scientific reports

Check for updates

OPEN

Association between gastric polyps and decreased bone mineral density in patients with chronic gastritis

Guotao Liu[1] & Jianyuan Zhang[2]✉

Gastric polyps indicate the disturbance of gastric microecology and inflammatory status, which may affect bone metabolism. We aimed to investigate the association between gastric polyps and bone mineral density (BMD) in patients with chronic gastritis (CG). In this cross-sectional study, we collected the clinical data of 627 inpatients with CG between July 2017 and August 2022. Gastric polyps were diagnosed through gastroscopy. BMD was measured using dual energy X-ray absorptiometry. Osteopenia or osteoporosis was defined as decreased BMD. Linear regression analysis was employed to assess the relationship between BMD with gastric polyps. Logistic regression analysis was conducted to evaluate the correlation between decreased BMD and gastric polyps. In results, the prevalence of gastric polyps in males and females with CG was 17.3% and 18.3%, respectively. The occurrence of decreased BMD was observed in 51.4% and 65.1% of males and females, respectively. Gastric polyps were negatively correlated with lumbar spine, femoral neck, and total femur BMD (β=-0.025, -0.043, -0.029, $p \leq 0.005$) in females with CG. Furthermore, gastric polyps significantly elevated the risk of osteoporosis or osteopenia (OR = 2.672, $p = 0.010$) among females with CG. However, no significant correlation between gastric polyps and BMD was detected in males with CG. In addition, gastric polyps in females were positively correlated with hypertension and high low-density lipoprotein cholesterol levels, while negatively correlated with high phosphorus levels. In conclusion, gastric polyps are negatively correlated with BMD and significantly increase the risk of osteoporosis or osteopenia in females with CG.

Keywords Gastric polyps, Bone mineral density, Osteoporosis, Osteopenia, Chronic gastritis

Osteoporosis is a systemic bone disease characterized by low bone mass, damaged bone microstructure, increased fragility, and an increased risk of fractures[1]. Osteoporosis can occur at any age, but is more common in postmenopausal women and elderly men. According to epidemiological surveys, the prevalence of osteoporosis in people over 65 years old in China was 32%, including 51.6% in women and 10.7% in men[2], which revealed substantial impact on public health and economy.

The risk factors associated with osteoporosis encompass race, advancing age, menopause, sedentary lifestyle, vitamin D insufficiency, endocrine disorders, gastrointestinal disorders, hematological disorders, prolonged use of proton pump inhibitors (PPIs) and corticosteroid, etc. Chronic gastritis (CG), one of the most prevalent digestive system diseases, has recently attracted increasing attention for its relationship with bone metabolism. Factors such as *Helicobacter pylori (H. pylori)* infection, long-term use of PPIs, entero-osseous hormones abnormal secretion, low leptin levels, and hypochlorhydria stomach related to CG may affect bone metabolism and lead to decreased bone mineral density (BMD)[3]. A retrospective study in South Korea showed that postmenopausal women with chronic atrophic gastritis exhibited decreased bone mineral density and an increased likelihood of developing osteopenia or osteoporosis[4]. According to Aasarød's study, patients with chronic atrophic gastritis showed a decrease in bone formation markers and an increase in bone resorption markers[5].

Gastric polyps are characterized as elevated lesions found on the surface of the gastric mucosa. Current studies have shown that gastric polyps are related to chronic inflammatory stimulation[6], *H. pylori* infection[7], long-term use of PPIs[8], bile reflux[9], genetic factors, dietary habits[10], smoking, etc. The formation of gastric polyps indicates

[1]Department of Health care, Cheeloo College of Medicine, Qilu Hospital (Qingdao), Shandong University, Qingdao 266035, Shandong, China. [2]Department of Neurology, Cheeloo College of Medicine, Qilu Hospital (Qingdao), Shandong University, Qingdao 266035, Shandong, China. ✉email: zjy028605@qlyyqd.com

the disturbance of gastric microecology and persistent inflammatory status, which may affect bone metabolism. To date, no studies have investigated the association between gastric polyps and bone metabolism. Therefore, we conducted this study to explore the relationship between gastric polyps and BMD in patients with CG.

