



# The Relationship between Dietary Patterns and Bone Mineral Density of 476 Middle-Aged and Aged People

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(Received 14 Nov 2020; accepted 12 Feb 2021)

## Abstract

**Background:** To investigate the relationship between different dietary patterns and the levels of bone mineral density (BMD) in middle-aged and aged people, and to provide references for the nutritional prevention of osteoporosis.

**Methods:** A total of 476 residents aged 45 yr or more in Qiqihar City were enrolled from Aug 2018 to Feb 2019. They took a Food Frequency Questionnaire for dietary survey. Their dietary patterns were analyzed using the factor analysis method, and BMD were detected using ultrasound bone densitometer, to explore the relationship between different dietary patterns and BMD levels.

**Results:** Four dietary patterns were obtained in the survey: relatively balanced, oil-salt, milk-tuber, and aquatic. Among them, the prevalence of osteoporosis reached 21.8%. High-level relatively balanced dietary pattern (OR=0.588, 95%CI= 0.363-0.951) and high-level dairy-potato food dietary pattern (OR=0.668, 95%CI= 0.370-0.983) were associated with lower risk of osteoporosis.

**Conclusion:** A balanced diet and a high intake of dairy-potato food dietary pattern were associated with a lower prevalence of osteoporosis. It is recommended that middle-aged and aged people should have a balanced diet with more dairy products and potatoes to protect bone health.

**Keywords:** Dietary pattern; Bone mineral density; China

## Introduction

In recent years, it has become an important method to study the relationship between nutrition and chronic diseases with dietary patterns. Compared with studies on nutrients or food

products, dietary patterns emphasize the analysis of dietary conditions from the overall perspective. It considers the interaction between nutrients, and is more effective to analyze the devel-



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opment effect of chronic diseases (1). Osteoporosis and its resulting fractures, especially hip fractures, are one of the main causes of disability and death in aged people (2-4). Dietary patterns in different regions are different. Qiqihar City may have characteristic dietary patterns due to multi-ethnic diet culture.

In order to understand the relationship between different dietary patterns and the levels of bone mineral density (BMD) in aged people, we aimed to conduct dietary survey and BMD measurement for aged people in some communities of Qiqihar City, to provide reference for exploring the dietary intervention and management of bone health.

## **Materials and Methods**

### ***Subjects***

Middle-aged and aged residents were enrolled in this study, who participated in the national physical examination project in eight communities of Qiqihar City from Aug 2018 to Feb 2019. Inclusion criteria: 1) People aged 45 or more; 2) People living in the residence for 10 yr or more. Exclusion criteria: 1) People with various major diseases that may affect bone metabolism, such as endocrine abnormalities, serious liver and kidney diseases, diabetes, bone tumor or bone joint diseases; 2) People taking drugs affecting bone metabolism, such as calcium agents, and hormones, for a long time; 3) People with poor mobility, cognitive communication disorder, or inability to complete the questionnaire and BMD test for other reasons.

The study has been reviewed and approved by the Ethics Committee of Qiqihar Medical University, and the objects were volunteered to participate in the study with signed informed consent.

### ***Questionnaire***

1) Questionnaire for general conditions: General conditions (age, gender, etc.) and living habits (smoking, drinking, tea and physical activity);

2) Questionnaire for dietary survey: Simplified Food Frequency Questionnaire (FFQ), which was developed to investigate the types, frequency and intake of the surveyed residents over the past 12 months based on the dietary characteristics of local residents.

### ***Physical examination***

The calcaneus BMD of the objects was tested by OsteoPro Smart ultrasonic bone densitometer from Korea. Height and weight were measured on a calibrated altimeter and a scale, respectively.

### ***Diagnostic criteria for osteoporosis***

According to the diagnostic criteria of the WHO and information provided by the bone densitometer manufacturer, osteoporosis is diagnosed (5).  $T \geq -1$  indicates normal bone mass,  $-2.5 < T < -1$  indicates the reduced bone mass, and  $T \leq -2.5$  indicates the osteoporosis.

### ***Quality control***

The questionnaire was completed one-on-one between the object and the investigators, who needed to be given unified professional training. During the survey, the objects were provided with a questionnaire of food intake with a mold for measuring food and a standard food map. Physical examination was done by professionals and all instruments underwent standard correction before use. All data and information were double input and consistency checked to ensure that the data were accurate.

