Bone mineral density in adults with osteoarthritis or rheumatoid arthritis: a cross-sectional study of a nationwide population.

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Research article

Keywords: osteoarthritis; degenerative arthritis; rheumatoid arthritis; bone health; NHANES

Posted Date: May 15th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-28236/v1

Abstract

Background

It is reported that osteoporosis commonly occurs in rheumatoid arthritis (RA), whereas there is a controversial relationship with osteoarthritis (OA). In this study, we aimed to investigate the relations between OA, RA and bone mineral density (BMD) in adults aged 20–59 years.

Methods

We merged and analyzed the database from the National Health and Nutrition Examination Survey (NHANES) 2011–2018. Arthritis status and types of arthritis were obtained from questionnaires. Lumbar BMD was measured by dual-energy X-ray absorptiometry. The associations between OA, RA and lumbar BMD were evaluated using logistic regression models. Subgroup analyses stratified by gender and race were performed. The association between disease duration of arthritis and lumbar BMD was also investigated.

Results

A total of 11094 adults aged 20–59 years were analyzed in this study. Compared with the non-arthritis group, participants with OA had a higher lumbar BMD (β = 0.023; 95% CI: 0.011–0.035), while no significant association was observed in rheumatoid arthritis (β = 0.014; 95% CI: -0.003–0.031). In the subgroup analyses stratified by gender, males with OA had a higher lumbar BMD compared with those without (β = 0.014; 95% CI: -0.003–0.031). However, this association changed in females (β = 0.007; 95% CI: -0.008–0.021). On the other hand, no significant association was observed in RA in both males and females (males: β = 0.023; 95% CI: -0.003–0.048, females: β = 0.008; 95% CI: -0.015–0.031). Moreover, the disease duration of arthritis was not associated with lumbar BMD in both OA (β=-0.0001; 95% CI: -0.0017–0.0015) and RA (β = 0.0006; 95% CI: -0.0012–0.0025).

Conclusions

The correlation between OA and lumbar BMD differed by sex. Patients with OA were more likely to have higher lumbar BMD in males, but not in females. On the other hand, no significant association was found in RA both in males and females.

Introduction

Osteoporosis (OP), osteoarthritis (OA), and rheumatoid arthritis (RA) are a series of disorders called musculoskeletal pathologies that cause intolerable pains, movement disorders, and even permanent disability[1]. With the aging of the social population, these diseases have reached about 1 in 4 adults in

developed countries[2, 3]. RA is an autoimmune disease of unknown etiology with a homeostatic imbalance[4]. As a biomechanical disease, the onset and development of OA are closely related to inflammatory and catabolic alterations[5]. OP is a systemic disease associated with a dramatic loss of bone mineral density (BMD). As two notable silent rheumatic diseases, OA and OP have been included on the World Health Organization disease-disabling list[1, 6].

It is reported that OP commonly occurs in RA, whereas there is a controversial relationship with OA[7–10]. In this study, we therefore investigated the relations between OA, RA and BMD in adults aged 20–59 years using a population-based sample from the National Health and Nutrition Examination Survey (NHANES) database.

Methods

Study population

The NHANES program is a series of surveys focusing on health topics of US population of all ages. The data collection and analysis require special statistical analysis due to the multistage, complex clustered probability design of the survey, rather than based on a simple random sample of the US population[11].

The current study used the data from NHANES 2011–2018. The study population was restricted to adults aged 20–59 years (enrollment from NHANES 2011–2018, n = 14934). Participants without data on arthritis diagnosis (n = 23), lumbar BMD (n = 3398), or with cancer (n = 419) were excluded. Finally, a total of 11094 subjects were analyzed in this study. The ethics review board of the National Center for Health Statistics (NCHS) approved all protocols, and written informed consent was obtained from each participant[12]

Arthritis

A diagnosis of arthritis was based on the medical conditions questionnaires collected by NHANES during the household interviews. Arthritis was classified as OA, RA, psoriatic arthritis, other, and don't know (or refused) if the participants reported ever being told they had arthritis by a doctor or other health professional. We defined the disease duration of arthritis as age in years at screening minus age when the doctor told the participants they had arthritis.

