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Construct Validation of the Dietary Inflammatory Index among African Americans

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Abstract

Objectives—Chronic inflammation is linked to many chronic conditions. One of the strongest modulators of chronic inflammation is diet. The Dietary Inflammatory Index (DII) measures dietary inflammatory potential and has been validated previously, but not among African Americans (AAs).

Design—Cross-sectional analysis using baseline data from the Healthy Eating and Active Living in the Spirit (HEALS) intervention study.

Setting—Baseline data collection occurred between 2009 and 2012 in or near Columbia, SC.

Participants—African-American churchgoers

Measurements—Baseline data collection included c-reactive protein (CRP) and interleukin-6 from blood draws, anthropometric measures, and numerous questionnaires. The questionnaires included a food frequency questionnaire which was used for DII calculation. The main analyses were performed using quantile regression.

Results—Subjects in the highest DII quartile (i.e., more pro-inflammatory) were younger, more likely to be married, and had less education and greater BMI. Individuals in DII quartile 4 had statistically significantly greater CRP at the 75th and 90th percentiles of CRP versus those in quartile 1 (i.e., more anti-inflammatory).

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Ethical Standards

The study was approved by the Institutional Review Board of the USC and all participants provided written informed consent.

Conclusion—Construct validation provides support for using the DII in research among AA populations. Future research should explore avenues to promote more anti-inflammatory diets, with use of the DII, among AA populations to reduce risk of chronic disease.

Keywords

Dietary Inflammatory Index; diet; inflammation; validation; African Americans

Introduction

Acute inflammation is necessary for proper wound healing and combating infections (1). However, inflammation that becomes chronic due to repeated stressors on the body (e.g., smoking, poor diet, obesity) increases risk for a variety of chronic conditions including cardiovascular disease, diabetes, cancer, and others, as well as mortality (1). Diet is a strong modulator of chronic systemic inflammation (2). Until recently, there was no dietary tool that summarized inflammatory potential of one's diet. However, researchers at the University of South Carolina developed the Dietary Inflammatory Index™ (DII) (3) which quantifies dietary inflammatory potential on around a 16-point scale from maximally anti- to pro-inflammatory.

Initial validation work indicated an odds ratio (OR) of 1.08 (95% confidence interval [95%CI] = 1.01–1.16) for c-reactive protein (CRP) >3.0mg/L for a one-unit increase in the DII (corresponding to about 7% of its global range) based on 24-hour dietary recalls in the Seasonal Variation in Blood Lipids study (SEASONS) (4). Additionally, the DII has been construct validated in the Buffalo Cardio-Metabolic Occupational Police Stress study (BCOPS) (5) and in the Women's Health Initiative (WHI) (6). Further corroboration of the validation of the DII is that fact that it has been associated with a wide range of outcomes associated with inflammation. The DII was previously associated with several types of cancer (e.g., colorectal, prostate, pancreas, lung, esophageal) (6–12), cardiovascular disease (13), components of metabolic syndrome (5), telomere length (14), obesity (15), asthma (16), and mortality (17, 18). However, previous construct validation studies using inflammatory markers were mainly conducted among populations that were mainly European Americans. Therefore, the Healthy Eating and Active Living in the Spirit (HEALS) physical activity, diet, and stress reduction educational intervention was used for construction validation of the DII among an entirely African-American population, a group that disproportionately suffers from several chronic inflammation-related conditions (19). Specifically, it was hypothesized that those with greater (i.e., more pro-inflammatory) DII scores would have higher levels of CRP or interleukin-6 (IL-6) compared to those with lower DII scores.

Materials and Methods

Study Population

Baseline data from HEALS, an educational intervention focusing on healthy diet, physical activity, and stress reduction among a population of African-American churchgoers were used for this analysis. Study details can be found elsewhere (20). In short, the study took place between 2009 and 2012 and churches were recruited from the Midlands of South Carolina which spans about 40 miles from the University of South Carolina (USC), Columbia, SC campus. The study was approved by the Institutional Review Board of the USC and all participants provided written informed consent.

