Associated Factors for Osteoporosis and Fracture in Chinese Elderly

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Background: The factors associated with osteoporosis are poorly understood in the Chinese population. This study aimed to examine the factors associated with osteoporosis and with fractures in a Chinese elderly population.

Material/Methods: This was a cross-sectional study of elderly people living in Tianjin between 2012 and 2014. Bone mineral density was measured by dual X-ray absorptiometry. The subjects completed a questionnaire about lifestyle habits, personal and family medical history, calcium intake, and exercising. Data were gathered on occurrence of fracture at 5 years or August 2018, whichever occurred first.

Results: There were 298 individuals with osteoporosis (18.5% male, median age 67 years) and 397 without (46.3% male, median age 62 years). Male sex (OR=0.051, 95% CI: 0.021–0.126), age (OR=1.049, 95% CI: 1.099–1.202), being divorced/widowed (OR=2.445, 95% CI: 1.219–4.904), digestive ulcer history (OR=3.805, 95% CI: 1.539–9.405), family history of hunchback (OR=2.659, 95% CI: 1.145–6.175), family history of osteoarthropathy (OR=4.222, 95% CI: 2.128–8.375), fracture history (OR=2.138, 95% CI: 1.307–3.496), drinking green tea (OR=0.352, 95% CI: 0.217–0.574), and exercising (OR=0.303, 95% CI: 0.193–0.475) were independently associated with osteoporosis. Digestive ulcer history (OR=3.183, 95% CI: 1.178–8.5992), exercising (OR=0.354, 95% CI: 0.139–0.903), and taking calcium supplements during follow-up (OR=0.262, 95% CI: 0.112–0.611) were independently associated with fractures in patients with osteoporosis.

Conclusions: Female sex, age, marital status, history of digestive ulcer and fracture, and family history of hunchback and osteoarthropathy are associated with osteoporosis among elderly subjects, while drinking green tea and exercising are inversely associated. Among the patients with osteoporosis, a history of digestive ulcer is associated with fractures, while exercising and taking calcium supplements are inversely associated.

MeSH Keywords: Frail Elderly • Osteoporosis • Risk Factors

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Background

Osteoporosis is a generalized skeletal disorder characterized by compromised bone strength and deterioration of bone quantity and quality, often leading to fragility fracture [1]. With the aging of the global population, osteoporosis has become a serious social and public health problem. According to the World Health Organization (WHO), the diagnostic criterion for osteoporosis is a T-score of any part of the body ≤–2.5 standard deviations (SD) [1]. At present, about 200 million people have osteoporosis worldwide and the incidence has jumped to seventh place among all common diseases, with a prevalence of 10–58%, according to the population studied [1–6]. With its recent and continuous economic development, the Chinese population is rapidly aging [7] and since age is one of the main risk factors for osteoporosis [1,6], the threat of osteoporosis to public health is becoming more significant in China [8,9].

Osteoporosis seriously affects the quality of life of elderly people, and the most serious complication of osteoporosis is fracture [1]. Indeed, women with osteoporosis have a rate ratio of 4.03 of fracture compared with women with normal bone mineral density (BMD) [10]. In addition, osteoporotic fractures in the elderly are associated with increased mortality [11], loss of autonomy, nursing home referral, and increased risk of geriatric syndromes like delirium [12].

Postmenopausal women, persons ≥65 years of age, white people, people of Asian descent, and people with small body frame are the most affected by osteoporosis [1, 6]. In addition, lifestyle factors (e.g., low calcium intake, vitamin D deficiency, excess vitamin A intake, inadequate physical activity, smoking, and alcohol abuse), genetic factors (e.g., parental history of hip fracture, cystic fibrosis, hemochromatosis, porphyria, osteogenesis imperfecta, and hypophosphatasia), endocrine disorders (e.g., hyperparathyroidism, hypogonadal states, diabetes mellitus, and hyperthyroidism), gastrointestinal disorders (e.g., celiac disease, Crohn’s disease, and cirrhosis), hematologic disorders and cancers, rheumatologic and autoimmune disorders (e.g., rheumatoid arthritis and systemic lupus erythematosus), and medications (e.g., hormonal therapies, steroids, immunosuppressants, and proton pump inhibitors) are known to increase the risk of osteoporosis [1,6,13–15]. In China, studies showed that sex, older age, lower weight, and lower body mass index (BMI) were associated with osteoporosis (reviewed by Chen et al. [8]). Nevertheless, the exact contribution is not understood for most risk factors.

