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Macronutrient intake and depressive symptoms among Japanese male workers: The Furukawa Nutrition and Health Study

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ABSTRACT

This study was aimed to examine the cross-sectional association of protein, carbohydrate, and fat intake with depressive symptoms among 1794 Japanese male workers aged 18–69 years who participated in a health survey. Dietary intake was assessed with a validated self-administered diet history questionnaire. Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression (CES-D) scale. Odds ratio of depressive symptoms (CES-D scale of ≥ 16) was estimated by using multiple logistic regression with adjustment for covariates including folate, vitamin B6, vitamin B12, polyunsaturated fatty acid, magnesium, and iron intake. Multivariable-adjusted odds ratio of depressive symptoms for the highest quartile of protein intake was 26%, albeit not statistically significant, lower compared with the lowest. The inverse association was more evident when a cutoff value of CES-D score ≥ 19 was used. The multivariable-adjusted odds ratios (95% confidence intervals) for the highest through lowest quartile of protein intake were 1.00 (reference), 0.69 (0.47–1.01), 0.69 (0.44–1.09), and 0.58 (0.31–1.06) (P for trend=0.096). Neither carbohydrate nor fat intake was associated with depressive symptoms. Our findings suggest that low protein intake may be associated with higher prevalence of depressive symptoms in Japanese male workers.

1. Introduction

Depression is a common illness, with an estimated 350 million people affected and results from a complex interaction of social, psychological, and biological factors (WHO, 2012). Regarding environmental factor, diet has recently received considerable attention as a modifiable factor that could influence mental health. Growing body of literature indicates the association of micronutrients such as folate (Gilbody et al., 2007), vitamin B group (Dimopoulos et al., 2007; Merete et al., 2008; Murakami et al., 2008, 2010; Penninx et al., 2000; Sánchez-Villegas et al., 2009; Tiemeier et al., 2002; Watanabe et al., 2012), and magnesium (Jacka et al., 2009; Yary et al., 2013) with depression. There is evidence supporting of protective role of macronutrient on depression in animal studies. Several amino acids that constitute protein have been shown to have beneficial effects on mental function (Wong and Ong, 2001). Carbohydrate intake could lead to elevated insulin levels resulting in the release of tryptophan from protein, which in the brain is metabolized to serotonin (Fernstrom and Wurtman, 1971). As regards fat, some specific types of fatty acid have been reported to be associated with depression in human studies (Bots et al., 2008; German et al., 2011; Sánchez-Villegas et al., 2011; Woo et al., 2006).

However, several observational studies have observed no association of protein (Aparicio et al., 2013; German et al., 2011; Oishi et al., 2009; Park et al., 2010), carbohydrate (Aparicio et al., 2013; German et al., 2011; Park et al., 2010; Woo et al., 2006), and total fat (Aparicio et al., 2013; Bots et al., 2008; German et al., 2011; Oishi et al., 2009; Park et al., 2010; Woo et al., 2006) intake with depressive symptoms. The results of these studies may be limited due to relatively small in size (number of subjects less than 300 (Aparicio et al., 2013; German et al., 2011; Oishi et al., 2009; Park et al., 2010)), inclusion of elderly people only (60 years old and above (Aparicio et al., 2013; Bots et al., 2008; German et al., 2011; Oishi et al., 2009; Woo et al., 2006)), and/or un-adjustment for important factors associated with depressive symptoms

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including physical activity and sleeping habit (Aparicio et al., 2013; Bots et al., 2008; German et al., 2011; Oishi et al., 2009; Park et al., 2010; Woo et al., 2006). Furthermore, given greater biological value of animal protein than vegetable protein (Bourre, 2006), animal protein may be more beneficial for mental health than plant protein. However, no study examined the association of protein by food sources. Here, we examined the association of dietary intake of protein, carbohydrate, and fat with depressive symptoms among Japanese male workers. We also examined the association of protein and fat derived from animal and plant sources.

2. Methods

2.1. Study procedure and participants

As part of the Japan Epidemiology Collaboration on Occupational Health Study, the Furukawa Nutrition and Health Study, a nutritional epidemiological survey was conducted at the time of the periodic health examination among workers of a manufacturing company and its affiliated ones in Chiba Prefecture and Kanagawa Prefecture, Japan, in April 2012 and May 2013. Prior to the health checkup, we asked approximately 2800 workers to participate in the survey and fill out two types of survey questionnaire (one specifically designed for diet and another for overall health-related lifestyle). Of these, 2162 subjects (1930 male and 232 female aged 18–70 years) agreed to participate in the survey with a response rate of about 77%. On the day of health checkup, research staff checked the questionnaire for completeness and, where necessary, clarified with the subjects. Participants were asked to donate 7 ml of venous blood. Additionally, we obtained health checkup data including results of anthropometric and biochemical measurements and information on history of diseases. The study protocol was approved by the Ethics Committee of the National Center for Global Health and Medicine, Japan. Written informed consent was obtained from all participants prior to the survey.

Of 2162 participants, we excluded 100 participants who reported a history of cancer ($n=20$), cardiovascular disease ($n=25$), chronic hepatitis ($n=2$), chronic kidney disease including nephritis ($n=11$), pancreatitis ($n=3$), and mental disease ($n=45$). Of these, we further excluded 11 individuals who did not return study questionnaire ($n=3$) and dietary questionnaire ($n=9$). Some participants had two or more conditions for exclusion. Furthermore, we excluded 30 participants who had missing data on outcome and covariates used in the present analysis. And then, female were excluded ($n=214$). Of the 1806 remaining participants, those with extremely high or low energy intake (exceeding 3 standard deviations) were excluded, leaving 1794 male for analysis. We analyzed the data in male only for the following reasons: 1) the number of female was small, 2) the etiology of mood disorder differs biologically and sociologically between male and female, and 3) dietary habits and certain nutrient intakes differ between male and female.

