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Dietary patterns derived by reduced rank regression (RRR) and depressive symptoms in Japanese employees: The Furukawa nutrition and health study

Takako Miki [a,b,*], Takeshi Kochi [c], Keisuke Kuwahara [a,d], Masafumi Eguchi [c], Kayo Kurotani [a], Hiroko Tsuruoka [c], Rie Ito [c], Isamu Kabe [c], Norito Kawakami [b], Tetsuya Mizoue [a], Akiko Nanri [a]

[a] Department of Epidemiology and Prevention, Center for Clinical Sciences, National Center for Global Health and Medicine, Tokyo, Japan
[b] Department of Mental Health, Graduate School of Medicine, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
[c] Department of Health Administration, Furukawa Electric Corporation, Tokyo, Japan
[d] Teikyo University Graduate School of Public Health, Tokyo, Japan

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ABSTRACT

Depression has been linked to the overall diet using both exploratory and pre-defined methods. However, neither of these methods incorporates specific knowledge on nutrient-disease associations. The aim of the present study was to empirically identify dietary patterns using reduced rank regression and to examine their relations to depressive symptoms. Participants were 2006 Japanese employees aged 19–69 years. Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale. Diet was assessed using a validated, self-administered diet history questionnaire. Dietary patterns were extracted by reduced rank regression with 6 depression-related nutrients as response variables. Logistic regression was used to estimate odds ratios of depressive symptoms adjusted for potential confounders. A dietary pattern characterized by a high intake of vegetables, mushrooms, seaweeds, soybean products, green tea, potatoes, fruits, and small fish with bones and a low intake of rice was associated with fewer depressive symptoms. The multivariable-adjusted odds ratios of having depressive symptoms were 0.62 (95% confidence interval, 0.48–0.81) in the highest versus lowest tertiles of dietary score. Results suggest that adherence to a diet rich in vegetables, fruits, and typical Japanese foods, including mushrooms, seaweeds, soybean products, and green tea, is associated with a lower probability of having depressive symptoms.

1. Introduction

Depression, a common condition in the general population, reduces work productivity, lowers quality of life, and increases mortality (Doris et al., 1999). Previous epidemiologic evidence suggested that several kinds of nutrients and foods, such as n-3 polyunsaturated fatty acids, folate, other vitamins, minerals, fruits, and vegetables, are beneficial against depression, but the results have been generally inconclusive (Murakami and Sasaki, 2010). In addition, the investigation of foods or nutrients in isolation may not be a suitable way to assess the interactive or synergic effects among nutrients (Hu, 2002). In daily life, we do not consume foods or nutrients in isolation but rather in combination as meals. This fact highlights the importance of exploring dietary patterns associated with depression.

Dietary pattern analysis, which assesses the effect of overall diet on disease risk, has emerged as a complement to traditional approaches (Hu, 2002). This method may be particularly useful when multiple nutrients are involved in the development of a disease (Hu, 2002). Two types of technique have been commonly used to examine the association between dietary pattern and depression: *a priori* defined methods (e.g., diet quality score) and exploratory methods (e.g., principal component analysis). In their recent meta-analysis of dietary patterns derived by these methods, Lai et al. suggested that a healthy diet was associated with reduced odds of depression. Besides, the authors also found significant heterogeneity among studies, making it difficult to obtain a

* Corresponding author at: Department of Mental Health, Graduate School of Medicine, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. Fax: +81 3 5841 3592.
E-mail address: takakomiki-tky@umin.ac.jp (T. Miki).

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reliable summary estimate of the association between dietary patterns and depression (Lai et al., 2014).

These methods have advantages and limitations. Diet quality score, which is calculated based on existing knowledge such as recommended diet, captures only limited aspects of the diet and does not consider the correlation structure of food and nutrient intakes (Hoffmann et al., 2004). In contrast, an exploratory statistical approach determines dietary patterns based solely on inter-correlations among dietary variables. However, this method does not incorporate any existing knowledge of nutrient-disease associations and may not capture dietary patterns relevant to disease risk (Hoffmann et al., 2004). Neither method aims to identify dietary patterns that are specific to a disease of interest (Michels and Schulze, 2005).

To overcome these issues, a new *a posteriori* method has been proposed, reduced rank regression (RRR) (Hoffmann et al., 2004). This technique identifies dietary patterns based on several nutrients or biomarkers that have been linked to the disease of interest. This combination of disease-specific knowledge and dietary information of the study population suggests that RRR is an appropriate and promising statistical method to determine dietary patterns associated with an outcome of interest (Hoffmann et al., 2004). To date, RRR has been applied to explore the relationship between an inflammation-prone dietary pattern and depression risk (Lucas et al., 2014). To our knowledge, however, it has not been used to identify dietary patterns based on knowledge of nutrient-mood associations.