Materials and methods

Participants

The participants were inpatients with CG in the healthcare department of Qilu Hospital (Qingdao) of Shandong University from July 2017 to August 2022. Patients with CG were identified by previous clinical diagnosis and patient self-reports. The specific type of CG was not found. A total of 627 participants were included, consisting of 378 females and 249 males, with an age range of 31–86 years (average 58.21 ± 9.06 years old). All participants underwent gastroscopy examinations, obtained relevant biopsy pathological results, and had BMD assessed. Exclusion criteria included malignant tumors, thyroid diseases, parathyroid diseases, rheumatic diseases, abnormal liver or kidney function, cirrhosis, acute gastrointestinal bleeding, chronic obstructive pulmonary disease, and acute infections. In addition, we also excluded individuals with specific medication history, such as history of glucocorticoid use, *H. pylori* infection treatment, recent (within the past two weeks) or long-term (continuous use for more than six months) use of PPIs, recent use of antibiotics, history of osteoporosis treatment, and history of estrogen supplementation. As a clinical data survey based on cross-sectional analysis, it was approved by the Ethics Committee of Qilu Hospital (Qingdao) of Shandong University (KYLL-KS-2023165). Due to the retrospective nature of the study, the Ethics Committee of Qilu Hospital (Qingdao) of Shandong University waived the need of obtaining informed consent' in the manuscript. The procedures described in the study followed the principles of the Declaration of Helsinki, and all participants' information were anonymized.

Findings from gastroscopy

Gastric polyps were evaluated via gastroscopy (GIF-H290, Olympus Co., Tokyo, Japan). To determine the pathological characteristics of gastric polyps, biopsies or endoscopic resections were performed in all patients with gastric polyps, and pathological diagnosis was conducted using hematoxylin and eosin (HE) staining. In the pathological diagnosis related to gastritis, we assessed the pathological changes of the gastric mucosa, including inflammation, activity, atrophy, intestinal metaplasia, and dysplasia, using HE staining. The Warthin-Starry silver staining method was employed for the diagnosis of *H. pylori* infection. All of this work was carried out by pathologists in our hospital's pathology department. The presence of gastric mucosal atrophy and intestinal metaplasia was classified as precancerous conditions, while gastric mucosal dysplasia was categorized as precancerous lesions. Both precancerous conditions and precancerous lesions were categorized into the single variable "Precancerous Changes".

Bone mineral density measurement

The BMD of lumbar spine (L1-L4), femoral neck, and total femur were measured by dual energy X-ray absorptiometry (Hologic Discovery A, Waltham, MA, USA) by an experienced technician. According to the World Health Organization criteria[11], a T-score≤-2.5 indicates osteoporosis, and $-2.5 < T < -1$ indicates osteopenia. In this study, we defined decreased BMD as either osteoporosis or osteopenia.

Clinical data collection

The demographic characteristics including gender, age, weight, height, and medical history of the patients were recorded. Body mass index (BMI) was computed as the ratio of weight to the square of height (kg/m^2). Fasting blood samples were collected from all patients in the morning. The biochemistry automatic analyzer (Hitachi 7170, Tokyo, Japan) was utilized to measure the alkaline phosphatase (ALP), calcium (Ca), low-density lipoprotein cholesterol (LDL), and phosphorus (P) levels.

Statistical analysis

The Statistical Product and Service Solutions (SPSS, version 26.0) software was used for data analysis. Continuous variables were described as mean ± standard deviation or median (P25-P75) according to normality test results. Categorical variables were described as frequencies and percentages. Group comparisons for variables were conducted using independent-sample *t* test, chi-square test, or Mann-Whitney *U* test. Univariate and multivariate linear regression analysis were used to assess the relationship between BMD and gastric polyps. Risk factors for decreased BMD were explored using univariate logistic regression analysis. The association between gastric polyps and decreased BMD was investigated using multivariate logistic regression analysis. In addition, risk factors for the occurrence of gastric polyps were explored using multivariate logistic regression analysis. Statistical significance was considered when the two-tailed $p<0.05$.

Results

Clinical characteristics

The population characteristics of this study were illustrated in Table 1. A total of 627 patients with CG were enrolled, comprising 378 females and 249 males. The incidence rates of gastric polyps among females and males were recorded as 18.3% and 17.3%, respectively. Among female patients, the gastric polyps group exhibited a significant decrease in the BMD of lumbar spine, femoral neck, and total femur compared to the non-gastric polyp group, along with a significantly increased incidence of decreased BMD (81.2% vs. 61.5%). However, among male patients, only the BMD of femoral neck showed a significant reduction in the gastric polyps group compared to the non-gastric polyp group; no significant changes were observed in the BMD of lumbar spine or total femur, nor was there a notable increase in the incidence of decreased BMD.

