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The association of red meat, poultry, and egg consumption with risk of hip fractures in elderly Chinese: A case–control study☆

Fang-fang Zeng [a,1], Fan Fan [a,1], Wen-qiong Xue [a], Hai-li Xie [a], Bao-hua Wu [a,b], Su-lan Tu [a,c], Wei-fu Ouyang [a,d], Yu-ming Chen [a,*]

[a] Guangdong Provincial Key Laboratory of Food, Nutrition and Health, School of Public Health, Sun Yat-sen University, Guangzhou 510080, People's Republic of China
[b] Guangzhou Orthopaedics Trauma Hospital, Guangzhou 510045, People's Republic of China
[c] Orthopaedics Hospital of Baishi District, Jiangmen, Guangdong 529030, People's Republic of China
[d] Guangdong General Hospital, Guangzhou, Guangdong 510080, People's Republic of China

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ABSTRACT

Background/purpose: The epidemiological evidence that the consumption of red meat, poultry or eggs may be associated with the risk of hip fractures is inconsistent and no studies have differentiated between types of red meat or poultry. We evaluated the association between the consumption of red meat, poultry or eggs and the risk of hip fracture.

Methods: A 1:1 age- (±3 years) and gender-matched case–control study of 646 pairs (female/male: 484/162) of elderly Chinese was conducted between June 2009 and January 2013 in Guangdong, China. Information on meat and egg consumption was collected using a 79-item food frequency questionnaire administered in face-to-face interviews. Conditional logistic regression was used to test the relationship between intake of red meat, poultry, and eggs and the risk of hip fracture. Multivariate ORs and their 95% CIs were estimated.

Results: After adjusting for potential confounders, risk of hip fracture was found to be positively associated with total red meat consumption (P for trend <0.001), but not with total poultry or egg consumption. The adjusted ORs (95% CIs) for hip fractures, comparing extreme quartiles, were 2.94 (1.82, 4.76) for total red meat, 1.11 (0.74, 1.66) for total poultry, and 0.99 (0.63, 1.56) for eggs. Subtype analyses indicated that the unfavorable effect of total red meat was primarily associated with the consumption of fatty pork and organ meat, whereas fatty and lean poultry had opposite effects. Men with higher fatty pork intake tended to have greater risk than women (P interaction = 0.019).

Conclusions: Our findings suggest that greater consumption of fatty, but not lean, red meat and poultry may increase the risk of hip fracture. These results provide preliminary evidence for the feasibility of a dietary program for the prevention of hip fractures, which should be confirmed by further studies.

Introduction

Hip fractures, the leading cause of osteoporotic-related disability and death, occur predominantly in older age groups and the incidence increases exponentially with age [1,2]. With the rapid increase in the number of older people and the increase in life expectancy worldwide, the estimated number of hip fractures is predicted to rise from 1.7 million in 1990 to 6.3 million in 2050 [1]. The age-specific rates of hip fractures have been declining in most countries in the West but increasing in some areas of Asia. Xia et al. reported that the hip fracture incidence among those older than 50 years increased 2.76-fold for women and 1.61-fold for men from 1990 to 2006 in Beijing, China [3]. Better understanding of the risk factors for hip fracture in these regions is clearly of merit. Although predisposing factors for bone health, such as history of fracture and glucocorticoid use, have been well documented [1], there is increasing speculation that dietary factors may influence bone health.

Foods from animal sources such as red meat, poultry, fish, and eggs are the primary dietary components in China and many other countries [4,5]. Such foods are concentrated dietary sources of macro- and micronutrients and have been hypothesized to have complex effects on bone health [6]. These foods contain high-quality protein and bioavailable micronutrients (e.g., zinc) that might have beneficial effects on bone mineral density and lower the risk of fracture [7–10]. On the other hand, abundant saturated fat, excessive cholesterol, and other micronutrients (e.g., sulfur and phosphate) may produce excess acid ions, which might have deleterious effects on the bone reabsorption

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* Corresponding author at: Department of Medical Statistics & Epidemiology, School of Public Health, Sun Yat-sen University, Guangzhou 510080, People's Republic of China. Fax: +86 20 87330446.
E-mail address: chenyum@mail.sysu.edu.cn (Y. Chen).
[1] Zeng FF and Fan F contributed equally to this article.

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of dietary calcium and urinary calcium excretion, and consequently have an adverse effect on bone mineralization [11,12]. Moreover, the effect of meat consumption could be attributed to a "substitution effect" because higher meat intake might replace other healthy foods such as fruit and vegetables [13].

To date, few epidemiological studies have assessed the association between the consumption of animal-source foods (red meat, poultry, and eggs) and the risk of osteoporosis and fractures. The studies that have been conducted – three prospective, two case–control, and one cross-sectional study – have reported that high consumption of red meat, poultry, and eggs is associated with higher, lower, or null risk of osteoporosis [14–19]. These conflicting findings call for further study. Moreover, these studies were conducted on Western populations and were limited by the small number of cases (<300); insufficient dietary data to assess the potential role of different types of meat with distinct ingredients and to elucidate possible mechanisms; and failure to adjust for potential confounders, especially in observational studies.

Thus, the aim of the present study was to examine whether the dietary intake of different types of red meat, poultry (with or without skin), and eggs is associated with a subsequent risk of hip fracture in a 1:1 matched case–control study with 646 pairs of elderly Chinese from Guangdong Province, a coastal region of China.

