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Original article

Dietary pattern, serum magnesium, ferritin, C-reactive protein and anaemia among older people

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SUMMARY

Background & aims: Epidemiological data of dietary patterns and anaemia among older Chinese remains extremely scarce. We examined the association between dietary patterns and anaemia in older Chinese, and to assess whether biomarkers of serum magnesium, C-reactive protein (CRP) and serum ferritin can mediate these associations.

Methods: We analysed the 2009 China Health and Nutrition Survey data (2401 individuals aged ≥60 years for whom both dietary and biomarker data are available). Dietary data was obtained using 24 h-recall over three consecutive days. Fasting blood samples and anthropometry measurement were also collected. Factor analysis was used to identify dietary patterns. Factor scores representing dietary patterns were used in Poisson regression models to explore the association between each dietary pattern and anaemia.

Results: Of the 2401 participants, 18.9% had anaemia, 1.9% had anaemia related to inflammation (AI), and 1.3% had iron-deficiency anaemia (IDA). A traditional dietary pattern (high intake of rice, pork and vegetables) was positively associated with anaemia; a modern dietary pattern (high intake of fruit and fast food) was inversely associated with anaemia. Progressively lower magnesium and BMI levels were associated with increasing traditional dietary quartiles; while a progressively higher magnesium and BMI levels were associated with increasing modern dietary quartiles ($p < 0.001$). There were no significant differences ($p > 0.05$) in CRP and serum ferritin across quartiles for either dietary pattern. In the fully adjusted model, the prevalence ratio (PR) of anaemia, comparing the fourth quartile to the first quartile, was 1.75 (95% CI: 1.33; 2.29) for a traditional dietary pattern, and 0.89 (95% CI: 0.68; 1.16) for a modern dietary pattern. The association between dietary patterns and anaemia is mediated by serum magnesium.

Conclusion: Traditional dietary pattern is associated with a higher prevalence of anaemia among older Chinese. Future studies need to examine whether correcting micronutrient deficiency (e.g. magnesium) by promoting overall healthy diet, rather than iron supplementation, is a suitable strategy for anaemia prevention in older Chinese people.

1. Introduction

Anaemia is a major public health problem in developing countries [1]. It increases the risks of cardiovascular disease, and is associated with a lower quality of life. The prevalence of anaemia was 15.2% in 2002 China national data [2,3]. And its prevalence increased with age [4]. The only previously trialled measure to prevent anaemia was the use of iron-fortified soy sauce in some cities in China, which aimed to reduce the prevalence of iron deficiency anaemia among women of reproductive age [5]. Thus, prevention of anaemia is still a challenge as only limited measures have been taken against this public health problem [3].

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Anaemia of chronic inflammation (AI) and iron-deficiency anaemia (IDA) are common types of anaemia. Factors associated with anaemia, include infectious diseases, iron deficiency, a lack of certain vitamins, and other nutritional deficiencies that influence haemoglobin metabolism [3]. AI develops as a result of chronic inflammatory disorders such as cancer, chronic infections, or autoimmune diseases, all of which are common in older populations [6]. C-reactive protein (CRP: infection indicator) and serum ferritin (marker for iron stored) are important biochemical parameters for AI and IDA [7]. An negative association between serum magnesium and anaemia, and between ferritin and anaemia, has been reported in previous studies [8,9].

Current knowledge about the link between dietary factors and anaemia has mainly focused on individual nutrients [8,9]. However, people eat a variety of foods in real life. Dietary patterns can be useful indicators of the impact of diet on health outcomes, as they illustrate the combined effects of food consumed. There is growing interest in the association between dietary pattern and disease in the Chinese population, particularly for cardiovascular diseases, obesity and hypertension [10]. However there are only a limited number of studies on the association between dietary pattern and anaemia in the Chinese population [3]. Furthermore, no previous study has reported the association between dietary patterns and anaemia by looking at serum magnesium, ferritin and CRP.

Although structural population ageing (greater proportion of people aged 60 and over, and a smaller proportion of people in their young and middle ages) has been identified since 1999 in China, population surveys of diet and nutrition often do not include people who are aged 60 or over [11]. The objective of the present study was to fill this gap by investigating dietary patterns in relation to the prevalence of anaemia considering key biomarkers and BMI, especially for the older Chinese population.