Characteristics	Female ($n=378$)			Male ($n=249$)		
	Gastric polyps (-) ($n=309$)	Gastric polyps (+) ($n=69$)	p	Gastric polyps (-) ($n=206$)	Gastric polyps (+) ($n=43$)	p
Age (years)	56 (51, 64)	71 (58, 74)	<0.001	56 (48, 62)	70 (59, 76)	<0.001
<60 (%)	169 (54.7)	30 (43.5)	<0.001	181 (87.9)	20 (46.5)	<0.001
≥60 (%)	140 (45.3)	39 (56.5)		25 (12.1)	23 (53.5)	
BMI (kg/m^2)	24.78 ± 3.28	25.28 ± 3.29	0.257	26.24 ± 2.98	24.90 ± 4.02	0.043
Diabetes mellitus (%)			0.049			0.649
No	252 (81.6)	49 (71.0)		145 (70.4)	34 (79.1)	
Yes	57 (18.4)	20 (29.0)		61 (29.6)	9 (20.9)	
Hypertension (%)			0.002			0.504
No	212 (68.6)	34 (49.3)		108 (52.4)	20 (46.5)	
Yes	97 (31.4)	35 (50.7)		98 (47.6)	23 (53.5)	
Ca (mmol/L)	2.30 ± 0.10	2.30 ± 0.11	0.728	2.29 ± 0.11	2.27 ± 0.13	0.218
P (mmol/L)	1.25 ± 0.15	1.21 ± 0.16	0.037	1.16 ± 0.16	1.04 ± 0.19	<0.001
ALP (U/L)	66.08 ± 19.17	70.23 ± 20.40	0.109	64.07 ± 17.20	60.60 ± 13.72	0.215
LDL (mmol/L)	3.09 ± 0.73	3.27 ± 1.00	0.150	2.97 ± 0.75	2.48 ± 0.84	<0.001
BMD (g/m^2)						
Lumbar spine	0.937 ± 0.148	0.872 ± 0.140	0.001	1.009 ± 0.141	1.009 ± 0.151	0.978
Femoral neck	0.741 ± 0.126	0.643 ± 0.245	<0.001	0.835 ± 0.118	0.791 ± 0.114	0.025
Total femur	0.859 ± 0.125	0.792 ± 0.133	<0.001	0.957 ± 0.130	0.929 ± 0.148	0.212
Decreased BMD (%)			0.002			0.603
No	119 (38.5)	13 (18.8)		100 (48.5)	19 (44.2)	
Yes	190 (61.5)	56 (81.2)		106 (51.5)	24 (55.8)	
H. pylori infection (%)			0.537			0.015
No	171 (55.3)	41 (59.4)		107 (51.9)	27 (62.8)	
Yes	138 (44.7)	28 (40.6)		99 (48.1)	16 (37.2)	
Precancerous changes(%)			0.150			0.884
No	155 (50.2)	28 (40.6)		95 (46.1)	20 (46.5)	
Yes	154 (49.8)	41 (59.4)		111 (53.9)	23 (53.5)	

Table 1. The characteristics of patients according to gastric polyps. Data are mean (SD) for continuous variables and n (%) for category variables. Results are based on independent-sample *t* test, chi-square test, or Mann-Whitney *U* test. ALP, alkaline phosphatase; BMI, body mass index; BMD, bone mineral density; Ca, calcium; H. pylori, Helicobacter pylori; LDL, low-density lipoprotein cholesterol; P, phosphorus.

Association between gastric polyps and BMD

As depicted in Table 2, univariate linear regression analysis revealed a negative correlation between age (≥60 years), high ALP levels, and gastric polyps in female patients with the BMD of lumbar spine, femoral neck, and total femur; conversely, a positive correlation was observed with high BMI. Furthermore, multiple linear regression analysis (Table 3) adjusting for age, BMI, diabetes mellitus, hypertension, *H. pylori* infection, precancerous changes, Ca levels, P levels, ALP levels, and LDL levels showed a significant negative association between the BMD of lumbar spine, femoral neck, and total femur (β=-0.025, -0.043, -0.029, $p \leq 0.005$) with gastric polyps in female patients. However, no significant difference was found in male patients (data not shown).

Association between decreased BMD and clinical characteristics in females

As presented in Table 4; Fig. 1, the univariate logistic regression analysis revealed significant positive correlations between decreased BMD and age (≥60 years), hypertension, high ALP levels, and gastric polyps in female patients (OR = 6.707, 1.615, 1.039, 2.698, $p<0.05$); whereas a significant negative correlation was observed with high BMI (OR = 0.923, $p = 0.016$). In the multivariate logistic regression analysis adjusting for age, BMI, diabetes mellitus, hypertension, *H. pylori* infection, precancerous changes, Ca levels, P levels, ALP levels, and LDL levels; it was identified that gastric polyps exhibited a significant positive association with decreased BMD (OR = 2.672, $p = 0.010$) (Table 5).

Association between gastric polyps and other clinical characteristics

As shown in Table 6, after adjusting for age, BMI, diabetes mellitus, hypertension, *H. pylori* infection, precancerous changes, Ca levels, P levels, ALP levels and LDL levels, multivariate logistic regression analysis found that the incidence of gastric polyps was positively correlated with hypertension and high LDL levels (OR = 1.966, 1.570, $p<0.05$), while negatively correlated with high P levels (OR = 0.107, $p<0.05$).