Clinic Data

At baseline, participants underwent clinic examinations, which took place in their respective churches, where height, hip and waist circumferences, and weight were measured. Body fat percent was obtained using a bioelectrical impedance assessment (Tanita TBF-300WA Body Composition Analyzer, Arlington Heights, Illinois). Participants provided a blood sample for characterization of inflammatory biomarkers. All samples were run in duplicate with coefficients of variance of 3.9% and 3.7% for CRP and IL-6, respectively. Participants were provided with BodyMedia's (Pittsburgh, Pennsylvania) SenseWear® physical activity monitor (SWA) to track physical activity.

Questionnaire Data and the DII

Questionnaires at baseline obtained information on demographics, lifestyle factors, health history, diet, ethnic identity (Multigroup Ethnic Identity Measure [MEIM]), and several psychosocial measures including social approval and desirability, which have previously been shown to bias dietary and physical activity self-reporting (20–22). The 144-item food frequency questionnaire (FFQ) obtained information on frequency and serving size of commonly consumed foods and beverages which were used to estimate nutrient intake.

The DII is grounded in peer-reviewed research (i.e., 1,943 articles) examining the relationship between dietary components (termed food parameters) and inflammation to create inflammatory effect scores for each food parameter. At the same time, actual intake of each food parameter is standardized to a "world" database consisting of mean (and standard deviation) of the intake of that dietary component from 11 populations around the world (i.e., Australia, Bahrain, Denmark, India, Japan, Mexico, New Zealand, South Korea, Taiwan, the United Kingdom and the United States). A z-score was created by subtracting the "world" means from actual intake and dividing this by the standard deviation. In order to dampen the effect of [right] skewness, these z-scores were then converted to percentile values and centered on zero by doubling the percentile and subtracting 1. These values were multiplied by the literature derived inflammatory effect score and summed across food parameters. DII scores were calculated per 1,000 calories consumed to account for varying energy intake between people. DII information can be found elsewhere (3). These are the 31 DII food parameters available through HEALS: carbohydrates; protein; total, saturated, monounsaturated, polyunsaturated, and trans fat; alcohol; fiber; cholesterol; omega 3 and omega 6 fatty acids; niacin; thiamin; riboflavin; vitamins A, B6, B12, C, D, and E; iron; magnesium; zinc; selenium; folate; beta carotene; isoflavones; onion; garlic; and tea.

Statistical Analyses

Analyses were performed using SAS 9.4 (SAS Institute, Cary, NC)®. Descriptive statistics were computed using frequencies or means ± standard deviations. The assumptions of linear regression were violated. Therefore, quantile regression was used. Quantile regression allows for assessment of associations throughout the distribution of the outcome of interest after controlling for selected covariates. Beta coefficients and 95% confidence intervals (CIs) were obtained for CRP and IL-6 at the 25th, 75th, and 90th, percentiles of their distributions, respectively, for DII quartiles 2–4 (quartile 1 was referent). Additionally, CRP was categorized as ≤3.0mg/L vs. >3.0mg/L and logistic regression was used to obtain ORs and 95%CIs for DII quartiles 2–4 compared to quartile 1.

Results

The HEALS population were mostly female (79%), married (60%), and had at least a high school education (82%). The average age was 54.8±11.4 years with an average body mass index (BMI) of 33.5±7.5 kg/m^2. Overall, the mean DII was −0.48±2.15 which is slightly anti-inflammatory. Table 1 displays population characteristics by DII quartile. Those with more pro-inflammatory diets (i.e., quartile 4) were younger, more likely to be married, were employed full time, and had worse perceived health and higher BMI.

Table 2 displays beta coefficients and 95%CIs of CRP and IL-6 by DII quartiles at various percentiles (i.e., 25th, 75th, and 90th) of CRP. The 75th and 90th percentiles of CRP for the fourth quartile of the DII were significantly greater than for the first DII quartile ($\beta_{0.75}$=3.95, 95%CI=1.71–6.19; $\beta_{0.90}$=6.83, 95%CI=1.11–12.55) after adjustment for gender, age, insurance, perceived health, and MEIM scores. Similar results were not observed for IL-6 (Table 2). When CRP was dichotomized as ≤3.0mg/L vs. >3.0mg/L, after adjustment, the odds of a CRP value >3.0mg/L for DII quartiles 2–4 were as follows: quartile 2 (OR=3.16, 95%CI=1.56–6.41), quartile 3 (OR=1.90, 95%CI=0.94–3.84), and quartile 4 (OR=3.17, 95%CI=1.52–6.62). The odds ratio for a one-unit increase (corresponds to about 7% of its global range) in the DII for a CRP value >3.0mg/L was 1.24 (95%CI=1.09–1.40). Results remained unchanged after additional adjustment for BMI or body fat percent. The same was true after additional adjustment of non-steroidal anti-inflammatory drugs or aspirin (data not tabulated).

