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Original article

Dietary inflammatory index and mental health: A cross-sectional analysis of the relationship with depressive symptoms, anxiety and well-being in adults

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SUMMARY

Background & aims: The relationship between diet, inflammation and mental health is of increasing interest. However, limited data regarding the role of dietary inflammatory potential in this context exist. Therefore the aim of this work was to examine associations between the inflammatory potential of habitual diet and mental health outcomes in a cross-sectional sample of 2047 adults (50.8% female).
Methods: Diet was assessed using a self-completed food frequency questionnaire from which dietary inflammatory index (DII®) scores were determined. Depressive symptoms, anxiety and well-being were assessed using the CES-D, HADS-A and WHO-5 screening tools.
Results: Logistic regression analyses revealed that higher energy-adjusted DII (E-DII®) scores, reflecting a more pro-inflammatory diet, were associated with increased risk of depressive symptoms (odds ratios (OR) 1.70, 95% confidence intervals (CI) 1.23–2.35, $p = 0.001$) and anxiety (OR 1.60, 95% CI 1.15–2.24, $p = 0.006$) and lower likelihood of well-being (OR 0.62, 95% CI 0.46–0.83, $p = 0.001$), comparing highest to lowest tertile of E-DII. In gender-stratified analyses associations were noted in women only. Women with the highest E-DII scores were at elevated risk of depressive symptoms (OR 2.29, 95% CI 1.49–3.51, $p < 0.001$) and anxiety (OR 2.00, 95% CI 1.30–3.06, $p = 0.002$), while likelihood of reporting good well-being was lower (OR 0.55, 95% CI 0.36–0.79, $p = 0.002$), relative to those with the lowest E-DII scores.
Conclusions: These findings, which suggest that a pro-inflammatory diet is associated with adverse mental health, may be of clinical and public health significance regarding the development of novel nutritional psychiatry approaches to promote good mental health.

1. Introduction

The prevalence of mental health disorders, which has been increasing over recent decades, represents a major public health concern. Current worldwide prevalence of depression is estimated to be 350 million [1]. According to the WHO more than one in four of European adults have experienced a psychological disorder [2]. Data from the Global Burden of Disease Study highlight the significant contribution of mental health and depressive disorders to the global burden of non-communicable disease, through years lived with disability [1]. Thus identification of new preventive measures or strategies to attenuate disease development is essential. Multifactorial processes, most likely involving biological, social, genetic and environmental factors, contribute to an individual's psychological health and well-being [3]. There is growing interest in the possible contribution of modifiable lifestyle behaviours, such as habitual dietary intake, to the development of common mental

Abbreviations: CES-D, centre for epidemiologic studies depression scale; CRP, C reactive protein; CVD, cardiovascular disease; DII, dietary inflammatory index; FFQ, food frequency questionnaire; HADS, hospital anxiety and depression scale; IL-6, interleukin 6; OR, odds ratio; TNF-α, tumour necrosis factor α; WHO-5, World Health Organization-5 well being index.

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health disorders. Moreover, rather than focussing on selected nutrients or foods the emerging field of nutritional psychiatry has turned its attention to investigating the relationship between dietary patterns and mental health.

Healthy dietary patterns such as the Norwegian and Mediterranean diets, which are characterized by a high intake of fruit, vegetables, wholegrains, fish and lean meats, have been associated with lower likelihood of developing depression [4,5]. Conversely, increased risk of depression has been reported among those with an unhealthy or Western-style diet, which is typified by high consumption of energy-dense, high-fat and high-sugar products, processed and red meats, refined grains and alcohol [6,7]. However meta-analysis and systematic reviews have not yet provided confirmation, partly due to a limited number of studies [4,5]. Dietary patterns and dietary quality also have been linked with well-being, anxiety and stress [8–11], indicating that the biological mechanisms underpinning diet-mental health associations extend beyond depressive symptoms. Inflammation has been proposed as a substrate for mechanisms linking diet to mental health. Increasing evidence suggests that depression is associated with increased concentrations of pro-inflammatory cytokines [12,13]. Despite a high degree of heterogeneity observed in earlier meta-analyses, a recent and the largest meta-analysis of cytokines and chemokines in major depressive disorder (MDD) provides confirmation that concentrations of tumour necrosis factor α (TNF-α) and interleukin 6 (IL-6), amongst other cytokines and chemokines, are significantly elevated in individuals with MDD [14].