Characteristics	Lumber spine		Femoral neck		Total femur	
	β (95% CI)	*p*	β(95% CI)	*p*	β(95% CI)	*p*
Age (years)						
<60years (%)	0		0		0	
≥60years (%)	-0.052 (-0.067, -0.038)	<0.001	-0.044 (-0.059, -0.030)	<0.001	-0.044 (-0.057, -0.032)	<0.001
BMI (kg/m^2)	0.010 (0.005, 0.014)	<0.001	0.010 (0.006, 0.015)	<0.001	0.013 (0.009, 0.016)	<0.001
Diabetes mellitus (%)						
No	0		0		0	
Yes	-0.011 (-0.029, 0.008)	0.256	-0.010 (-0.029, 0.009)	0.298	-0.008 (-0.024, 0.009)	0.353
Hypertension (%)						
No	0		0		0	
Yes	-0.007 (-0.023, 0.008)	0.351	-0.0103 (-0.029, 0.003)	0.108	-0.008 (-0.022, 0.006)	0.257
Ca (mmol/L)	0.054 (-0.095, 0.203)	0.475	0.069 (-0.084, 0.221)	0.375	0.094 (-0.034, 0.222)	0.151
P (mmol/L)	0.010 (-0.088, 0.108)	0.838	0.053 (-0.047, 0.154)	0.298	0.043 (-0.041, 0.128)	0.315
ALP (U/L)	-0.002 (-0.003, -0.002)	<0.001	-0.001 (-0.002, -0.001)	0.001	-0.002 (-0.002, -0.001)	<0.001
LDL (mmol/L)	-0.016 (-0.035, 0.003)	0.093	-0.004 (-0.024, 0.016)	0.686	-0.001 (-0.018, 0.015)	0.901
H. pylori infection (%)						
No	0		0		0	
Yes	0.008 (-0.007, 0.023)	0.305	0.008 (-0.007, 0.024)	0.290	0.012 (-0.001, 0.025)	0.065
Precancerous changes (%)						
No	0		0		0	
Yes	-0.007 (-0.022, 0.008)	0.376	-0.015 (-0.030, 0.000)	0.057	-0.009 (-0.022, 0.004)	0.186
Gastric polyps						
No	0		0		0	
Yes	-0.032 (-0.052, -0.013)	0.001	-0.049 (-0.068, -0.029)	<0.001	-0.034 (-0.050, -0.017)	<0.001

Table 2. The association between clinical characteristics and BMD in females. Results are based on univariate linear regression analysis. ALP, alkaline phosphatase; BMI, body mass index; BMD, bone mineral density; Ca, calcium; CI, confidence interval; *H. pylori*, *Helicobacter pylori*; LDL, low-density lipoprotein cholesterol; P, phosphorus.

Model	Lumber spine		Femoral neck		Total femur	
	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*
Model 1	-0.027 (-0.045, -0.009)	0.004	-0.044 (-0.063, -0.025)	<0.001	-0.029 (-0.045, -0.013)	<0.001
Model 2	-0.029 (-0.047, -0.012)	0.001	-0.047 (-0.065, -0.029)	<0.001	-0.032 (-0.047, -0.018)	<0.001
Model 3	-0.025 (-0.042, -0.008)	0.005	-0.043 (-0.061, -0.024)	<0.001	-0.029 (-0.043, -0.014)	<0.001

Table 3. The association between gastric polyps and BMD in females. BMD, bone mineral density; CI, confidence interval. Results are based on multiple linear regression analysis. Model 1 was adjusted for age; Model 2 was adjusted for age and BMI; Model 3 was adjusted for age, BMI, diabetes mellitus, hypertension, *H. pylori* infection, precancerous changes, Ca, P, ALP, and LDL.

Discussion

In this cross-sectional study, the results showed that gastric polyps were negatively correlated with the BMD of lumber spine, femoral neck, and total femur and significantly increased the risk of osteoporosis or osteopenia in females with CG.

To date, the research on the relationship between the stomach and bone metabolism primarily focused on exploring the correlation between CG, *H. pylori* infection, or long-term use of PPIs and bone mineral density. However, there is no unified conclusion yet. A study in South Korea showed that postmenopausal women aged above 60 with atrophic gastritis exhibited an increased risk of osteoporosis[12]. A study in Norway reported that males with atrophic gastritis showed decreased BMD of lumber, but not females[5]. According to Mizuno's study, *H. pylori* infection and atrophic gastritis which was diagnosed by serology increased the risk of osteoporosis[13]. Inflammation in the stomach, especially in the presence of *H. pylori* infection, increased the levels of interleukin-1 (IL-1), interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α), which promoted bone resorption and cause bone loss[14]. Yang et al. reported that an elevated risk of hip fracture was observed in individuals undergoing prolonged PPI therapy, especially when administered at higher dosages[15]. Lespessailles et al. also reported that long-term use of PPIs increases the risk of fragile fractures[16]. To the opposite, Kakehasi et al. reported that no correlation was found between *H. pylori*-related gastritis and autoimmune gastritis with a decrease in women's bone mineral density[17]. Another cross-sectional study in mainland China showed that individuals aged above

