study.

Methods: We used multiple linear and logistic regression models, controlling for potential confounders, to test whether baseline DII predicted concentrations of interleukin-6, high-sensitivity C-reactive protein (hs-CRP), tumor necrosis factor alpha receptor 2, or an overall biomarker score combining all three inflammatory biomarkers.

Results: The DII was associated with the four biomarkers with beta estimates (95% confidence interval) comparing the highest with lowest DII quintiles as follows: interleukin-6: 1.26 (1.15–1.38), $P_{trend} < .0001$; tumor necrosis factor alpha receptor 2: 81.43 (19.15–143.71), $P_{trend} = .004$; dichotomized hs-CRP (odds ratio for higher vs. lower hs-CRP): 1.30 (0.97–1.67), $P_{trend} = .34$; and the combined inflammatory biomarker score: 0.26 (0.12–0.40), $P_{trend} = .0001$.

Conclusions: The DII was significantly associated with inflammatory biomarkers. Construct validity of the DII indicates its utility for assessing the inflammatory potential of diet and for expanding its use to include associations with common chronic diseases in future studies.

Introduction

Many dietary factors are known to affect inflammation. A Western-style diet, rich in proinflammatory foods that are high in sugar (especially desserts and soft drinks), refined grains, red and processed meats, and fried foods, increases levels of inflammatory markers such as C-reactive protein (CRP) and interleukin-6 (IL-6) [1]. By contrast, diets rich in fruits, vegetables, whole grains,

J.R.H. owns controlling interest in Connecting Health Innovations LLC (CHI), a company planning to license the right to his invention of the dietary inflammatory index (DII) from the University of South Carolina to develop computer and smart phone applications for patient counseling and dietary intervention in clinical settings. N.S. also is an employee of CHI. This affiliation does not have any direct effect on the present study. The other authors have no conflicts of interest to disclose.

* Corresponding author. Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, 915 Greene Street, Rm 236, Discovery I Building, Columbia, SC 29208. Tel.: +1-803-576-5638; fax: +1-803-576-5624.
E-mail address: ssteck@sc.edu (S.E. Steck).

http://dx.doi.org/10.1016/j.annepidem.2015.03.009
1047-2797/

legumes, nuts, olive oil, and fish (e.g., Mediterranean-type diet) tend to be associated with reduced chronic inflammation [2–4]. Specific components of such diets (e.g., fruits and vegetables, omega-3 polyunsaturated fatty acids, fiber, moderate alcohol intake, vitamin E, vitamin C, β-carotene, and magnesium) can reduce inflammatory biomarkers [5,6].

Dietary indices and dietary pattern analysis have emerged as alternative and complementary approaches to examining relationships between diet and chronic diseases [7,8]. Conceptually, dietary indices or patterns represent a broader picture of food and nutrient consumption, and may thus be a better tool to predict disease risk than are individual foods or nutrients [9–11]. Several dietary indices exist to assess the overall quality of diet [12–14]. The dietary inflammatory index (DII) [15] was developed to assess the quality of diet with regard to its inflammatory potential. The goal in creating the DII was to provide a tool that could assess an individual's diet on a continuum from maximally anti-inflammatory to maximally pro-inflammatory. Previously, the DII was construct validated using high-sensitivity CRP (hs-CRP) measurements in a longitudinal cohort of 494 individuals followed in Central Massachusetts with intensive dietary monitoring using 24-hour dietary recall interviews (24HR) and 7-day dietary recalls [16] for one year [17].

In the present study, our objective was to conduct a construct validation of the food frequency questionnaire (FFQ)-derived DII in a much larger population by evaluating its association with an extended number of inflammatory biomarkers (IL-6, hs-CRP, and tumor necrosis factor alpha receptor 2 [TNFα-R2]), and an overall inflammatory biomarker score derived from a combination of the three biomarkers.