Materials and methods

Participants

The study was approved by Sun Yat-sen University's School of Public Health Ethics Committee, and written informed consent was obtained from each participant.

The detailed eligibility criteria and recruitment methods have been described previously [20]. Briefly, the cases were hip fracture patients admitted consecutively to four hospitals: the First Affiliated Hospital of Sun Yat-sen University, Guangzhou Orthopedics Trauma Hospital, Guangdong General Hospital, and the Orthopedics Hospital of Baishi District in Jiangmen City, Guangdong province. Between June 2009 and January 2013, 1281 patients aged 55 to 80 who had resided in Guangdong province for over 10 years were admitted with hip fractures diagnosed within 2 weeks of their potential enrollment into the study and confirmed by X-ray image. Of these, 635 (49.6%) were excluded, either because they declined to participate (94, 7.3%); had pathological or high energy fractures (69, 5.4%); reported chronic diseases such as diabetes, cardiovascular disease, or cancer that might have changed their dietary habits (267, 20.8%); reported difficulties in routine activities or communication (189, 14.8%); or reported implausibly low or high energy intake (<800 or >4000 kcal for males and <500 or >3500 kcal for females) (16, 1.2%). Ultimately, 646 (50.4%) hip fracture patients were included in the study. Among these, 433 (67.0%) had femoral neck fractures and 213 (33.0%) had intertrochanteric fractures.

Controls were individually matched to the cases by sex and years. Controls were subject to the same inclusion and exclusion criteria as cases except for history of fracture. There were two sets of controls: 183 (28.3%) hospital controls were inpatients who were admitted to the above-mentioned hospitals and Zhongshan Ophthalmic Center within one week and could be matched to the cases; 463 (71.7%) community controls were apparently healthy community residents recruited in the same cities invited through a variety of strategies such as written invitations, flyers, or referrals.

Trained interviewers collected data on the dietary habits and potential confounders (e.g., smoking, drinking, occupation, physical activity, family history of chronic diseases, and medical histories) of cases and controls by means of a structured questionnaire administered in face-to-face interviews.

The food frequency questionnaire

The dietary section of the questionnaire consisted of a modified 79-item semi-quantitative food frequency questionnaire (FFQ), including seven red meat items, three poultry items, and one egg item. The FFQ was verified among the local population and the adjusted correlation coefficients between the FFQ and six 3-day dietary records were 0.59 for red meat, 0.50 for poultry, and 0.39 for eggs [21]. Daily mean nutrient and energy intakes were calculated using the Chinese Food Composition Table, 2002 [22].

The questionnaire focused on habitual intake of food and beverages during the year preceding the disease diagnosis (case-patients) or interview (control participants). Each food item had five frequency options (never, per year, per month, per week, and per day) and one quantity option (amount). The daily intake was then calculated for each food. We used pictures of portion sizes to help participants estimate the amount of food consumption.

Six items assessed fresh red meat consumption, classified as fatty pork, lean pork, pig feet and pig skin, beef and mutton, viscera (e.g., pig tripe, beef tripe, tongue, heart, and chitlins) and organs (e.g., liver, kidney, brain, and chicken giblets). One item assessed processed red meat consumption (e.g., bacon, sausage, ham, and luncheon meat). Three items assessed poultry consumption, classified as poultry with skin (e.g., chicken, duck, and goose with skin), skinless poultry (e.g., chicken, duck, and goose without skin), and chicken feet. Egg consumption (including chicken and duck eggs) was also included as an independent food group in the analysis.

Statistical analysis

Analyses were performed for total red meat consumption, total poultry consumption, egg consumption, consumption of individual red meat groups (fatty pork, lean pork, pig feet and pig skin, beef and mutton, viscera, organs, and processed red meat), consumption of fresh meat combined (all red meat groups except for processed red meat), and consumption of poultry with and without skin. First, each food group or item was adjusted for total energy intake using the residual method [23]. We applied a log transformation for total energy intake to adjust for the extremely skewed distribution of total energy intake and food groups or items, and a square root transformation for daily food intake to achieve an approximately normal distribution. We tested for differences between males and females (independent *t*-test), and between cases and controls by gender (paired *t*-test) for each food group or item. The energy-adjusted residuals were categorized into quartiles (Q1–Q4) of intake on the basis of the distribution of the residuals among controls to estimate their associations with risk of hip fracture, and the lowest 25% (Q1) was chosen as the reference group.

We used conditional logistic regressions to analyze the association between each food group or item and hip fracture risk. Univariate and multivariate analyses were used to calculate odds ratios (ORs) with their corresponding 95% confidence intervals (CIs). For multivariate analyses, potential confounders included age, BMI, education, marital status, occupation, household income, house orientation, family history of fractures, passive smoking, tea drinking, calcium supplement use, multivitamin use, daily energy intake, physical activity, and four factors generated using factor analysis (explained 25.2% of total variance) from 24-items of energy-adjusted intakes of other foods or food groups except for red meat, poultry, and eggs and these confounders were introduced using the forward stepwise method. Significance levels for the entry and removal of these confounders were 0.05 and 0.10, respectively. To test for linear trends, we included each food category as a continuous variable.

Separate analyses were conducted for males and females. We further adjusted for years since menopause, a history of user (≥3 month) of oral contraceptive during child-bearing period, and of estrogen after