Lumbar BMD

Lumbar spine is one site typically evaluated for the assessment and treatment of osteoporosis, and BMD measurement at this site has been used as a clinical trial outcome for over three decades[13]. As the most widely accepted method, the dual-energy X-ray absorptiometry (DXA) scans provide bone measurements for lumbar spine. In NHANES program, the scans were acquired on the Hologic Discovery model A densitometers (Hologic, Inc., Bedford, Massachusetts), and were analyzed with Hologic APEX version 4.0 software. Further details of the DXA examination protocol are located on the NHANES website.

Demographic data and other questionnaire data

Age, gender, race, educational level, ratio of family income to poverty, vigorous recreational activities, and smoked at least 100 cigarettes in life were recorded using questionnaires managed by interviewer-administers. Race was self-reported as Non-Hispanic White, Non-Hispanic Black, Mexican American, Other Hispanic, and Other race-including multi-racial. The description of vigorous recreational activities was based on the patient self-report described as the following question: 'Do you do any vigorous-intensity sports, fitness, or recreational activities that cause large increases in breathing or heart rate like running or basketball for at least 10 minutes continuously? '

Laboratory data

Biospecimens were collected for laboratory analysis to provide detailed information on the nutritional status and health of the participants. The collecting, processing, storing, and shipping of the biospecimens took place in the mobile examination center. The detailed measurement processes of blood urea nitrogen, total protein, total cholesterol, alkaline phosphatase, serum potassium, serum sodium, serum phosphorus, serum uric acid, and serum calcium can be found at the NHANES website.

Statistical analysis

To assure national representation, we used weighted analysis recommended by the analytical guideline edited by NCHS. P-value was calculated using a weighted chi-square test for categorical variables and using a weighted linear regression model for continuous variables.

The relations between arthritis and lumbar BMD were examined using multivariable logistic regression. Three models were constructed: model 1, no covariates were adjusted; model 2, age, gender, race were adjusted; model 3, age, gender, race, educational level, body mass index, ratio of family income to poverty, vigorous recreational activities, smoked at least 100 cigarettes in life, blood urea nitrogen, total protein, total cholesterol, alkaline phosphatase, serum potassium, serum sodium, serum phosphorus, serum uric acid, and serum calcium were adjusted. Besides, following the STROBE guideline[14], we performed subgroup analyses to make better use of the data. We also performed multivariable logistic regression to explore the association between disease duration of arthritis and lumbar BMD. We performed all analyses using package R version 3.4.3 (http://www.R-project.org) and EmpowerStats software (http://www.empowerstats.com). The significance level was set to 0.05.

Results

Study sample

The characteristics of the samples are presented in Table 1. The mean age of the participants with arthritis (47.99 ± 9.36 years) was significantly higher than the mean age of those without arthritis (37.59 ± 11.34 years). Compared with the non-arthritis group, arthritis group had a higher proportion of females (56.08% vs. 46.17%). Race, educational level, body mass index, vigorous recreational activities, smoked at

least 100 cigarettes in life, blood urea nitrogen, total protein, total cholesterol, alkaline phosphatase, serum uric acid, serum sodium, and serum calcium were also significantly different between the two groups ($p < 0.05$).

Multiple regression model

As shown in Table 2, the association between arthritis and lumbar BMD was not significant in the unadjusted model (β = 0.007; 95% CI: -0.001–0.015). However, this association became significant after adjustment (model 2: β = 0.017; 95% CI: 0.008–0.025, model 3: β = 0.018; 95% CI: 0.010–0.027). Moreover, we evaluate the relationships between different types of arthritis and lumbar BMD. Compared with the non- arthritis group, participants with osteoarthritis or degenerative arthritis and psoriatic arthritis had a higher lumbar BMD (osteoarthritis or degenerative arthritis: β = 0.023; 95% CI: 0.011–0.035, psoriatic arthritis: β = 0.024; 95% CI: 0.005–0.043), while no significant association was observed in RA (β = 0.014; 95% CI: -0.003 − 0.031).

Subgroup analyses

In the subgroup analyses stratified by gender (Table 3), male adults with osteoarthritis or degenerative arthritis had a higher lumbar BMD compared with those without (β = 0.014; 95% CI: -0.003–0.031). However, this association changed in female adults (β = 0.007; 95% CI: -0.008–0.021). On the other hand, no significant association was observed in RA both in males and females (males: β = 0.023; 95% CI: -0.003–0.048, females: β = 0.008; 95% CI: -0.015–0.031).