Characteristics	OR (95% CI)	*p*
Age (years)		
<60years (%)	1.00 (reference)	
≥ 60years (%)	6.707 (4.066, 11.063)	<0.001
BMI (kg/m^2)	0.923 (0.865, 0.985)	0.016
Diabetes mellitus (%)		
No	1.00 (reference)	
Yes	1.689 (0.964, 2.958)	0.067
Hypertension (%)		
No	1.00 (reference)	
Yes	1.615 (1.021, 2.555)	0.040
Ca (mmol/L)	0.280 (0.034, 2.276)	0.234
P (mmol/L)	0.678 (0.170, 2.701)	0.582
ALP (U/L)	1.039 (1.024, 1.054)	<0.001
LDL (mmol/L)	1.070 (0.818, 1.399)	0.621
H. pylori infection (%)		
No	1.00 (reference)	
Yes	0.753 (0.492, 1.151)	0.190
Precancerous changes (%)		
No	1.00 (reference)	
Yes	1.004 (0.658, 1.534)	0.984
Gastric polyps		
No	1.00 (reference)	
Yes	2.698 (1.415, 5.145)	0.003

Table 4. The association between clinical characteristics and decreased BMD in females. Results are based on univariate logistic regression analysis. ALP, alkaline phosphatase; BMI, body mass index; BMD, bone mineral density; Ca, calcium; CI, confidence interval; *H. pylori*, *Helicobacter pylori*; LDL, low-density lipoprotein cholesterol; OR, odds ratio; P, phosphorus.

50 with *H. pylori* infection had no association with osteoporosis[18]. In this study, we classified gastritis into non-atrophic gastritis and atrophic gastritis based on the pathological results of gastric biopsy. We further defined the variable of precancerous changes according to the histological changes of chronic gastritis: atrophy, intestinal metaplasia, or dysplasia. There were a total of 340 patients with non-atrophic gastritis and 287 patients with atrophic gastritis. We have also grouped patients according to the presence of *H. pylori* infection or the presence of non-atrophic versus atrophic gastritis or the severity of atrophic gastritis (mild, moderate, severe) in order to compare the differences in the bone mineral density, but no statistically significant differences were found. These differences arose from heterogeneity in terms of race, gender, and age on one hand, and from differences in research methods, such as varying sample sizes, different methods of bone mineral density measurement, and different diagnostic methods for gastric disorders (serological or histological methods) on the other hand.

Gastric polyps were closely associated with gastric disorders mentioned above. Hyperplastic polyps were associated with gastritis and gastric atrophy[6], and inflammation may play a role in promoting polyp development. *H. pylori* infection exhibited a strong correlation with hyperplastic gastric polyps, and subsequent *H pylori* eradication could lead to their regression[19]. There was an association between long-term use of PPIs and fundic gland polyps, and there have been case reports of patients whose gastric polyps disappeared after omeprazole withdrawal[20]. Accompanied by gastric mucosa atrophy, decreased gastric acid secretion may lead to poor calcium absorption, which increases the risk of osteoporosis[21]. Increased PH values and gastrin secretion could lead to hyperplasia of gastric glands and the development of gastric polyps[9]. To the best of our knowledge, this was the first study that explores the relationship between gastric polyps and bone mineral density. A previous study reported that age-related bone loss in the forearms, hips, and lumbar spine ranged from 0.002 to 0.006 g/cm^2 per year in both men and postmenopausal women[22]. While in this study, after multivariable adjustment, it showed a significant negative association between BMD of lumbar spine, femoral neck, and total femur (β=-0.025, -0.043, -0.029, $p \leq 0.005$) with gastric polyps in female patients. Compared to the bone mineral density decline caused by aging, the β value meant great clinical significance. However, based on our limited sample size, we identified a total of 112 patients with gastric polyps, comprising 52 cases of hyperplastic polyps and 60 cases of fundic gland polyps, with no other pathological types of gastric polyps found. We also compared the bone mineral density among patients with different pathological types of gastric polyps but did not observe any statistically significant differences (Table S1-3).