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), which was incorporated into the lifestyle questionnaire. This scale consists of 20 questions addressing 6 symptoms of depression, including depressed mood, guilt or worthlessness, helplessness or hopelessness, psychomotor retardation, loss of appetite, and sleep disturbance experienced during the preceding week. Each question is scored on a scale of 0–3 according to the frequency of the symptom, and the total CES-D score ranges from 0 to 60. The criterion validity of the CES-D scale has been well established both in Western (Radloff, 1977) and Japanese (Shima et al., 1985) subjects. Depressive symptoms were defined as present when subjects had a CES-D score of ≥ 16. A cutoff value of ≥ 19, which may be suitable for Japanese (Wada et al., 2007), was also used.

2.3. Dietary assessment

Dietary habits during the preceding month were assessed using a validated brief self-administered diet history questionnaire (BDHQ) (Kobayashi et al., 2012), which consists of five sections: 1) the frequency of 46 food and non-alcoholic beverage intake; 2) daily frequency of rice and miso soup intake; 3) the frequency of alcoholic drinking and the amount of consumptions for five alcoholic beverages per typical drinking occasion; 4) usual cooking methods; and 5) 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, with reference to the standard tables of food composition in Japan (Science and Technology Agency, 2005). Protein, carbohydrate, and fat intake were adjusted for total energy intake by using nutrient densities (% energy). According to the validation study of the BDHQ using 16-day weighed dietary records as the gold standard, Pearson correlation coefficient for energy-adjusted intake of carbohydrate, fat, and protein, in 92 male and 92 female of 31–76 years of age was 0.64, 0.59, and 0.38 respectively, in male and 0.48, 0.56, and 0.35 respectively, in female (Kobayashi et al., 2012).

2.4. Other variables

Marital status, night and rotating shift work, job grade, smoking, alcohol drinking, physical activity during work and housework or on commuting to work, and leisure-time physical activity were elicited in the questionnaire. Physical activities during work and housework or on commuting and leisure-time were expressed as the sum of metabolic equivalent (MET) multiplied by the duration of time (in hours) across all levels of physical activity. Body height was measured to the nearest 0.1 cm with subjects standing without shoes. Body weight in light clothes was measured to the nearest 0.1 kg. Body mass index was calculated as weight in kilograms divided by squared height in meters.

2.5. Statistical analysis

Participants were classified into quartile of % energy from protein, carbohydrate, or fat intake. Data were expressed as means (standard deviation) and percentages for continuous variables and categorical variables. Trend association between confounding factors and each macronutrient intake were tested by using linear regression analysis for continuous variables and the Mantel–Haenszel chi-square test for categorical variables, treating median intake in each quartile of macronutrient intake as continuous variable.

Multiple logistic regression was performed to estimate odds ratios and 95% confidence intervals of depressive symptoms for the quartile of protein, carbohydrate, and fat intake, taking the lowest quartile category as a reference. Variables identified as potential confounding factors, due to their association with macronutrient intake and depression, were included in the models. The first model was adjusted for age (year, continuous) and site (survey in April 2012 or in May 2013), and the second model was further adjusted for body mass index (kg/m^2, continuous), marital status (married or other), job grade (high, middle, or low), night or rotating shift work (yes or no), smoking (never-smoker, quitter, current smoker consuming <20 cigarettes/day, or current smoker consuming ≥ 20 cigarettes/day), leisure-time physical activity (METs-hour/week, quartile), physical activity at work and housework or on commuting to work (METs-hour/day, quartile), alcohol consumption (nondrinker, occasional drinker, drinker consuming <23 g of ethanol/day, drinker consuming 23– <46 g of ethanol/day, or drinker consuming ≥ 46 g of ethanol/day), total energy intake (kcal/day, continuous), and intake of folate (μg/1000 kcal), vitamin B6 (mg/1000 kcal), vitamin B12 (μg/1000 kcal), polyunsaturated fatty acids (% energy), magnesium (mg/1000 kcal), and iron (mg/1000 kcal). These nutrients including folate, vitamin B6, vitamin B12, polyunsaturated fatty acids, magnesium, and iron have previously been shown to be associated with decreased depression. Moreover, protein, carbohydrate, and fat intake (% energy) were mutually adjusted. Trend association was assessed by treating median intake in each quartile of macronutrient intake as continuous variable. We also analyzed protein and fat derived from animal and plant sources. Two-side P values <0.05 were regarded as statistically significant. All analyses were performed using Statistical Analysis System (SAS) software version 9.3 (SAS Institute, Cary, NC, USA).

3. Results

The characteristics of study participants according to quartile categories of protein, carbohydrate, and fat intake are shown in Table 1. Participants with a higher intake of protein or fat were less likely to be current smokers, to be engaged in night or rotating shift work, and to consume carbohydrate. They also consumed more folate, vitamin B6, vitamin B12, polyunsaturated fatty acids, magnesium, and iron. Participants with a higher intake of protein were older compared with those with a lower intake. Participants with a higher carbohydrate intake were younger and were more likely to be engaged in night or rotating shift work and physically active in job. In addition, they were less likely to consume fat, protein, folate, vitamin B6, vitamin B12, polyunsaturated fatty acids, magnesium, and iron.

In total, 499 participants (27.8%) were identified as having depressive symptoms. The odds ratios of depressive symptoms according to quartile categories of protein, carbohydrate, and fat intake are shown in Table 2. Protein intake was suggestively associated with decreased prevalence of depressive symptoms