Therefore, the aim of the present study was to examine the factors associated with osteoporosis and with fractures in a Chinese elderly population (outpatients and subjects from the health examination center). The results could help identify patients in need of closer follow-up.

Material and Methods

Study design and subjects

This was a cross-sectional study of elderly people living in Tianjin between September 2012 and May 2014 and surveyed at the Affiliated Hospital of Logistics College of Chinese People’s Armed Police Force Hospital. Subjects with lower back pain, hip pain, or knee pain from the outpatient clinic and subjects from the health examination center were recruited. These clinics are open to the general population, but treat specific diseases. The study was approved by the local ethics committee (no. 2018-0003).

The inclusion criteria were: 1) elderly (age ≥60 years of age); 2) followed up at an outpatient clinic (geriatrics, arthropathy, and osteoporosis); and 3) household registered in Tianjin and has lived in Tianjin for ≥10 years at study entry. The exclusion criteria were: 1) history of taking steroids; 2) mental disorder; 3) senile dementia; or 4) did not cooperate or loss to follow-up.

BMD measurement

BMD measurement was performed using a Discovery dual-energy Bone Densitometer (Hologic, Inc., Bedford, MA, USA). The BMD values of the lumbar spine, femoral neck, and Ward’s triangle were measured. The instrument was controlled by a computer and the results were analyzed automatically. The BMD results were expressed as g/cm². Osteoporosis was diagnosed in the presence of a T-score ≤–2.5 [1,14].

Questionnaire

The questionnaire was self-designed and discussed among orthopedic, nursing, and epidemiology experts. The questionnaire collected the sociodemographic and general health data of the subjects, including sex, age, weight, height, BMI, education level, marital status, lifestyle habits (smoking, drinking alcohol, coffee, and green tea), family history (parents, spouse, children’s history of hunchback and osteoarthropathy), history of present illness (bone and joint pain, low back pain, other systems), history of fracture, past history (prostatic hyperplasia and digestive ulcer), calcium intake, and leisure time physical activity (i.e., exercising).

Follow-up

Patients with T-score ≤–2.5 were followed up by telephone at 5 years after enrollment or August 2018, whichever occurred first, to record whether any fracture occurred and whether calcium supplements were taken during these 5 years.

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Table 1. Characteristics of all subjects.