The mechanism by which gastric polyps affect bone metabolism may involve the following aspects. First, coexisting atrophic gastritis or long-term use of PPIs leaded to reduced gastric acid and poor calcium absorption[3]. Second, leptin and ghrelin levels decreased in gastric disorders. The potential impact of decreased levels of circulating leptin following weight loss on bone density reduction should not be overlooked in any

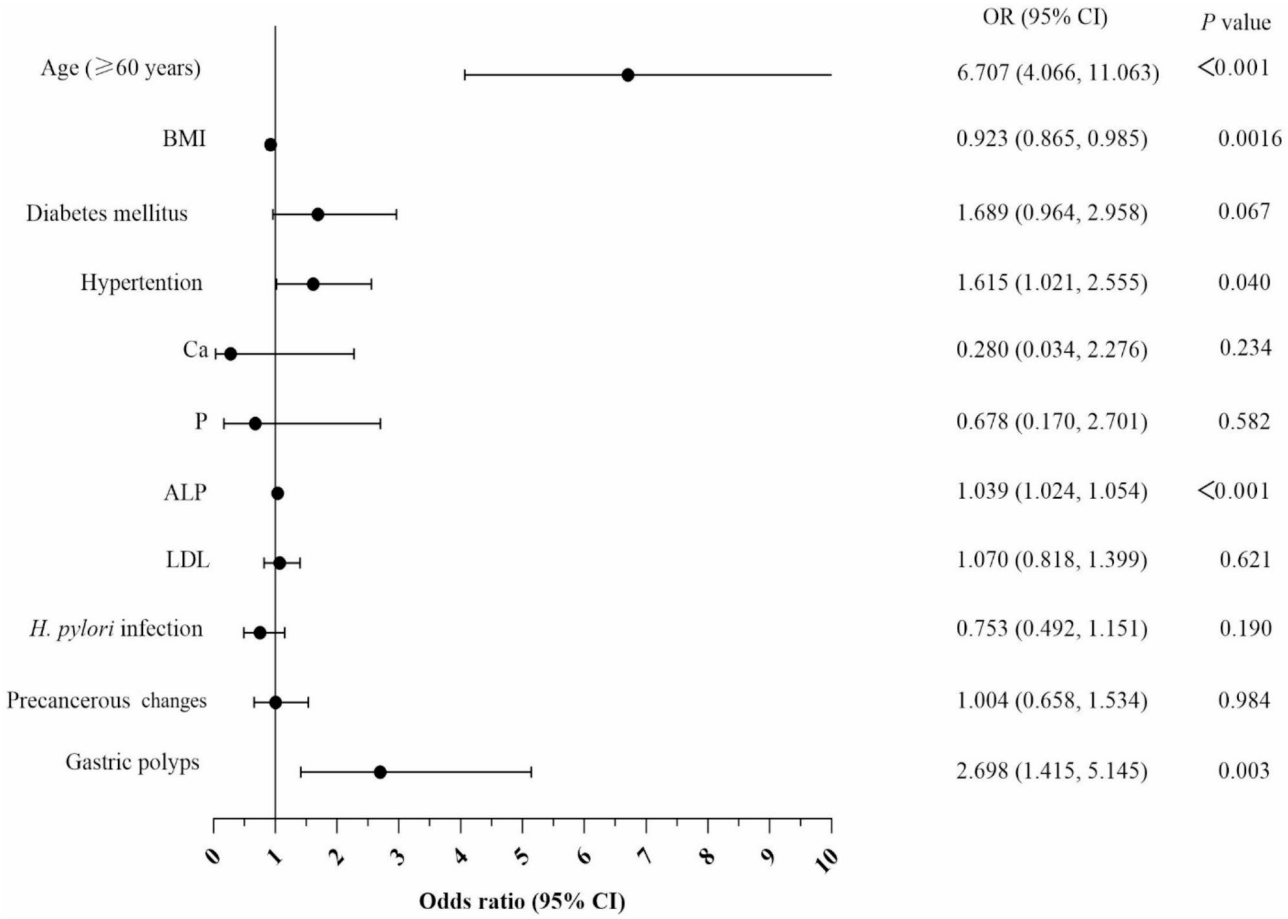

Fig. 1. Forest plot of factors associated with decreased BMD in females. ALP, alkaline phosphatase; BMI, body mass index; BMD, bone mineral density; Ca, calcium; CI, confidence interval; *H. pylori*, *Helicobacter pylori*; LDL, low-density lipoprotein cholesterol; OR, odds ratio; P, phosphorus.

Model	OR (95% CI)	*p*
Model 1	2.548 (1.279, 5.076)	0.008
Model 2	2.793 (1.381, 5.650)	0.004
Model 3	2.672 (1.266, 5.639)	0.010

Table 5. The association between gastric polyps and decreased BMD in females. Results are based on multivariate logistic regression analysis. BMD, bone mineral density; CI, confidence interval; OR, odds ratio. Model 1 was adjusted for age; Model 2 was adjusted for age and BMI; Model 3 was adjusted for age, BMI, diabetes mellitus, hypertension, *H. pylori* infection, precancerous changes, Ca, P, ALP, and LDL.

gastrointestinal disorder[23]. Leptin exerted a direct stimulatory effect on osteoblast differentiation and on bone growth[24]. On the other hand, Ersoy et al. reported a significant reduction in ghrelin levels in individuals with hyperplastic gastric polyp, as compared to those with chronic active gastritis[25]. While ghrelin could promote bone formation through the enhancement of osteoblast-like cell proliferation and DNA synthesis in rats[26]. Third, intragastric inflammation, especially the upregulation of inflammatory factors in *H. pylori*-related gastritis could cause bone loss[14]. Furthermore, our study findings indicated that the observed correlation might exhibit a greater magnitude among females compared to males, potentially due to the higher susceptibility of women to osteoporosis, particularly following menopause.