In the subgroup analyses stratified by race (Table 4), non-Hispanic White adults with osteoarthritis or degenerative arthritis had a higher lumbar BMD compared with those without (β = 0.014; 95% CI: -0.003–0.031). no significant associations were observed in other osteoarthritis or degenerative arthritis groups or any RA groups.

Associations between disease duration of arthritis and lumbar BMD.

As shown in Table 5, the disease duration of arthritis was not associated with lumbar BMD both in osteoarthritis or degenerative arthritis (β=-0.0001; 95% CI: -0.0017–0.0015) and RA (β = 0.0006; 95% CI: -0.0012–0.0025).

Discussion

The present study demonstrated that patients with OA were more likely to have higher lumbar BMD in males, but not in females. On the other hand, no significant association was found in RA in both males and females.

Despite years of research, the association of OP with OA is still discussed. Both diseases depend on bone metabolism and positively correlated with aging. In a study comprised 359 postmenopausal women aged 50–89 years, Povoroznyuk et al[15] found that women with a symptomatic OA had a significantly higher lumbar BMD compared with controls. The cross-sectional data of a Korean national survey found a negative association of lumbar BMD with the presence of knee OA[16]. A recent prospective study provided strong evidence that high femoral neck BMD is a prognostic risk factor for the development of knee and hip radiographic OA[17]. In addition, higher BMD has been shown to reduce the risk of fractures in both men and women[18, 19]. The concomitant presence of OP and OA in patients with hip or spine OA were also reported[20, 21].

The biologic mechanism by which BMD influences OA has not been established, and previous statistically significant findings may result from uncontrolled and unmeasured confounding factors, such as skeletal growth factors[22], bone geometry[23, 24], bone morphology[25], and genetic[26]. In this study, we found the correlation between OA and lumbar BMD differed by sex. One possible explanation is that high BMI and weight-bearing activities, which increase the risk of damage to articular cartilage leading to OA, are also beneficial to the preservation of bone mass.

OP in RA patients may be mediated through several mechanisms: pro-inflammatory state, glucocorticoids use, low level of physical activity, and the classic risk factors for OP[27]. However, in a cross-sectional study including 152 Korean, Kweon et al[28] found no significant difference in lumbar BMD between patients with RA aged over 50 years and control individuals. In a study of 138 postmenopausal RA patients, Mori et al[29] found that disease duration was significantly related to BMD using multivariate linear regression analyses. On the contrary, in a study of 76 RA patients, the results suggested that the reduction in BMD was less than expected in the first decade of the disease compared with the reference population[30]. In a study of 299 Korean female patients with RA, Lee et al[31] found no significant association between disease duration of RA and BMD. Our data suggested there were no significant associations between RA, disease duration of RA and BMD in both males and females. The reasons for the different conclusions may be attributed to the variations among these studies, including demographic characteristics, sample size, study design, and controlled confounders.

The strengths of this study include a population-based sample with a wide age range that is generalizable to a community population, subgroup analyses for sensitivity test, and adjustment for many potential confounders. There are also several limitations. First, due to the cross-sectional nature of this study, we were unable to elucidate the causal relationship between arthritis and BMD. More longitudinal studies investigating the causality between them are needed. Second, the diagnosis of arthritis was based on the patient's self-report that might be subject to bias. However, the consistency of self-reported arthritis and clinical confirmation has been documented[32, 33]. Third, the missing information on different sites of arthritis preclude us to estimate the associations between OA, RA and BMD in specific sites. Fourth, study results cannot be generalized to the participants with cancer because these special populations were excluded in the analyses. Finally, there might be other confounding factors we did not control for in our study. For example, glucocorticoids used for the treatment of RA were

not adjusted in this study. However, it was reported that there was no significant association between cumulative glucocorticoid dose and BMD after adjustment of confounders [31]. The results of a population-based study also showed no significant difference between corticosteroid treated patients with RA and non-steroid group, indicating that the independent effect of corticosteroids on BMD is only minimal[34].

In summary, our results indicated that there is an inverse relationship between OP and the presence of OA in males, but not in females. There was no significant association between RA and lumbar BMD in both males and females. Our findings may provide some important implications for better understanding the linking between OA, RA and bone health.

Declarations

Author contributions

ZXZ, HTJ contributed to data collection, analysis and writing of the manuscript. PJT contributed to study design and writing of the manuscript.