Limited data regarding the association between the inflammatory potential of habitual diet and mental health conditions exist. Lucas et al. identified a dietary pattern related to circulating levels of C reactive protein (CRP), IL-6 and TNF-α receptor 2 and examined its relationship with risk of depression among participants in the Nurses' Health Study [15]. They reported a 30–40% increased risk of depression, depending on definition, comparing highest to lowest quintiles (i.e. most pro-inflammatory vs. most anti-inflammatory). In recent years the Dietary Inflammatory Index (DII®) was developed to characterize an individual's diet on a continuum from maximally anti- to pro-inflammatory [16]. Thus far, the DII has been associated with CRP [17,18], IL-6 [19,20], and TNF-α [19]. To date, only three studies have examined the association between the DII and depression; all report increased risk of incident depression among those with the most pro-inflammatory diet [21–23]. However, no data on the relationship between dietary inflammatory potential and other mental health measures such as anxiety and well-being exist. Therefore, the primary objective of the present study was to examine associations between dietary inflammatory potential and a range of mental health measures including depressive symptoms, anxiety and psychological well-being in a cross-sectional sample of men and women.

2. Subjects and methods

2.1. Study design and subject recruitment

The Cork and Kerry Diabetes and Heart Disease Study (Phase II) was a single-centre, cross-sectional study conducted between 2010 and 2011 [24]. A population representative random sample was recruited from a large primary care centre in Mitchelstown, County Cork, Ireland (Mitchelstown cohort). The Livinghealth Clinic includes 8 general practitioners and serves a catchment area of approximately 20,000 with a mix of urban and rural residents. Mitchelstown cohort participants were randomly selected from all registered attending patients in the 50–69-year age group. In total, 3807 potential participants were selected from the practice list. Following exclusion of duplicates, deaths and ineligibles, 3043 were invited to participate in the study and of these 2047 White individuals (49.2% male) completed the questionnaire and physical examination components of the baseline assessment (response rate 67%). Ethics committee approval conforming to the Declaration of Helsinki was obtained from the Clinical Research Ethics Committee of University College Cork. All participants provided written informed consent. Following exclusion of individuals without food frequency questionnaire (FFQ) data the remaining 1992 participants were used in the analyses.

2.2. Clinical and anthropometric data

All participants attended the clinic in the morning after an overnight fast (minimum 8 h). Fasting blood samples were taken on arrival. Participants completed a General Health Questionnaire (GHQ), the FFQ, and the International Physical Activity Questionnaire (IPAQ). Data on age, gender, medical history and medication use were gathered through a self-completed GHQ. Depressive symptoms, well-being and anxiety were assessed using a range of questionnaires including the 20-item Centre for Epidemiologic Studies Depression Scale (CES-D) [25], designed to evaluate the frequency and severity of depressive symptoms, the Hospital Anxiety and Depression Scale (HADS), using only the anxiety subscale [26] and the World Health Organisation (WHO) −5 Well Being Index [27]. Subjects with CES-D scores ≥16, HADS scores ≥13 and WHO-5 scores of >13 were identified as having depressive symptoms, anxiety and good well-being, respectively. History of depression and anxiety was assessed using the following questions: “Have you ever had depression?” “Have you ever had anxiety?” Subjects were then asked “If yes, when did it start? In the last year/1–5 years ago/>5 years ago.” Data regarding antidepressant medication use were collected. Subjects who indicated a diagnosis of depression or anxiety or current anti-depressant medication use were classified as having a mental health disorder. The presence of cardiovascular disease (CVD) was obtained from the GHQ by asking study participants if they had been diagnosed with any one of the following seven conditions: Heart Attack (including coronary thrombosis or myocardial infarction), Heart Failure, Angina, Aortic Aneurysm, Hardening of the Arteries, Stroke, or any other Heart Trouble. Subjects who indicated a diagnosis of any one of these conditions were classified as having CVD. Type 2 diabetes was defined according to the American Heart Association guidelines of fasting plasma glucose (FPG) ≥ 7 mmol/L or doctor diagnosed diabetes. Blood pressure was measured according to the European Society of Hypertension Guidelines using an Omron M7 Digital BP monitor on the right arm, after a 5-min rest in the seated position. The average of the second and third measurements was used for analyses. Hypertension was defined as average systolic blood pressure (SBP) ≥ 140 mmHg or diastolic blood pressure (DBP) ≥ 90 mmHg or being on hypertensive medication. Anthropometric measurements were recorded with calibrated instruments according to a standardised protocol. Body weight was measured in kilograms without shoes; to the nearest 100 g using a Tanita WB100MA® weighing scales (Tanita Corporation, IL, USA). Height was measured in centimetres to one decimal place using a Seca Leicester® height gauge (Seca, Birmingham, UK). BMI was calculated as weight (kg)/height $(m)^2$. Individuals with a BMI ≥ 30 kg/m^2 were defined as obese.

2.3. Dietary inflammatory index

Diet was assessed using a modified version of the self-completed EPIC FFQ [28]. This FFQ was then incorporated into the Irish National

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