2. Materials and methods

2.1. China Health and Nutrition Survey (CHNS)

CHNS is an ongoing open cohort longitudinal survey of nine waves (1989–2011). The survey uses a multistage random-cluster sampling process to select samples from nine provinces [12], which covers all levels of socioeconomic development in China. Details are described elsewhere [11,13]. We included 2401 participants aged 60 years or over in the present study for whom both dietary and biomarker data were collected in 2009. All participants gave their written informed consent. The survey was approved by the institutional review committees of the University of North Carolina and the National Institute of Nutrition and Food Safety [12]. The University of Newcastle, Australia has also approved use of data in this study (Approval Number: H-2013-0360).

2.2. Dietary data collection and food grouping

Dietary assessment is based on a combination of data collected at the individual level, and a food inventory taken at the household level. Household food consumption was determined by weighing all food consumed by the household over three consecutive randomly selected days. The three consecutive days during which detailed household food consumption data have been collected were randomly allocated from Monday to Sunday and are almost equally balanced across the seven days of the week for each sampling unit. Household food consumption was determined by examining changes in inventory from the beginning to the end of each day, in combination with a weighing and measuring technique. All food remaining after the last meal before initiation of the survey was weighed and recorded. All purchases as well as foods produced at home were recorded. Wasted foods were weighed, or estimated when weighing was not possible. At the end of the survey, all remaining food was again weighed and recorded.

For individual dietary data, each household member was asked to report all food consumed over the previous 24 h for each of the three days, including food consumed away from home. Interviewers recorded the types and amounts of food consumed at each meal during the previous day. The amount of food in each dish was estimated from the household inventory and the proportion of each dish consumed was reported by each person. Details are described elsewhere [11,12].

The food groups included were based on a food system developed specifically for the CHNS and the Chinese Food Composition Table [14,15]. Initially, 33 food groups were included. As some food items were consumed by less than 5% of participants, food intakes were further collapsed into 27 food groups based on similarity of nutritional profiles. The 27 food groups included are: rice; wheat flour and wheat noodles; wheat buns and bread; corn and coarse grains; deep-fried wheat; starchy roots and tubers; pork; organ meat; processed meats; poultry and game; other meat (beef, lamb, donkey and rabbit); fish and seafood; milk; eggs and egg products; fresh legumes; legume products; dried legumes; fresh vegetables, non-leafy; fresh vegetables, leafy; pickled, salted or canned vegetables; dried vegetables; cakes; fruits; nuts and seeds; beer; liquor and fast food.

Mean consumption of each food group per day was calculated from dietary data, as liang (Chinese ounce, 1 liang = 50 g). For consumption of alcoholic beverages, soft drink and tea, mean consumption was calculated from the questionnaire. Respondents were asked ‘do you drink any kind of alcoholic beverage (beer or liquor)?’, and were asked further questions on drinking frequency, types and quantity consumed in a week. Also, participants were asked ‘do you normally drink tea?’ and ‘do you drink soft drinks or sugared fruit drinks?’ Further questions on drinking frequency and number of cups consumed per day (a cup is approximately 240 mL) were asked. Energy intake was also calculated by CHNS based on Chinese Food Composition Table.

2.3. Biomarker and anthropometric data

Blood was collected by venepuncture and tested immediately for glucose and haemoglobin A1c (HbA1c) after an overnight fast for individuals age 7 or above in 2009 [12]. As described above, a multistage, random cluster process was used to draw the sample in each province. Total 9244 individuals aged 7 and older provided fasting blood and anthropometry data. Among these, 2401 were aged 60 and above. Plasma and serum samples were then frozen, and stored at −86 °C for later laboratory analysis. All samples were analysed in a national central lab in Beijing with strict quality control [16].

We focus on biomarkers of high sensitivity CRP, haemoglobin, serum magnesium, and ferritin in the present study. The immunoturbidimetric method with reagents from Denka Seiken, was used to measure CRP [16]. Anaemia was defined as a haemoglobin concentration below 12 g/dl in women, and 13 g/dl in men [17]. Anaemia with chronic infection (CRP $\geq$10 mg/l) was defined as AI [18]. Anaemia plus serum ferritin concentration <15 ng/ml [17], also without chronic infection (CRP<10 mg/l) was defined as IDA [18].

Height and body weight were measured by trained health workers based on a standard protocol recommended by the World Health Organization [12,13]. Body Mass Index (BMI) was divided into four categorical levels based on the criteria recommended by the Working Group on Obesity in China, which are underweight:

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