Funding

This study received no funding.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Ethical Statement

The ethics review board of the National Center for Health Statistics approved all NHANES protocols and written informed consents were obtained from all participants.

Acknowledgements

The authors appreciate the time and effort given by participants during the data collection phase of the NHANES project.

References

1. Franco-Trepat E, Guillan-Fresco M, Alonso-Perez A, Jorge-Mora A, Francisco V, Gualillo O, Gomez R: **Visfatin Connection: Present and Future in Osteoarthritis and Osteoporosis**. *Journal of clinical*

medicine 2019, **8**(8).

2. Barbour KE, Helmick CG, Boring M, Brady TJ: **Vital Signs: Prevalence of Doctor-Diagnosed Arthritis and Arthritis-Attributable Activity Limitation - United States, 2013-2015**. *MMWR Morbidity and mortality weekly report* 2017, **66**(9):246-253.
3. National Collaborating Centre for Chronic C: **National Institute for Health and Clinical Excellence: Guidance**. In: *Rheumatoid Arthritis: National Clinical Guideline for Management and Treatment in Adults.* London: Royal College of Physicians (UK) Royal College of Physicians of London.; 2009.
4. McInnes IB, Schett G: **The pathogenesis of rheumatoid arthritis**. *The New England journal of medicine* 2011, **365**(23):2205-2219.
5. Gomez R, Villalvilla A, Largo R, Gualillo O, Herrero-Beaumont G: **TLR4 signalling in osteoarthritis–finding targets for candidate DMOADs**. *Nature reviews Rheumatology* 2015, **11**(3):159-170.
6. Geusens PP, van den Bergh JP: **Osteoporosis and osteoarthritis: shared mechanisms and epidemiology**. *Current opinion in rheumatology* 2016, **28**(2):97-103.
7. Clayton ES, Hochberg MC: **Osteoporosis and osteoarthritis, rheumatoid arthritis and spondylarthropathies**. *Current osteoporosis reports* 2013, **11**(4):257-262.
8. Ramonda R, Sartori L, Ortolan A, Frallonardo P, Lorenzin M, Punzi L, Musacchio E: **The controversial relationship between osteoarthritis and osteoporosis: an update on hand subtypes**. *International journal of rheumatic diseases* 2016, **19**(10):954-960.
9. Im GI, Kim MK: **The relationship between osteoarthritis and osteoporosis**. *Journal of bone and mineral metabolism* 2014, **32**(2):101-109.
10. Dequeker J, Aerssens J, Luyten FP: **Osteoarthritis and osteoporosis: clinical and research evidence of inverse relationship**. *Aging clinical and experimental research* 2003, **15**(5):426-439.
11. Dillon CF, Weisman MH: **US National Health and Nutrition Examination Survey Arthritis Initiatives, Methodologies and Data**. *Rheumatic diseases clinics of North America* 2018, **44**(2):215-265.
12. Zipf G, Chiappa M, Porter KS, Ostchega Y, Lewis BG, Dostal J: **National health and nutrition examination survey: plan and operations, 1999-2010**. *Vital and health statistics Ser 1, Programs and collection procedures* 2013(56):1-37.
13. Kanis JA, Johnell O: **Requirements for DXA for the management of osteoporosis in Europe**. *Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA* 2005, **16**(3):229-238.
14. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP: **The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies**. *Lancet (London, England)* 2007, **370**(9596):1453-1457.
15. Povoroznyuk VV, Zaverukha NV, Musiienko AS: **Bone mineral density and trabecular bone score in postmenopausal women with knee osteoarthritis and obesity**. *Wiadomosci lekarskie (Warsaw, Poland : 1960)* 2020, **73**(3):529-533.