Here, we used RRR to identify dietary patterns and investigate their association with depressive symptoms among Japanese employees.

2. Methods

2.1. Study procedure and participants

Data for the present study was derived from the Furukawa Nutrition and Health Study, which has been described in detail elsewhere (Nanri et al., 2014). A nutritional epidemiological survey was conducted during periodic health checks in April 2012 (factory A) and May 2013 (factory B) among employees of a manufacturing company and their affiliated companies located in Japan's Kanto region. Of 2828 health examination attendants (11% women), 2162 employees agreed to participate in the study (response rate, 76%). We assessed lifestyle, including diet and health status, and obtained health examination data. The protocol of the study was approved by the ethics committee of the National Center for Global Health and Medicine, Japan, and secondary analysis of the Furukawa Nutrition and Health Study data was approved by the ethics committee of the University of Tokyo. Written informed consent was obtained from each participant.

We excluded 100 participants with a history of cancer ($n=20$); cardiovascular disease ($n=25$); chronic hepatitis ($n=2$); kidney disease, including nephritis ($n=11$); pancreatitis ($n=3$); and mental disorders, such as depression and neurotic disorder ($n=45$). Some participants had two or more these conditions. We excluded these participants because such diseases might affect dietary habits or depressive symptoms and thereby cause reverse causality. Of the remaining 2062, we excluded 11 individuals who did not return the study questionnaires and 33 participants who had missing data on the outcome and covariates of the present analysis. We additionally excluded 12 participants with extreme total energy intake (>3 standard deviations). Finally, 2006 participants (1792 men and 214 women) aged 19–69 years old were included in the analysis.

2.2. Depressive symptoms

Depressive symptoms were assessed using a Japanese version (Shima et al., 1985) of the Center for Epidemiologic Studies Depression (CES-D) scale (Radloff, 1977). This scale consists of 20 items addressing 6 typical symptoms of depression experienced during the preceding week, including depressed mood, guilt or worthlessness, helplessness or hopelessness, psychomotor retardation, loss of appetite, and sleep disturbance. Each item is scored on a scale of 0–3 according to the frequency of the symptom, and the scores are then summed to give the total CES-D score, ranging from 0 to 60. The criterion validity of the CES-D scale has been well established in both Western (Radloff, 1977) and Japanese (Shima et al., 1985) subjects. Participants with a CES-D score ≥ 16 were considered to have depressive symptoms (Radloff, 1977). Another cutoff of ≥ 19, which might be suitable for Japanese workers (Wada et al., 2007), was also used.

2.3. Dietary assessment

Dietary habits during the preceding one-month period were assessed using a validated brief self-administered diet history questionnaire (BDHQ) (Kobayashi et al., 2012) consisting of five sections: (1) intake frequency of 46 food and non-alcoholic beverage items; (2) daily intake of rice and miso soup; (3) frequency of alcoholic drinking and amount of consumption of five alcoholic beverages per typical drinking occasion; (4) usual cooking method; and (5) general dietary behavior. Dietary intakes for 58 food and beverage items, energy, and selected nutrients were estimated using an ad hoc computer algorithm for the BDHQ (Kobayashi et al., 2011), with reference to the Standard Tables of Food Composition in Japan (Science and Technology Agency, 2005a; Science and Technology Agency, 2010b). According to a validation study of the BDHQ using 16-day weighted dietary records as standard, correlation coefficients were >0.40 for the intake of many foods, beverages (Kobayashi et al., 2011), and nutrients used in our study (Kobayashi et al., 2012).

2.4. Other variables

The survey questionnaire assessed marital status, job grade, night and rotating shift work, overtime work, smoking, physical activity during work and housework or in commuting to work, and leisure-time physical activity. Physical activity during work and housework or in commuting and leisure-time were expressed as the sum of metabolic equivalents (METs) multiplied by the duration of time (in hours) across physical activities with different levels.

2.5. Statistical analysis

Dietary patterns were determined using RRR techniques (Hoffmann et al., 2004). RRR identifies linear functions of food groups (i.e., the dietary patterns) that explain as much of the variation of selected nutrients that are potentially protective or contributing factors to the relevant disease as possible. Therefore, the score for dietary patterns analyzed by this method is likely to be associated with the disease. We selected the following six nutrients as potentially protective factors for depression: folate (Gilbody et al., 2007), vitamin C (Woo et al., 2006; Oishi et al., 2009), magnesium (Jacka et al., 2009, 2012; Yary et al., 2013), calcium (Bae and Kim, 2012), iron (Woo et al., 2006), and zinc (Amani et al., 2010; Jacka et al., 2012; Maserejian et al., 2012; Yary and Aazami, 2012; Vashum et al., 2014). In addition, we found that these nutrients were inversely associated with depressive symptoms in a preliminary analysis in our study population. Dietary

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