Discussion

This study found that more pro-inflammatory (i.e., greater) DII scores were associated with elevated CRP concentrations among African Americans. Additionally, those with higher DII values were younger, had worse perceived health, less education, and higher BMI. Compared to other dietary indices, the DII is grounded in peer-reviewed research (i.e., nearly 2,000 research articles), is standardized to world dietary intake, and can easily be calculated from numerous dietary reporting tools (3).

Previously, the DII was construct validated in several population including SEASONS, BCOPS, and the WHI (4–6). For example, in the WHI analyses (n=2,567 postmenopausal women), the fifth quintile of DII scores, compared to the first, was associated with elevated IL-6, high-sensitivity CRP, and tumor necrosis factor-α (all p≤0.02) (6). Besides construct validation based on inflammatory markers, the DII has been associated with several chronic inflammation-related conditions. For example, the DII was associated with cancer (8), and metabolic syndrome components (5), among others. Also, theoretically, DII values should lower after adoption of healthy, more anti-inflammatory diets. This was confirmed in a previous study, which indicated that compared to baseline DII values, DII values after a 2-month intervention were lower for vegan (mean DII: 0.3 vs. −1.2), vegetarian (mean DII: 0.4 vs. −1.0), and pesco-vegetarian (0.9 vs. −0.7) diets (23).

This study also found that individuals with lower DII scores were older and more likely to not be married. Interestingly, those who were widowed or divorced/separated were more likely to be in DII quartile 1 and also were older than those who were married (data not shown). However, it should be noted that several previous studies have observed lower DII scores among younger individuals or those who are married (8). This is the first time the DII has been analyzed in an exclusively African-American population. Unique dynamics of this church-based population, including strong cultural ties to food traditions and faith may explain differences with other studies. Other associations were in the theoretically correct direction or were similar to previous research (8). These include lower DII scores among those with better self-perceived health, lower BMI, and in those with a higher educational level.

Compared to other dietary indices, the DII has unique advantages in that it was specifically designed to predict dietary inflammatory potential. This is the first study to validate this construct in an entirely African-American population. Other strengths include the wide range of covariates examined as potential confounders and the novel use of quantile regression. Limitations of this study include the use of an FFQ. Although validated, the FFQ does not allow for inclusion of all 45 food parameters, only 31 were used. Considering that this was a faith-based community, results may not be generalizable to all African Americans. The DII has proven to be useful time and again in predicting inflammation or inflammation-related conditions. Recent evidence suggests that pro-inflammatory states, which may be brought on by pro-inflammatory diets, may lead to increased frailty and cognitive decline in older adults (24, 25). Now that the DII has been validated among an older African-American population, future research should explore adoption and benefits of more anti-inflammatory diets among these populations, especially in relation to frailty, cognitive decline, and chronic disease risk.

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Table 1

Baseline population characteristics according to dietary inflammatory index quartiles

Characteristic	Frequency (%) or Mean ± STD				p-value
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	
Age[a]					<0.01
Mean ± STD	59.6 ± 10.1	56.7 ± 10.2	53.0 ± 12.6	48.4 ± 9.5	
Sex					0.67
Female	69 (83%)	64 (78%)	62 (76%)	66 (80%)	
Male	14 (17%)	18 (22%)	20 (24%)	16 (20%)	
Marital Status					0.02
Married or living w/partner	38 (47%)	46 (58%)	52 (67%)	51 (65%)	
Widowed	14 (17%)	6 (8%)	4 (5%)	6 (8%)	
Divorced or separated	16 (20%)	20 (25%)	7 (9%)	13 (16%)	
Single, never married	13 (16%)	8 (10%)	15 (19%)	9 (11%)	
Education Status					0.07
High school or less	10 (13%)	14 (17%)	20 (25%)	14 (18%)	
Some college	21 (27%)	31 (39%)	22 (28%)	36 (46%)	
Complete college	28 (35%)	19 (24%)	17 (22%)	17 (22%)	
Postgraduate	20 (25%)	16 (20%)	20 (25%)	12 (15%)	
Employment Status					0.01
Full time	34 (42%)	37 (46%)	47 (59%)	50 (63%)	
Part time	7 (9%)	3 (4%)	7 (9%)	8 (10%)	
Retired	33 (41%)	34 (43%)	20 (25%)	12 (15%)	
Not employed	7 (9%)	6 (8%)	5 (6%)	9 (11%)	
Perceived Health					0.02
Excellent or very good	40 (49%)	21 (27%)	26 (33%)	25 (32%)	
Good	35 (43%)	40 (51%)	43 (54%)	43 (54%)	
Fair or poor	6 (7%)	18 (23%)	10 (13%)	11 (14%)	
Smoking Status					0.76
Current or Former	14 (17%)	18 (22%)	13 (16%)	15 (18%)	
Never	69 (83%)	64 (78%)	69 (84%)	67 (82%)	