There were some limitations that needed to be acknowledged in this study. First, the sample size was relatively small. Second, this study adopted a cross-sectional design at a single center. Third, the variables of dietary habits, amount of exercise, sunlight exposure, and estrogen levels could not be collected. Therefore, additional longitudinal studies are needed to evaluate causality.

In conclusion, gastric polyps are negatively correlated with the BMD of lumber spine, femoral neck, and total femur and significantly increase the risk of osteoporosis or osteopenia in females with CG.

Characteristics	OR (95% CI)	*p*
Age (years)		
<60years (%)	1.00 (reference)	
≥60years (%)	1.069 (0.586, 1.950)	0.828
BMI (kg/m^2)	1.023 (0.938, 1.115)	0.613
Diabetes mellitus (%)		
No	1.00 (reference)	
Yes	1.479 (0.756, 2.893)	0.253
Hypertension (%)		
No	1.00 (reference)	
Yes	1.966 (1.046, 3.697)	0.036
Ca (mmol/L)	0.361 (0.023, 5.654)	0.468
P (mmol/L)	0.107 (0.018, 0.654)	0.016
ALP (U/L)	1.008 (0.994, 1.022)	0.266
LDL (mmol/L)	1.570 (1.100, 2.240)	0.013
H. pylori infection (%)		
No	1.00 (reference)	
Yes	0.810 (0.463, 1.417)	0.460
Precancerous changes (%)		
No	1.00 (reference)	
Yes	1.713 (0.964, 3.043)	0.066

Table 6. The association between gastric polyps and other clinical characteristics in females. Results are based on multivariate logistic regression analysis adjusted for age, BMI, diabetes mellitus, hypertension, *H. pylori* infection, precancerous changes, Ca levels, P levels, ALP levels and LDL levels. ALP, alkaline phosphatase; BMI, body mass index; Ca, calcium; CI, confidence interval; *H. pylori*, *Helicobacter pylori*; LDL, low-density lipoprotein cholesterol; OR, odds ratio; P, phosphorus.

Data availability

The corresponding author will consider reasonable requests for sharing the data that supports this study.

Received: 27 May 2024; Accepted: 18 March 2025
Published online: 25 March 2025

References

1. Consensus development conference Diagnosis, prophylaxis, and treatment of osteoporosis. *Am. J. Med.* **94**, 646–650. https://doi.org/10.1016/0002-9343(93)90218-e (1993).
2. Wang, L. et al. Prevalence of osteoporosis and fracture in China. *JAMA Netw. Open.* **4**. https://doi.org/10.1001/jamanetworkopen.2021.21106 (2021).
3. Kitay, A. & Geibel, J. P. Stomach and bone. *Adv. Exp. Med. Biol.* **1033**, 97–131. https://doi.org/10.1007/978-3-319-66653-2_6 (2017).
4. Lee, S., Yun, J. M., Park, J. H. & Kwon, H. Association between chronic atrophic gastritis and bone mineral density among women older than 40 years of age in Korea. *Korean J. Family Med.* https://doi.org/10.4082/kjfm.22.0139 (2024).
5. Aasarød, K. M. et al. Impaired skeletal health in patients with chronic atrophic gastritis. *Scand. J. Gastroenterol.* **51**, 774–781. https://doi.org/10.3109/00365521.2016.1141317 (2016).
6. Abraham, S. C., Singh, V. K., Yardley, J. H. & Wu, T. T. Hyperplastic polyps of the stomach: associations with histologic patterns of gastritis and gastric atrophy. *Am. J. Surg. Pathol.* **25**, 500–507. https://doi.org/10.1097/00000478-200104000-00010 (2001).
7. Jain, R. & Chetty, R. Gastric hyperplastic polyps: A review. *Dig. Dis. Sci.* **54**, 1839–1846. https://doi.org/10.1007/s10620-008-0572-8 (2008).
8. Kroupa, R. et al. The association between duration of and indications for proton pump inhibitor use and risk of gastric polyps. *Eur. J. Gastroenterol. Hepatol.* **35**, 829–835. https://doi.org/10.1097/meg.0000000000002587 (2023).
9. Zheng, E. et al. Impact of gender and age on the occurrence of gastric polyps: data analysis of 69575 southeastern Chinese patients. *Turkish J. Gastroenterol.* **26**, 474–479. https://doi.org/10.5152/tjg.2015.0099 (2015).
10. Cao, W., Hou, G., Zhang, X., San, H. & Zheng, J. Potential risk factors related to the development of gastric polyps. *Immunopharmacol. Immunotoxicol.* **40**, 338–343. https://doi.org/10.1080/08923973.2018.1490317 (2018).
11. Kanis, J. A. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis: synopsis of a WHO report. WHO Study Group. *Osteoporos. International: J. Established as Result Cooperation between Eur. Foundation Osteoporos. Natl. Osteoporos. Foundation USA*. **4**, 368–381. https://doi.org/10.1007/bf01622200 (1994).
12. Gong, Y. et al. Atrophic gastritis: A related factor for osteoporosis in elderly women. *PLoS ONE* **9**. https://doi.org/10.1371/journal.pone.0101852 (2014).
13. Mizuno, S. et al. Serologically determined gastric mucosal condition is a predictive factor for osteoporosis in Japanese men. *Dig. Dis. Sci.* **60**, 2063–2069. https://doi.org/10.1007/s10620-015-3576-1 (2015).
14. Raggatt, L. J. & Partridge, N. C. Cellular and molecular mechanisms of bone remodeling. *J. Biol. Chem.* **285**, 25103–25108. https://doi.org/10.1074/jbc.R109.041087 (2010).
15. Yang, Y. X., Lewis, J. D., Epstein, S. & Metz, D. C. Long-term proton pump inhibitor therapy and risk of hip fracture. *Jama* **296**. https://doi.org/10.1001/jama.296.24.2947 (2006).