| Variable                                      | T >–2.5 (n=397) | T ≤–2.5 (n=298) | P     |
|-----------------------------------------------|------------------|------------------|-------|
| Age (years)                                   | 62 [60, 85]      | 67 [60, 88]      | <0.001|
| Sex, n (%)                                    |                  |                  |       |
| Female                                        | 213 (53.7)       | 243 (81.5)       |       |
| Male                                          | 184 (46.3)       | 55 (18.5)        |       |
| Body mass index (kg/m²)                       | 24.5 [16.9, 36.1]| 23.5 [12.5, 31.3]| <0.001|
| Marital status, n (%)                         |                  |                  |       |
| Married                                       | 362 (91.2)       | 218 (73.2)       | <0.001|
| Divorced/widowed                              | 35 (8.8)         | 80 (26.8)        |       |
| Education level, n (%)                        |                  |                  | 0.001 |
| Senior high school/university                 | 271 (68.3)       | 168 (56.4)       |       |
| Illiteracy/primary school/junior high school  | 126 (31.7)       | 130 (43.6)       |       |
| History of prostatic hyperplasia, n (%)       | 5 (1.3)          | 2 (0.7)          | 0.442 |
| History of digestive ulcer, n (%)             | 10 (2.5)         | 33 (11.1)        | <0.001|
| Family history of hunchback, n (%)            | 14 (3.5)         | 28 (9.4)         | 0.001 |
| Family history of osteoarthropathy, n (%)     | 22 (5.5)         | 57 (19.1)        | <0.001|
| History of fall and injury, n (%)             | 0 (0.0)          | 36 (12.1)        | <0.001|
| History of fracture, n (%)                    | 63 (15.9)        | 110 (36.9)       | <0.001|
| History of taking calcium, n (%)              | 76 (19.1)        | 88 (29.5)        | 0.001 |
| Smoking, n (%)                                |                  |                  |       |
| Never                                         | 260 (65.5)       | 191 (64.1)       | 0.703 |
| Occasional/quitting smoking/quit smoking      | 362 (91.2)       | 257 (86.9)       |       |
| Drinking alcohol, n (%)                       |                  |                  |       |
| Never                                         | 234 (58.9)       | 231 (77.5)       | <0.001|
| Occasional/quitting drinking/drinking         | 163 (41.1)       | 67 (22.5)        |       |
| Drinking coffee per week, n (%)               |                  |                  |       |
| Never                                         | 362 (91.2)       | 290 (97.3)       | 0.002 |
| Occasional/everyday                           | 35 (8.8)         | 8 (2.7)          |       |
| Drinking green tea per day, n (%)             |                  |                  |       |
| Never                                         | 189 (47.6)       | 224 (75.2)       | <0.001|
| Less than 1 cup/2–3 cups/more than 3 cups    | 208 (52.4)       | 74 (24.8)        |       |
| Weekly physical exercise, n (%)               |                  |                  |       |
| Never                                         | 66 (16.6)        | 157 (52.7)       | <0.001|
| Occasional/often                              | 331 (83.4)       | 141 (47.3)       |       |
| Taking calcium agents within the 5-year follow-up (anti-osteoporosis therapy), n (%) | | | |
| Not taken                                      | 209 (52.6)       | 68 (22.8)        | <0.001|
| Regular/discontinuous                         | 188 (47.4)       | 220 (77.2)       |       |
| Bone mineral density of lumbar spine (g/cm²)  | 0.97 [0.47, 1.07]| 0.72 [0.33, 1.31]| <0.001|
| Bone mineral density of femoral neck (g/cm²)  | 0.74 [0.54, 1.43]| 0.55 [0.30, 0.71]| <0.001|
| Bone mineral density of Ward’s triangle (g/cm²)| 0.56 [0.31, 1.09]| 0.34 [0.10, 0.74]| <0.001|
Data collection

After the questionnaire was returned, it was validated and captured by 2 persons. Discrepancies in data entry were detected using data comparison. Questionnaires with >5% of missing data were rejected.

Statistical analysis

Continuous data that did not conform to the normal distribution were described as medians (range) and analyzed using nonparametric tests. Categorical data were described as frequencies (percentage) and analyzed using the chi-square test or Fisher’s exact test, as appropriate. Logistic regression analysis was performed in the general population with osteoporosis as the outcome, and variables with significant differences in the univariable analyses were incorporated into the multivariable analysis (enter method). Statistical analysis was performed using SPSS 21.0 (IBM, Armonk, NY, USA). Two-tailed P-values <0.05 were considered statistically significant.

Results

Characteristics of the subjects

A total of 695 subjects were included in the study; among them, 298 (42.9%) were diagnosed with osteoporosis and their BMD was lower at all 3 sites compared with patients without osteoporosis (all P<0.001) (Table 1). Among the osteoporotic patients, 8 were lost to follow-up (2.7%).

Associated factors for osteoporosis in all subjects

Table 2 presents the associated factors for osteoporosis. The multivariable analysis showed that male sex (odds ratio

Table 2. Associated factors for osteoporosis in all subjects.

