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Original Study

Association Between Diet Inflammatory Index and Osteoporotic Hip Fracture in Elderly Chinese Population

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A B S T R A C T

Background: Chronic inflammation provides the substrate for various mechanisms involved in osteoporotic fracture. The Dietary Inflammatory Index (DII) could shed light on the effect of the inflammatory potential of the diet on osteoporotic hip fracture.
Objective: This study tested the hypothesis that higher DII scores are associated with greater hip fracture risk in an elderly Chinese population.
Methods: A 1:1 age- (±3 years), sex- and region-matched case-control study of 1050 pairs (female/male: 781/269) of elderly (age range = 52–83 years) Chinese was conducted in Guangdong, China (2009–2015). Cases were newly diagnosed (within 2 weeks) hip fracture patients and controls were recruited from either communities (n = 835 controls) or the hospital (n = 215). DII scores were calculated from self-reports using a validated 79-item food frequency questionnaire. Odds ratios (ORs) and their 95% confidence intervals (CIs) of the risk of hip fracture for DII scores were estimated from conditional logistic regression.
Results: The multivariable-adjusted ORs (95% CIs) for hip fracture across quartiles of DII scores were 1 (reference), 1.42 (1.01, 1.99), 1.63 (1.16, 2.28), and 2.44 (1.73, 3.45) (P trend <.001). Comparing extreme quartiles, the adjusted ORs (95% CIs) for hip fractures were 2.08 (1.38, 3.12) for female and 4.30 (1.89, 9.80) for male participants, respectively (P interaction = .26). When stratified by the source of controls, a dose-response positive relationship was observed between DII scores and hip fracture risk among community-based controls but not those from the hospital (P interaction = .16).
Conclusions: A proinflammatory diet appears to be positively associated with hip fracture risk.

Hip fractures are the most devastating consequence of osteoporosis; affecting 1 in 6 White women and leading to a 5- to 8-fold increased risk for all-cause mortality during the first 3 months after a fracture.[1] In Beijing, China, Xia et al[2] found that the age-adjusted rates of hip fracture over age 50 years increased 176% in women and 61% in men between 1990 and 1992 and 2002 and 2006. In vitro and

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Dr James R. Hebert 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. Dr Nitin Shivappa is an employee of CHI.

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rodent studies have shown that inflammation is involved in the pathogenesis of osteoporosis. For example, tumor necrosis factor (TNF)-α, a key proinflammatory cytokine, causes bone erosion in experimental models and these effects are exerted by osteoclasts.[3] Several large nested case-control studies have demonstrated that elevated levels of inflammatory markers such as the soluble receptors for interleukin (IL)-6 and TNF-α were associated with an increased risk of hip fractures in older women.[4,5] Thus, lowering inflammation may be an effective approach to reducing hip fracture risk.

Dietary factors are known to play a key role in the regulation of chronic inflammation and, in turn, on downstream health effects.[6] Specific components of the diet have been shown to have anti-inflammatory properties (eg, fiber and moderate amounts of ethanol). In contrast, some nutrients have been shown to be associated with higher levels of inflammation (eg, saturated fatty acids and trans fatty acids).[7] The Dietary Inflammatory Index (DII), a tool developed by researchers at the University of South Carolina's Cancer Prevention and Control Program, can be used in diverse populations to predict levels of inflammatory markers and related health outcomes.[8] The DII has been validated in a variety of cross-sectional and longitudinal studies with various inflammatory markers, including C-reactive protein (CRP),[7] IL-6,[9] and TNF-α.[10] Thus far, the DII has proven to be successful in predicting inflammatory markers,[7,11] obesity,[12] metabolic syndrome,[13] cardiovascular diseases,[14,15] cancer,[16–19] and mortality.[20] In a study of 160 postmenopausal Iranian women, higher DII scores were associated with lower bone mineral density.[21] Only 1 study conducted in members of the Women's Health Initiative (WHI) cohort found that more inflammatory diet was associated with increased lower hip fracture risk in White women younger than 63 years.[22]

Therefore, the aim of this study is to determine the association between DII and the risk of hip fracture in elderly Chinese.

Methods

Participants

This was a 1:1 matched case-control study conducted between June 2009 and October 2015 in Guangdong Province, China. More detailed information about this study is given by Xie et al.[23] Briefly, cases were consecutive newly diagnosed (within 2 weeks) patients with hip fractures admitted to the following hospitals: Guangzhou Orthopedics Trauma Hospital, Guangdong General Hospital, First Affiliated Hospital of Sun Yat-sen University, and the Orthopedics Hospital of Baishi District in Jiangmen city, Guangdong Province. A total of 1050 people aged 52–83 years participated in this study.