### ***Statistical analysis***

The dataset was established with EpiData 3.1 for parallel double input. Data analysis was conducted with SPSS (Chicago, IL, USA) 23.0. The measurement data were described by  $\bar{x} \pm s$ , comparisons among groups were realized with  $t$  test, counting data were represented by  $[n(\%)]$ , and the comparison for rate was performed by  $\chi^2$  test. Dietary patterns were analyzed through factor analysis and maximum orthogonal rotation methods. The relationship between dietary patterns and BMD levels was explored through the

multifactor logistic regression analysis. All hypothesis tests were bilateral tests, with the test level of  $\alpha = 0.05$ .

## Results

### General conditions

A total of 476 people living in Qiqihar City, including 180 males (47.9%) and 296 females (52.1%), were included in this study, who were aged ( $60.93 \pm 6.85$ ) yr old, with the minimum age of 45 yr old and the maximum age of 87 yr old, BMI ( $25.34 \pm 3.52$ ) kg/m<sup>2</sup>. Among which, there were 88 smokers (18.5%), 37 regular drinkers (7.7%), 103 regular tea drinkers (21.6%), and 192 regular exercisers (40.3%).

### Analysis on dietary patterns

KMO statistic calculation and Bartlett spherical test were performed for various food intakes, with the KMO statistics of  $0.793 > 0.6$ , and the Bartlett spherical test  $P < 0.001$ . It indicated that the data are suitable for factor analysis because of the common factors of various food intake. The common factors were extracted by the main composition analysis method of factor analysis,

with characteristic root greater than 1 as the standard. After that, four common factors were obtained, with characteristic values of 3.928, 1.466, 1.269 and 1.024, respectively. The variance contribution rates of the four factors were 29.12%, 11.28%, 9.76%, and 7.88%, respectively, with the cumulative variance contribution rate of 58.04%. The maximum variance orthogonal rotation was performed for the initial factor load. If the factor load was  $> 0.50$ , it was considered that the food item had a strong correlation with the dietary pattern. Each dietary pattern was named according to its main food characteristics, and four dietary patterns were finally obtained by combining the lithotriptic map and factor interpretation: 1) relatively balanced dietary pattern, with relatively higher intake of cereals, vegetables, fruits, meat and nuts, but lower intake of milk, edible oil and salt; 2) oil-salt food dietary pattern, with relatively higher intake of oil and salt; 3) dairy-potato food dietary pattern, with relatively higher intake of milk, followed by potato; 4) aquatic food dietary pattern, with prominently higher intake of aquatic animal food. The factor load distribution of each dietary pattern is shown in Table 1.

**Table 1:** Distribution of dietary pattern factor load in 476 middle-aged and aged people living in communities

<i>Type of Food</i>	<i>Relatively balanced dietary pattern</i>	<i>Oil-salt food dietary pattern</i>	<i>Dairy-potato food dietary pattern</i>	<i>Aquatic food dietary pattern</i>
Refined cereals	0.735	0.079	0.036	0.185
Coarse cereals	0.742	0.011	0.033	0.019
Potatoes	0.256	0.017	0.568	0.015
Beans and their products	0.150	0.014	0.067	0.007
Vegetables	0.776	0.049	0.264	0.092
Fruits	0.635	0.045	0.425	0.110
Fungus, algae	0.087	0.021	0.025	0.000
Milk	0.019	0.013	0.850	0.037
Meat	0.557	0.069	0.170	0.039
Aquatic Products	0.002	0.010	0.019	0.977
Eggs	0.648	0.014	0.097	0.020
Nuts	0.650	0.015	0.056	0.079
Edible oil	0.040	0.847	0.007	0.033
Salt	0.001	0.854	0.016	0.027

The factor scores were calculated through the regression method, and the objects were classi-

fied into dietary patterns with the highest factor scores. In this survey, there were 35 people with

relatively balanced dietary pattern (7.4%), 167 people with oil-salt food dietary pattern (35.1%), 218 people with dairy-potato food dietary pattern (45.8%) and 56 people with aquatic food dietary pattern (11.7%).