| Variable                                                                 | Univariable logistic regression | Multivariable logistic regression |
|--------------------------------------------------------------------------|---------------------------------|----------------------------------|
|                                                                          | OR (95% CI)                     | P                                | OR (95% CI)                     | P                                |
| Gender (Male vs. Female)                                                 | 0.262 (0.184, 0.373)            | <0.001                           | 0.051 (0.021, 0.126)            | <0.001                           |
| Age                                                                      | 1.107 (1.079, 1.136)            | <0.001                           | 1.149 (1.099, 1.202)            | <0.001                           |
| Marital status (divorced/widowed vs. married)                            | 3.796 (2.466, 5.842)            | <0.001                           | 2.445 (1.219, 4.904)            | 0.012                            |
| Education level (illiteracy/primary school/junior high school vs. senior high school/university) | 1.664 (1.219, 2.273)           | 0.001                            | 0.69 (0.434, 1.097)             | 0.117                            |
| Body mass index                                                          | 0.892 (0.851, 0.935)            | <0.001                           | 0.583 (0.27, 1.259)             | 0.170                            |
| History of prostatic hyperplasia (yes vs. no)                            | 0.530 (0.102, 2.749)            | 0.450                            |                                 |                                  |
| History of digestive ulcer (yes vs. no)                                  | 4.819 (2.335, 9.946)            | <0.001                           | 3.805 (1.539, 9.405)            | 0.004                            |
| Family history of hunchback (yes vs. no)                                 | 2.837 (1.466, 5.490)            | 0.002                            | 2.659 (1.145, 6.175)            | 0.023                            |
| Family history of osteoarthropathy (yes vs. no)                          | 4.031 (2.402, 6.767)            | <0.001                           | 4.222 (2.128, 8.375)            | <0.001                           |
| History of fracture (yes vs. no)                                         | 3.102 (2.17, 4.435)             | <0.001                           | 2.138 (1.307, 3.496)            | 0.002                            |
| History of taking calcium (yes vs. no)                                   | 1.77 (1.244, 2.519)             | 0.002                            | 1.389 (0.869, 2.219)            | 0.169                            |
| Smoking (occasional/quit smoking/smoking vs. never)                      | 1.063 (0.776, 1.456)            | 0.703                            |                                 |                                  |
| Drinking alcohol (occasional/quit drinking/drinking vs. never)           | 0.416 (0.297, 0.584)            | <0.001                           | 1.521 (0.873, 2.651)            | 0.139                            |
| Drinking coffee per week (occasional/everyday vs. never)                 | 0.285 (0.13, 0.624)             | 0.002                            | 0.497 (0.188, 1.312)            | 0.158                            |
| Drinking tea per day (<1 cup/2–3 cups/>3 cups vs. never)                 | 0.3 (0.216, 0.417)              | <0.001                           | 0.352 (0.217, 0.574)            | <0.001                           |
| Weekly physical exercise (occasional/often vs. never)                    | 0.179 (0.126, 0.254)            | <0.001                           | 0.303 (0.193, 0.475)            | <0.001                           |
| Variable                                             | Non-fracture (n=271) | Fracture (n=27) | P   |
|------------------------------------------------------|----------------------|-----------------|-----|
| Age (years)                                          | 67 [60, 86]          | 65 [60, 88]     | 0.947 |
| Sex, n (%)                                           |                      |                 |     |
| Male                                                 | 221 (81.5)           | 22 (81.5)       | 0.993 |