16. Kim YH, Lee JS, Park JH: **Association between bone mineral density and knee osteoarthritis in Koreans: the Fourth and Fifth Korea National Health and Nutrition Examination Surveys**. *Osteoarthritis and cartilage* 2018, **26**(11):1511-1517.
17. Bergink AP, Rivadeneira F, Bierma-Zeinstra SM, Zillikens MC, Ikram MA, Uitterlinden AG, van Meurs JBJ: **Are Bone Mineral Density and Fractures Related to the Incidence and Progression of Radiographic Osteoarthritis of the Knee, Hip, and Hand in Elderly Men and Women? The Rotterdam Study**. *Arthritis & rheumatology (Hoboken, NJ)* 2019, **71**(3):361-369.
18. Stone KL, Seeley DG, Lui LY, Cauley JA, Ensrud K, Browner WS, Nevitt MC, Cummings SR: **BMD at multiple sites and risk of fracture of multiple types: long-term results from the Study of Osteoporotic Fractures**. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research* 2003, **18**(11):1947-1954.
19. Cummings SR, Cawthon PM, Ensrud KE, Cauley JA, Fink HA, Orwoll ES: **BMD and risk of hip and nonvertebral fractures in older men: a prospective study and comparison with older women**. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research* 2006, **21**(10):1550-1556.
20. Chan MY, Center JR, Eisman JA, Nguyen TV: **Bone mineral density and association of osteoarthritis with fracture risk**. *Osteoarthritis and cartilage* 2014, **22**(9):1251-1258.
21. Lingard EA, Mitchell SY, Francis RM, Rawlings D, Peaston R, Birrell FN, McCaskie AW: **The prevalence of osteoporosis in patients with severe hip and knee osteoarthritis awaiting joint arthroplasty**. *Age and ageing* 2010, **39**(2):234-239.
22. Hunter DJ, Spector TD: **The role of bone metabolism in osteoarthritis**. *Current rheumatology reports* 2003, **5**(1):15-19.
23. Ding C, Cicuttini F, Jones G: **Tibial subchondral bone size and knee cartilage defects: relevance to knee osteoarthritis**. *Osteoarthritis and cartilage* 2007, **15**(5):479-486.
24. Javaid MK, Lane NE, Mackey DC, Lui LY, Arden NK, Beck TJ, Hochberg MC, Nevitt MC: **Changes in proximal femoral mineral geometry precede the onset of radiographic hip osteoarthritis: The study of osteoporotic fractures**. *Arthritis and rheumatism* 2009, **60**(7):2028-2036.
25. Nelson AE, Golightly YM, Renner JB, Schwartz TA, Liu F, Lynch JA, Gregory JS, Aspden RM, Lane NE, Jordan JM: **Variations in Hip Shape Are Associated with Radiographic Knee Osteoarthritis: Cross-sectional and Longitudinal Analyses of the Johnston County Osteoarthritis Project**. *J Rheumatol* 2016, **43**(2):405-410.
26. Yau MS, Yerges-Armstrong LM, Liu Y, Lewis CE, Duggan DJ, Renner JB, Torner J, Felson DT, McCulloch CE, Kwoh CK *et al*: **Genome-Wide Association Study of Radiographic Knee Osteoarthritis in North American Caucasians**. *Arthritis & rheumatology (Hoboken, NJ)* 2017, **69**(2):343-351.
27. Ibanez M, Ortiz AM, Castrejon I, Garcia-Vadillo JA, Carvajal I, Castaneda S, Gonzalez-Alvaro I: **A rational use of glucocorticoids in patients with early arthritis has a minimal impact on bone mass**. *Arthritis research & therapy* 2010, **12**(2):R50.

28. Kweon SM, Sohn DH, Park JH, Koh JH, Park EK, Lee HN, Kim K, Kim Y, Kim GT, Lee SG: **Male patients with rheumatoid arthritis have an increased risk of osteoporosis: Frequency and risk factors**. *Medicine (Baltimore)* 2018, **97**(24):e11122.
29. Mori Y, Kuwahara Y, Chiba S, Kogre A, Baba K, Kamimura M, Itoi E: **Bone mineral density of postmenopausal women with rheumatoid arthritis depends on disease duration regardless of treatment**. *Journal of bone and mineral metabolism* 2017, **35**(1):52-57.
30. Kroot EJ, Nieuwenhuizen MG, de Waal Malefijt MC, van Riel PL, Pasker-de Jong PC, Laan RF: **Change in bone mineral density in patients with rheumatoid arthritis during the first decade of the disease**. *Arthritis and rheumatism* 2001, **44**(6):1254-1260.
31. Lee SG, Park YE, Park SH, Kim TK, Choi HJ, Lee SJ, Kim SI, Lee SH, Kim GT, Lee JW *et al*: **Increased frequency of osteoporosis and BMD below the expected range for age among South Korean women with rheumatoid arthritis**. *International journal of rheumatic diseases* 2012, **15**(3):289-296.
32. El Miedany Y, El Gaafary M, Youssef SS, Palmer D: **Incorporating patient reported outcome measures in clinical practice: development and validation of a questionnaire for inflammatory arthritis**. *Clinical and experimental rheumatology* 2010, **28**(5):734-744.
33. March LM, Schwarz JM, Carfrae BH, Bagge E: **Clinical validation of self-reported osteoarthritis**. *Osteoarthritis and cartilage* 1998, **6**(2):87-93.
34. Kroger H, Honkanen R, Saarikoski S, Alhava E: **Decreased axial bone mineral density in perimenopausal women with rheumatoid arthritis--a population based study**. *Annals of the rheumatic diseases* 1994, **53**(1):18-23.