**Bone mineral density and the prevalence of osteoporosis in patients**

BMD T of the objects was (-1.48 ± 1.30), normal BMD, of which, there were 221 (46.4%) patients with normal BMD, 151 (31.7%) patients with

reduced bone mass, and 104 (21.8%) patients with osteoporosis, respectively. The morbidity rate of osteoporosis among the objects was 21.7%. General conditions in people with different BMD levels are shown in Table 2. There were significant differences in age ( $t = -2.898$ ,  $P < 0.001$ ), gender ( $\chi^2 = 25.794$ ,  $P < 0.001$ ) and smoking ( $\chi^2 = 11.317$ ,  $P < 0.001$ ) in the osteoporosis and non-osteoporosis groups, but there was no statistical differences among other factors.

**Table 2:** General comparison on different levels of BMD in 476 aged patients [ $(\bar{x} \pm s) / n (\%)$ ]

Variables	Non-osteoporosis group (n=372)	Osteoporosis group (n=104)	t/ $\chi^2$	P
Age (yr)	60.45±6.97	62.65±6.37	-2.898	0.004
BMI (kg/m <sup>2</sup> )	25.23±3.20	25.75±3.90	-1.393	0.164
Gender [n(%)]				
Male	121(32.5)	59(56.7)	25.794	<0.001
Female	251(67.5)	45(43.3)		
Smoking [n(%)]				
Yes	57(15.3)	31(29.8)	11.317	0.001
No	315(84.7)	73(70.2)		
Drinking [n(%)]				
Yes	26(7.0)	11(10.6)	1.459	0.227
No	346(93.0)	93(89.4)		
Tea drinking [n(%)]				
Yes	81(21.8)	22(21.2)	0.018	0.892
No	291(78.2)	82(78.8)		
Regular physical exercise [n(%)]				
Yes	153(41.1)	39(37.5)	0.445	0.505
No	219(58.9)	65(62.5)		

**Relationship between dietary patterns and bone mineral density**

Each dietary pattern factor was divided into four groups according to the score from low to high equally, named as Q1, Q2, Q3, and Q4. The comparison of BMD T values of people with various dietary patterns of Q1 (scored the lowest) and Q4 (scored the highest) is shown in Table 3. The difference was statistically significant in BMD T values between Q1 and Q4 with dairy-potato food dietary pattern ( $t = -3.609$ ,  $P < 0.05$ ), with no statistical differences in comparisons among other dietary patterns.

With the presence of osteoporosis as the stress variable (0=no, 1= yes), Q1 and Q4 of four dietary patterns were included in the equation for multivariate logistic regression analysis, indicating that after adjusting the three factors of gender, age, and smoking, high-level relatively balanced dietary pattern (OR=0.588, 95%CI=0.363~0.951) and high-level dairy-potato food dietary pattern (OR=0.668, 95%CI=0.370~0.983) can reduce the risk of osteoporosis. No statistical significance in differences of other dietary patterns and prevalence of osteoporosis was found (Table 4).

**Table 3:** Comparison of BMD T values in Q1 and Q4 with various dietary patterns

<i>Dietary pattern grouping</i>	<i>n</i>	<i>BMD T value (<math>\bar{x} \pm s</math>)</i>	<i>t</i>	<i>P</i>
Relatively balanced dietary pattern				
Q1	35	-1.51±0.73	-0.317	0.754
Q4	35	-1.45±0.85		
Oil-salt food dietary pattern				
Q1	167	-1.39±0.64	1.188	0.236
Q4	167	-1.47±0.59		
Dairy-potato food dietary pattern				
Q1	218	-1.58±0.82	-3.609	0.001
Q4	218	-1.34±0.54		
Aquatic food dietary pattern				
Q1	56	-1.55±0.79	-1.350	0.183
Q4	56	-1.37±0.61		

**Table 4:** Multivariate Logistic regression model analysis of 476 middle-aged and aged people with osteoporosis in Qiqihar City

<i>Variables</i>	<i>β</i>	<i>SE</i>	<i>Wald</i>	<i>P</i>	<i>OR</i>	<i>95%CI</i>
Relatively balanced dietary pattern (vs. Q1)						
Q4	-0.532	0.246	4.684	0.030	0.588	0.363 ~ 0.951
Oil-salt food dietary pattern (vs. Q1)						
Q4	0.409	0.259	2.500	0.114	1.505	0.907 ~ 2.499
Dairy-potato food dietary pattern (vs. Q1)						
Q4	-0.403	0.301	1.792	0.181	0.668	0.370 ~ 0.983
Aquatic food dietary pattern (vs. Q1)						
Q4	-0.303	0.272	1.243	0.265	0.738	0.433 ~ 1.259
Gender (vs. Male)	-0.543	0.215	6.358	0.012	0.581	0.381 ~ 0.886
Age	0.034	0.011	8.645	0.003	1.034	1.011 ~ 1.058
Smoking (vs. No)	0.689	0.253	7.421	0.006	1.991	1.213 ~ 3.267