| Female                                               | 50 (18.5)            | 5 (18.5)        |     |
| Body mass index (kg/m²)                              | 23.5 [16.3, 31.3]    | 23.6 [12.5, 30.5] | 0.610 |
| Marital status, n (%)                                |                      |                 | 0.210 |
| Married                                              | 201 (74.2)           | 17 (63.0)       |     |
| Divorced/widowed                                     | 70 (25.8)            | 10 (37.0)       |     |
| Education level, n (%)                               |                      |                 | 0.034 |
| Senior high school/university                        | 158 (58.3)           | 10 (37.0)       |     |
| Illiteracy/primary school/junior high school         | 113 (41.7)           | 17 (63.0)       |     |
| History of prostatic hyperplasia, n (%)              | 1 (0.4)              | 1 (3.7)         | 0.043 |
| History of digestive ulcer, n (%)                    | 25 (9.2)             | 8 (29.6)        | 0.001 |
| Family history of hunchback, n (%)                   | 25 (9.2)             | 3 (11.1)        | 0.749 |
| Family history of osteoarthropathy, n (%)            | 48 (17.7)            | 9 (33.3)        | 0.049 |
| History of fall and injury, n (%)                    | 81 (29.9)            | 5 (18.5)        | 0.214 |
| History of fracture, n (%)                           | 102 (37.6)           | 8 (29.6)        | 0.411 |
| History of taking calcium, n (%)                     | 78 (28.8)            | 10 (37.0)       | 0.370 |
| Smoking, n (%)                                       |                      |                 | 0.770 |
| Never                                                | 173 (63.8)           | 18 (66.7)       |     |
| Occasional/quit smoking/smoking                      | 98 (36.2)            | 9 (33.3)        |     |
| Drinking alcohol, n (%)                              |                      |                 | 0.653 |
| Never                                                | 211 (77.9)           | 20 (74.1)       |     |
| Occasional/quit drinking/drinking                    | 60 (22.1)            | 7 (25.9)        |     |
| Drinking coffee per week, n (%)                      | 102 (37.6)           | 8 (29.6)        | 0.365 |
| Never                                                | 263 (97.0)           | 27 (100.0)      |     |
| Occasional/everyday                                  | 134 (49.4)           | 7 (25.9)        |     |
| Drinking tea per day, n (%)                          |                      |                 | 0.206 |
| Never                                                | 201 (74.2)           | 23 (85.2)       |     |
| Less than 1 cup/2–3 cups/more than 3 cups           | 70 (25.8)            | 4 (14.8)        |     |
| Weekly physical exercise (occasional/often vs. never), n (%) |          |                 | 0.020 |
| Never                                                | 137 (50.6)           | 20 (74.1)       |     |
| Occasional/often                                     | 134 (49.4)           | 7 (25.9)        |     |
| Taking calcium agents within 5-year follow-up       |                      |                 | 0.001 |
| (Anti-osteoporosis therapy), n (%)                   |                      |                 |     |
| Not taken                                            | 55 (20.3)            | 13 (48.1)       |     |
| Regular/discontinuous                                | 216 (79.7)           | 14 (51.9)       |     |
| Bone mineral density of lumbar spine (g/cm²)         | 0.72 [0.33, 1.31]    | 0.68 [0.38, 0.96] | 0.050 |
| Bone mineral density of femoral neck (g/cm²)         | 0.55 [0.34, 0.71]    | 0.51 [0.30, 0.64] | 0.024 |
| Bone mineral density of Ward’s triangle (g/cm²)      | 0.34 [0.18, 0.74]    | 0.31 [0.10, 0.65] | 0.001 |
OR=0.051, 95% confidence interval [CI]: 0.021–0.126, P<0.001), age (OR=1.049, 95% CI: 1.099–1.202, P<0.001), being divorced/widowed (OR=2.445, 95% CI: 1.219–4.904, P=0.012), history of digestive ulcer (OR=3.805, 95% CI: 1.539–9.405, P=0.004), family history of hunchback (OR=2.659, 95% CI: 1.145–6.175, P=0.023), family history of osteoarthropathy (OR=4.222, 95% CI: 2.128–8.375, P<0.001), history of fracture (OR=2.138, 95% CI: 1.307–3.496, P=0.002), drinking green tea (OR=0.352, 95% CI: 0.217–0.574, P=0.001), and exercising (OR=0.303, 95% CI: 0.193–0.475, P<0.001) were independently associated with osteoporosis (Table 2).