16. Lespessailles, E. & Toumi, H. Proton pump inhibitors and bone health: an update narrative review. *Int. J. Mol. Sci.* **23**. https://doi.org/10.3390/ijms231810733 (2022).
17. Kakehasi, A. M., Rodrigues, C. B., Carvalho, A. V. & Barbosa, A. J. A. Chronic gastritis and bone mineral density in women. *Dig. Dis. Sci.* **54**, 819–824. https://doi.org/10.1007/s10620-008-0417-5 (2008).
18. Ye, Y. F. et al. Association of Helicobacter pylori infection with osteoporosis risk in a physical examination population. *Archives Osteoporos.* **17**. https://doi.org/10.1007/s11657-022-01074-0 (2022).
19. Suzuki, S. et al. Disappearance of multiple hyperplastic polyps after the eradication of Helicobacter pylori. *Gastrointest. Endosc.* **46**, 566–568. https://doi.org/10.1016/s0016-5107(97)70020-8 (1997).
20. Hamada, K., Takeuchi, Y., Akasaka, T. & Iishi, H. Fundic gland polyposis associated with Proton-Pump inhibitor use. *Eur. J. Case Rep. Intern. Med.* **2**. https://doi.org/10.12890/2017_000607 (2017).
21. Sipponen, P. & Härkönen, M. Hypochlorhydric stomach: a risk condition for calcium malabsorption and osteoporosis? *Scand. J. Gastroenterol.* **45**, 133–138. https://doi.org/10.3109/00365520903434117 (2009).
22. Warming, L., Hassager, C. & Christiansen, C. Changes in bone mineral density with age in men and women: A longitudinal study. *Osteoporos. Int.* **13**, 105–112. https://doi.org/10.1007/s001980200001 (2002).
23. Bernstein, C. N. & Leslie, W. D. The pathophysiology of bone disease in Gastrointestinal disease. *Eur. J. Gastroenterol. Hepatol.* **15**, 857–864. https://doi.org/10.1097/00042737-200308000-00004 (2003).
24. Isaia, G. C., D'Amelio, P., Di Bella, S. & Tamone, C. Is leptin the link between fat and bone mass? *J. Endocrinol. Investig.* **28**, 61–65 (2005).
25. Ersoy, O. et al. Evaluation of serum Ghrelin levels in patients with hyperplastic gastric polyps. *Turkish J. Gastroenterol.* **23**, 444–447. https://doi.org/10.4318/tjg.2012.0424 (2012).
26. Fukushima, N. et al. Ghrelin directly regulates bone formation. *J. Bone Mineral. Research: Official J. Am. Soc. Bone Mineral. Res.* **20**, 790–798. https://doi.org/10.1359/jbmr.041237 (2005).

Acknowledgements
Not applicable.

Author contributions
J.Z. participated in research design and manuscript revisions, contributing to the academic and professional quality of the paper. G.L. was responsible for data collection, analysis, interpretation, and drafting of the manuscript. All authors have read and approved the final manuscript.

Funding
This research was founded by grants from the Qingdao Clinical Research Center for Rare Diseases of Nervous System (22-3-7-lczx-3-nsh) and the Qingdao Technology Program for Health and Welfare (20-3-4-42-nsh).

Declarations

Competing interests
The authors declare no competing interests.

Additional information
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-95025-7.

Correspondence and requests for materials should be addressed to J.Z.