Control participants were individually matched on the basis of age (±3 years), sex, and region. Controls were subject to the same inclusion and exclusion criteria as cases with the exception of a history of any fracture. The controls in this study came from the following sources: (1) community-based (ie, apparently healthy community residents in the same cities who were invited through a variety of strategies such as written invitations, flyers, or referrals); and (2) hospital-based, consisting of inpatients hospitalized for <1 week with influenza, pneumonia, benign ophthalmic or otorhinolaryngological tumor, acute surgical disease, or a cataract in 1 eye. Both cases and controls who self-reported substantial changes in dietary habits or long-term (>6 months) adherence to controlled diets because of a disease diagnosis or weight control in the 5 years preceding the interview (n = 24 for cases and n = 11 for controls), unusual total energy intakes (ie, <800 or >4000 kcal/day for men and <500 or>3500 kcal/day for women, n = 22 pairs) and missing data for covariates (n = 3 pairs) were excluded from the current analysis.

Written informed consent was obtained from all participants before the interviews and the ethics committee of the School of Public Health of Sun Yat-sen University approved the study.

Diet Assessment

A validated 79-item food-frequency questionnaire querying about diet in the past year was administered to both cases and controls, using an instruction manual that included validated photographs of generic foods and portion sizes.[24] Food consumption was estimated per day, per week, per month, or per year according to the choice of the respondents. Daily mean nutrient and energy intakes were calculated using the Chinese Food Composition Table, 2009.[25] The flavonoid values were derived from 2 US Department of Agriculture (USDA) databases of flavonoids[26] and proanthocyanidins,[27] and 1 Hong Kong database of isoflavones.[28] The consumption of vitamin D and β-carotene were calculated based on the USDA databases of carotenoids[29] and vitamin D.[30]

Trained physicians or research staff interviewed all participants with structured questionnaire containing demographic characteristics, habitual history (lifelong history of tobacco use, alcohol consumption, and tea drinking), history of selected diseases, family history of hip fracture, physical activity, and drug use.

Dietary Inflammatory Index

Descriptions of the construction of the DII[8] and its validation[7] have been published previously. Briefly, the DII is a scoring algorithm based on an extensive review of literature that examined the association between 6 well-known inflammatory biomarkers (IL-1β, IL-4, IL-6, IL-10, TNF-α, and CRP) and potential dietary factors. A total of 45 specific foods and nutrients were found to be related to these inflammatory markers and, therefore, became components of the DII.

Mean intake of every food variable is transformed with standardized values from a world database into a z score, then converted to a percentile and centered by doubling and subtracting 1. Finally, the centered percentile score for each food variable was multiplied by its associated literature-derived inflammatory effect score, and then these were summed across the 45 dietary variables, thus, providing an individual DII score. The higher the DII score, the more proinflammatory the diet; more negative values indicate more anti-inflammatory diets. For the current study, data on 34 of the 45 possible food parameters were available for DII calculation. The following proinflammatory factors were used to compute the score: total intakes of energy, protein, carbohydrate, total fat, saturated fatty acids, cholesterol, and vitamin B_{12}. These were the anti-inflammatory factors: alcohol, tea, monounsaturated fatty acids, polyunsaturated fatty acids (PUFAs), n−3 PUFAs, n−6 PUFAs, fiber, magnesium, niacin, thiamine, riboflavin, vitamin B_6, vitamin A, vitamin C, vitamin D, vitamin E, folic acid, beta carotene, anthocyanidins, flavan-3-ol, flavonols, flavonones, flavones, and isoflavones. The calculation of DII was conducted by 2 coauthors who were blinded to the group status.

Statistical Analysis

Participants were categorized into sex-specific quartiles based on the distribution of DII scores among the control participants, with sex-specific cutoffs being applied to the case group. Conditional logistic regression was used to assess the association between the DII and hip fracture risk. For each factor, the lowest quartile group was the referent. Univariable and multivariable analyses were applied to calculate odds ratios (ORs) with their corresponding 95% confidence intervals (CIs). Covariates included in the multivariable analyses were body mass index [BMI = weight (kg)/height $(m)^2$], education, personal income, smoking, physical activity, daily energy intake, family history