Characteristics of the patients with osteoporosis

Compared with the patients without fracture during the 5-year follow-up, the patients with fracture had a lower education level (P=0.001), higher frequency of digestive ulcer (29.6% vs. 9.2%, P=0.001), higher family history frequency of osteoarthropathy (33.3% vs. 17.7%, P=0.049), lower frequency of exercising (25.9% vs. 49.4%, P=0.02), and lower BMD at all 3 sites (all P<0.05) (Table 3). The use of calcium supplements was lower during the 5-year follow-up in the fracture group (51.9% vs. 79.7%, P=0.001).

Table 4. Associated factors for fracture in patients with osteoporosis within 5 years.

| Variable                                      | Univariable logistic regression | Multivariable logistic regression |
|-----------------------------------------------|---------------------------------|----------------------------------|
|                                               | OR (95% CI)  | P  | OR (95% CI)  | P  |
| Sex (Male vs. Female)                         | 1.005 (0.363, 2.781) | 0.993 |                             | |
| Age                                           | 1.015 (0.961, 1.073) | 0.594 |                             | |
| Marital status (divorced/widowed vs. married) | 1.689 (0.739, 3.862) | 0.214 |                             | |
| Education level (illiteracy/primary school/junior high school vs. senior high school/university) | 2.377 (1.049, 5.384) | 0.038 | 1.636 (0.678, 3.949) | 0.274 |
| Body mass index                               | 0.938 (0.828, 1.061) | 0.306 |                             | |
| History of prostatic hyperplasia (yes vs. no) | 10.385 (0.631, 170.921) | 0.101 |                             | |
| History of digestive ulcer (yes vs. no)       | 4.143 (1.646, 10.426) | 0.003 | 3.183 (1.178, 8.599) | 0.022 |
| Family history of hunchback (yes vs. no)      | 1.23 (0.346, 4.375) | 0.749 |                             | |
| Family history of osteoarthropathy (yes vs. no) | 2.323 (0.984, 5.483) | 0.054 |                             | |
| History of fracture (yes vs. no)              | 0.698 (0.295, 1.652) | 0.413 |                             | |
| History of taking calcium (yes vs. no)        | 1.456 (0.638, 3.319) | 0.372 |                             | |
| Smoking (occasional/quit smoking/smoking vs. never) | 0.883 (0.382, 2.04) | 0.770 |                             | |
| Drinking alcohol (occasional/quit drinking/drinking vs. never) | 1.231 (0.497, 3.049) | 0.654 |                             | |
| Drinking coffee per week (occasional/everyday vs. never) | 0 | (0, Inf) | 0.987 |                             |
| Drinking tea per day (<1 cup/2–3 cups/3+ cups vs. never) | 0.499 (0.167, 1.494) | 0.214 |                             |
| Weekly physical exercise (occasional/often vs. never) | 0.358 (0.147, 0.874) | 0.024 | 0.354 (0.139, 0.903) | 0.030 |
| Taking calcium agents within 5 years (regular/discontinuous vs. none) | 0.274 (0.122, 0.617) | 0.002 | 0.262 (0.112, 0.611) | 0.002 |

[OR]=0.051, 95% confidence interval [CI]: 0.021–0.126, P<0.001), age (OR=1.049, 95% CI: 1.099–1.202, P<0.001), being divorced/widowed (OR=2.445, 95% CI: 1.219–4.904, P=0.012), history of digestive ulcer (OR=3.805, 95% CI: 1.539–9.405, P=0.004), family history of hunchback (OR=2.659, 95% CI: 1.145–6.175, P=0.023), family history of osteoarthropathy (OR=4.222, 95% CI: 2.128–8.375, P<0.001), history of fracture (OR=2.138, 95% CI: 1.307–3.496, P=0.002), drinking green tea (OR=0.352, 95% CI: 0.217–0.574, P=0.001), and exercising (OR=0.303, 95% CI: 0.193–0.475, P<0.001) were independently associated with osteoporosis (Table 2).

Associated factors for fracture in the patients with osteoporosis

The multivariable analysis showed that a history of digestive ulcer (OR=3.183, 95% CI: 1.178–8.599, P=0.022), exercising (OR=0.354, 95% CI: 0.139–0.903, P=0.030), and taking calcium supplements during follow-up (OR=0.262, 95% CI: 0.112–0.611, P=0.002) were independently associated with fractures in patients with osteoporosis (Table 4).
Discussion

The contribution of the risk factors for osteoporosis is poorly understood in the Chinese population. Therefore, this study aimed to examine the factors associated with osteoporosis and with fractures in a Chinese population. The present study showed that sex, age, being divorced/widowed, history of digestive ulcer, family history of hunchback, family history of osteoarthropathy, history of fracture, drinking green tea, and exercising are associated with osteoporosis among elderly Chinese subjects. Among the patients with osteoporosis, a history of digestive ulcer, exercising, and taking calcium supplements are associated with fractures.

The present study showed that female sex, older age, and family history of osteoarthropathy are risk factors for osteoporosis, which is already well known [1,6]. Furthermore, being divorced/widowed was also associated with osteoporosis. This is supported by a study from the United States that showed that marital disruption was associated with poor bone health in men and that marital quality was associated with a good bone health in women [16]. Digestive ulcers are a common manifestation of a variety of inflammatory digestive diseases and cirrhosis, and these diseases are often associated with malabsorption and malnutrition, as well as with osteoporosis [17]. Accordingly, the present study showed that the presence of digestive ulcer was independently associated with osteoporosis. Family histories of hunchback and osteoarthropathies and personal history of fracture are indicative of bone diseases that can affect bone metabolism and hence the risk of osteoporosis [18]. Previous studies indeed showed that kyphosis, diseases affecting bone metabolism, and history of falls and fractures were risk factors for osteoporosis [19–22]. In addition, some of those disorders can be the results of the osteoporosis itself. Indeed, kyphosis is associated with decreased BMD, and possibly results from increased fragility of the spine [23,24]. In the present study, a family history of hunchback and osteoarthritis were independently associated with osteoporosis. Those bone disorders cover a wide variety of diseases that have metabolic, inflammatory, genetic, and environmental etiologies, and additional study is necessary to refine their association with osteoporosis. Finally, drinking green tea and exercising were factors associated with osteoporosis. A recent meta-analysis showed that consuming green tea can reduce the risk of osteoporosis and the risk of hip fracture [25], mainly through the action of polyphenols that mitigate BMD loss [26]. Exercising is well known to be inversely associated with osteoporosis and bone degenerative diseases in general [27–29], supporting the validity of our results.