## Discussion

Dietary patterns are quite different in different regions, because of lack of unified division standard for dietary patterns, as well as different types

and quantity of food intakes in different places varying with geographical environments, eating habits, folk customs and other factors. There were four dietary patterns of middle-aged and aged residents in Qiqihar City in this study: relatively balanced dietary pattern, oil-salt food die-

tary pattern, dairy-potato food dietary pattern, and aquatic food dietary pattern. Among them, the relatively balanced dietary pattern can fully consume grains, vegetables, fruits, meat, eggs and other foods, with lower intake of edible oil and salt. The types and structures of this pattern of food intake is closest to the Dietary Guidelines for Chinese Residents. However, people with this dietary pattern accounted for the least, only 7.4% of the total population; while those with oil-salt food dietary pattern was more, accounting for 35.1%. This result indicated that some residents have unreasonable diet and high consumption of edible oil and salt. Qiqihar City is rich in milk source and high demand for dairy products. The dietary model accounting for the largest proportion in this survey is milk and potato. Therefore, in this survey, the dietary pattern with the largest proportion was milk and potato pattern, which was characterized by high dairy intake, reflecting the characteristics of high dairy intake of middle-aged and elderly residents in Qiqihar City.

The survey included 476 residents aged 45 or more in communities of Qiqihar City, with the prevalence of osteoporosis at 21.8%, which is close to those of other studies (6,7), but lower than other cases (36.87%) (8) and (30.7%) (9). Calcium, vitamin D, protein and other nutrients involved in the formation and transformation of bone are of great significance to bone health, thus it is more appropriate to study the relationship between nutrition with dietary patterns and osteoporosis. A healthy and balanced dietary pattern is the basis for maintaining bone health and prevention of osteoporosis (10,11).

This study found that high intake of relatively balanced food pattern is the protective factor for osteoporosis, which is consistent with the findings of PARK S (12). Although this pattern has relatively lower intake of dairy food, the intake of other food is rich. Therefore, this pattern is the best for dietary diversification of the four dietary patterns found in this survey: grains and potatoes ensure energy intake, rich meat and eggs provide ample protein, vegetables and fruits are the source of vitamins and minerals, and a certain amount of intake of bean products provides cal-

cium for the body, and a light diet with low oil and low salt reduces urinary calcium excretion is also more in line with the consensus of experts (13). Consequently, the results suggested that a balanced diet should still be an important choice to prevent osteoporosis. The difference in BMD T values between Q4 and Q1 with dairy-potato food pattern was statistically significant, and high-level dairy-potato food pattern in Logistic regression analysis also indicates that it is associated with a low risk of osteoporosis. The relationship between the dietary pattern with mainly milk and dairy food and low risk of osteoporosis has been supported in many studies (14), especially in the context of low intake of dairy food in China. The benefits of adequate dairy food on the prevention of osteoporosis may be more obvious. A cohort study conducted in Europe found that people with a higher intake of fish, olive oil and a lower intake of red meat had a 7% lower risk of hip fracture than people with a normal diet (15).

Another observation study also found a lower risk of osteoporosis in aged people with a Mediterranean diet, and the analysis of food categories indicates that beans, fish and olive oil are protective factors (16). However, the aquatic food dietary pattern in this study did not show a significant protection against osteoporosis, which may be related to the still lower absolute intake of aquatic food and the relative proportion of other food intakes.

## **Conclusion**

The dietary pattern has some relationship to the risk of osteoporosis. Middle-aged and aged people should ensure a diversified balanced diet and sufficient intakes of milk and dairy products, so as to promote bone health.

## **Ethical considerations**

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission,



redundancy, etc.) have been completely observed by the authors.

## Acknowledgements

This study was funded by Philosophy and Social Science Research Planning Project of Qiqihar City (Qsx2020-30YB).

## Conflict of interest

The authors declare that there is no conflict of interest.

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