Methods

Participants

The design of the Women's Health Initiative (WHI), a large and complex investigation of strategies for the prevention and control of common causes of morbidity and mortality among postmenopausal women, has been described in detail elsewhere [18]. Briefly, a total of 161,808 postmenopausal women aged 50 to 79 years were enrolled at 40 sites in the United States between 1993 and 1998. The women were enrolled into either the Clinical Trials (CT) component that included 68,132 women or the Observational Study (OS) component that included 93,676 women [18]. An emphasis was placed on the inclusion of women of racial or ethnic minority groups, who represented 17.1% of the overall sample.

Exclusion criteria for both the OS and CT included any medical condition associated with a predicted survival of less than three years, alcoholism, other drug dependency, mental illness (e.g., major depressive disorder), dementia, not likely to live in the area for at least three years, and active participation in another intervention trial. Demographic information and lifestyle data were obtained by self-report using standardized questionnaires. Certified staff performed physical measurements, including height and weight, and collected blood samples at the baseline clinic visit. The WHI protocol was approved by the institutional review boards (IRBs) at the Clinical Coordinating Center (CCC) at the Fred Hutchinson Cancer Research Center (Seattle, WA) and at each of the 40 Clinical Centers [19]. In addition, the University of South Carolina IRB approved the current analyses.

Dietary assessment

We used dietary data from the self-administered WHI FFQ completed by a subsample of 2567 WHI participants at baseline (1993–1998), reflecting average dietary intake over the previous three months. The nutrient database was derived from the University of Minnesota's Nutrition Coordinating Center nutrient database [20], which is based on the U.S. Department of Agriculture Standard Reference Releases and manufacturer information. In a previous study, the WHI FFQ produced nutrient estimates which were similar to those obtained from short-term dietary recalls and records [21]. The FFQ included questions on nutritional supplement use for 15 nutrient components of the DII; namely, iron, magnesium, niacin, riboflavin, selenium, thiamine, β-carotene, zinc, folic acid, and vitamins A, C, D, E, B6, and B12.

Table 1
Components of the DII with their inclusion status in the WHI FFQ

Number	DII component	Included in WHI FFQ?
1	Alcohol, g	Yes
2	Vitamin B12, μg	Yes
3	Vitamin B6, mg	Yes
4	β-Carotene, μg	Yes
5	Caffeine, g	Yes
6	Carbohydrate, g	Yes
7	Cholesterol, mg	Yes
8	Energy, kcal	Yes
9	Eugenol, mg	No
10	Total fat, g	Yes
11	Fiber, g	Yes
12	Folic acid, mg	Yes
13	Garlic, g	No
14	Ginger, g	No
15	Iron, mg	Yes
16	Magnesium, mg	Yes
17	MUFA, g	Yes
18	Niacin, mg	Yes
19	Omega 3, g	Yes
20	Omega 6, g	Yes
21	Onion, g	Yes
22	Protein, g	Yes
23	PUFA, g	Yes
24	Riboflavin, mg	Yes
25	Saffron, g	No
26	Saturated Fat, g	Yes
27	Selenium, mg	Yes
28	Thiamin, mg	Yes
29	Trans Fat, g	Yes
30	Turmeric, mg	No
31	Vitamin A, μg	Yes
32	Vitamin C, mg	Yes
33	Vitamin D, μg	Yes
34	Vitamin E, mg	Yes
35	Zinc, mg	Yes
36	Green tea or black tea, g	Yes
37	Flavan-3-ol	No
38	Flavones, mg	No
39	Flavonols, mg	No
40	Flavonones, mg	No
41	Anthocyanidins, mg	No
42	Isoflavones, mg	Yes
43	Pepper, g	No
44	Thyme or Oregano, mg	No
45	Rosemary, mg	No

MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

Description of the DII

Details of the development [15] and construct validation [17] of the DII have been described elsewhere. Briefly, investigators performed an extensive literature search to identify studies published in peer-reviewed journals that examined the association between six inflammatory biomarkers (IL-1β, IL-4, IL-6, IL-10, TNFα, and CRP) and 45 specific foods and nutrients (see Table 1 for components of the DII). A total of 1943 eligible articles published through 2010