Fractures are the main consequence of osteoporosis and can lead to mortality, especially in the elderly [1,10,11]. The follow-up part of the study showed that history of digestive ulcer, exercising, and taking calcium supplements were associated with fractures among patients with osteoporosis. As stated above, digestive ulcers often indicate the presence of inflammatory digestive diseases and cirrhosis, and these diseases are often associated with malabsorption and malnutrition, leading to osteoporosis [17]. In addition, the systemic inflammatory state often seen in those conditions may influence the progression of osteoporosis and hence affect the risk of fracture [30]. This association between digestive ulcers and osteoporosis and fragility fractures is supported by previous studies [17,30,31]. The use of proton pump inhibitors has been shown to be associated with an increased risk of osteoporosis [32], but whether this association is due to the drug itself or to the fact that it is used to treat peptic ulcers remains unknown. As indicated above, since exercising can prevent or slow the progression of osteoporosis [27–29], exercising can decrease the risk of fragility fractures [33]. Hence, patients with osteoporosis should be encouraged to perform exercises that are adapted to their condition. Finally, taking calcium supplements after a diagnosis of osteoporosis is included in the guidelines to reduce the risk of fragility fractures [34,35], despite some controversies on the subject [36,37]. Calcium and vitamin D are cost-effective for the treatment of osteoporosis and are more accessible than bisphosphonates [38]. Nevertheless, the compliance with vitamin D supplementation is low in China [39,40].

Due to its rapid economic development, the health care situation of China has dramatically changed over the past 3 decades, but with the Westernization of lifestyle, the health conditions of Chinese have also changed [41]. Many of the chronic diseases associated with a Western lifestyle are due to the genome being ill equipped to face the nutritional characteristics recently introduced into the diet [42]. In addition, Chinese and Western populations differ in term of genetics, which affect the development of chronic diseases [43,44]. Consequently, in China, the prevalence of osteoporosis has increased over the last 20 years, affecting about one-third of the individuals aged >50 years [8], compared to 21% of women and 6% of men in the European Union [2]. Hence, combined with the aging population phenomenon and the fact that China has the world’s largest population, the absolute number of patients with osteoporosis in China is important, and a better understanding of the disease in Chinese patients is paramount. Even though some factors for osteoporosis are shared between the Chinese and Western populations, their impact on disease may differ. Additional studies are necessary to examine these differences more closely.

Of course, the present study is not without limitations. This was a single-center investigation, and a larger sample size and a more in-depth questionnaire could provide additional answers about the risk factors of osteoporosis and fracture. A selection bias cannot be avoided in an observational study;
nevertheless, we recruited subjects from 3 outpatient clinics (geriatrics, arthropathy, and osteoporosis clinics) and the health examination center. Elderly people often go to these clinics for help with age-related diseases or routine medical examination. In addition, future prospective studies should include panels of biochemical and genetic markers, as well as a complete history of exposure to drugs and chemicals, which could help improve our understanding of the risk of developing the condition. We did not investigate family histories of osteoporosis and fractures and personal histories of reproduction, breastfeeding, and hormone supplements. Finally, the fractures observed in the present study were not confirmed to be osteoporosis-related, which could have biased the results.

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Conclusions

Female sex, age, marital status, history of digestive ulcer and fracture, and family history of hunchback and osteoarthropathy are associated with osteoporosis among Chinese elderly subjects, while drinking green tea and exercising are inversely associated. Among the patients with osteoporosis, a history of digestive ulcer is associated with fractures, while exercising and taking calcium supplements are inversely associated.

Conflict of interests

None.
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