Characteristic	Frequency (%) or Mean ± STD				p-value
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	
Alcohol Use					0.12
Current	28 (35%)	30 (37%)	28 (35%)	27 (34%)	
Former	20 (25%)	24 (30%)	28 (35%)	36 (45%)	
Never	32 (40%)	27 (33%)	24 (30%)	17 (21%)	
Number of Chronic Conditions					<0.01
None	10 (13%)	5 (6%)	23 (29%)	17 (21%)	
1	26 (33%)	17 (21%)	21 (26%)	29 (36%)	
2	28 (35%)	27 (34%)	18 (23%)	20 (25%)	
3	8 (10%)	22 (28%)	11 (14%)	10 (13%)	
>3	8 (10%)	9 (11%)	7 (9%)	4 (5%)	
Family History of Diabetes					0.56
Yes	54 (69%)	59 (74%)	53 (69%)	50 (63%)	
No	24 (31%)	21 (26%)	24 (31%)	29 (37%)	
Body Mass Index[a]					<0.01
Mean ± STD	31.3 ± 6.9	33.4 ± 6.6	34.4 ± 7.2	35.0 ± 8.8	
MEIM[a,b]					0.03
Mean ± STD	3.28 ± 0.40	3.22 ± 0.40	3.16 ± 0.48	3.12 ± 0.45	

Column percents may not equal 100 due to rounding. Frequencies my not equal population total due to missing data. DII quartile ranges: Quartile 1 = −5.62 to −2.19; Quartile 2 = −2.18 to −0.59; Quartile 3 = −0.58 to 1.05; Quartile 4 = 1.06 to 5.31.

[a]p-value represents the difference between DII quartile 1 and 4.

[b]The 12 items are ranked on a scale of 1–4 and are average to create the overall score.

Abbreviations: STD = standard deviation; MEIM = Multigroup Ethnic Identity Measures.

Table 2

Beta coefficients for c-reactive protein and interleukin-6 by DII quartiles using percentile regression

DII Quartiles	25th Percentile β (95%CI)	75th Percentile β (95%CI)	90th Percentile β (95%CI)
C-reactive Protein (mg/L)			
Quartile 2	0.17 (−0.57–0.91)	2.69 (1.02–4.36)	7.10 (1.45–13.74)
Quartile 3	0.29 (−0.25–0.83)	1.82 (−0.03–3.67)	3.99 (−0.54–8.52)
Quartile 4	0.58 (−0.40–1.57)	3.95 (1.71–6.19)	6.83 (1.11–12.55)
Interleukin-6 (pg/mL)			
Quartile 2	0.13 (−0.08–0.33)	0.12 (−0.60–0.83)	−0.14 (−1.42–1.14)
Quartile 3	0.33 (0.08–0.57)	0.71 (−0.20–1.62)	1.57 (−0.47–3.60)
Quartile 4	0.40 (0.09–0.70)	0.65 (−0.09–1.39)	0.76 (−0.60–2.13)

Adjustments: **C-reactive protein** = gender, insurance, perceived health, age, and the Multigroup Ethnic Identification Measure. **Interleukin-6** = family history of diabetes, insurance, perceived health, and the number of self-reported chronic diseases.

Abbreviations: DII = Dietary Inflammatory Index; 95%CI = 95% confidence interval.