Tables

Table 1 Characteristic of study sample with and without arthritis.

	Arthritis (n=1510)	Non-arthritis(n=9584)	P value
Age (years)	47.99 ± 9.36	37.59 ± 11.34	<0.0001
Age groups			<0.0001
20-29 years	5.97	30.31	
30-39 years	12.38	26.12	
40-49 years	27.09	24.53	
50-59 years	54.56	19.04	
Gender (%)			<0.0001
Male	43.92	53.83	
Female	56.08	46.17	
Race (%)			<0.0001
Mexican American	6.07	11.06	
Other Hispanic	5.07	7.71	
Non-Hispanic White	68.41	58.80	
Non-Hispanic Black	12.47	12.32	
Other race - including multi-racial	7.97	10.11	
Educational level (%)			<0.0001
Less than 9th grade	3.94	3.96	
9-11th grade	11.83	9.02	
High school graduate/GED or equivalent	22.99	21.67	
Some college or AA degree	35.13	32.47	
College graduate or above	26.11	32.87	
Not recorded	0	0.01	
Body mass index (kg/m2)	31.71 ± 8.00	28.56 ± 6.56	<0.0001
Ratio of family income to poverty	2.95 ± 1.72	2.94 ± 1.66	0.8213
Vigorous recreational activities (%)			<0.0001
Yes	19.99	36.63	
No	80.01	63.37	
Smoked at least 100 cigarettes in life (%)			<0.0001
Yes	51.38	38.63	
No	48.59	61.35	
Not recorded	0.03	0.02	
Blood urea nitrogen ((mmol/L)	4.82 ± 1.71	4.54 ± 1.49	<0.0001
Total protein (g/L)	70.60 ± 4.45	71.58 ± 4.29	<0.0001
Total cholesterol ((mmol/L)	5.11 ± 1.04	4.91 ± 1.02	<0.0001
Alkaline phosphatase (U/L)	71.50 ± 22.57	66.32 ± 22.73	<0.0001
Serum uric acid(umol/L)	323.79 ± 84.78	318.53 ± 80.72	0.0191
Serum sodium (mmol/L)	139.12 ± 2.43	139.25 ± 2.21	0.0369
Serum potassium (mmol/L)	3.95 ± 0.33	3.97 ± 0.31	0.1215
Serum phosphorus (mmol/L)	1.20 ± 0.17	1.20 ± 0.18	0.3971
Serum calcium (mmol/L)	2.34 ± 0.09	2.34 ± 0.08	0.0129
Disease duration of arthritis (years)	9.20 ± 8.90	/	
Which type of arthritis was it? (%)			/
Osteoarthritis or degenerative arthritis	41.61	/	
Rheumatoid arthritis	17.45	/	
Psoriatic arthritis	2.73	/	
Other	0.17	/	
Don't know or refused	24.20	/	
Lumbar bone mineral density (g/cm^2)	1.05 ± 0.16	1.04 ± 0.15	0.0861

Mean ± SD for continuous variables: P value was calculated by weighted linear regression model.

% for categorical variables: P value was calculated by weighted chi-square test.

Table 2 Associations between arthritis and lumbar bone mineral density.

	Model 1 β (95% CI, P)	Model 2 β (95% CI, P)	Model 3 β (95% CI, P)
Non- Arthritis	Reference	Reference	Reference
Arthritis	0.007 (-0.001, 0.015) 0.0861	0.017 (0.008, 0.025) 0.0001	0.018 (0.010, 0.027) <0.0001
Non- Arthritis	Reference	Reference	Reference
Osteoarthritis or degenerative arthritis	0.013 (0.001, 0.025) 0.0293	0.023 (0.012, 0.035) 0.0001	0.023 (0.011, 0.035) 0.0001
Rheumatoid arthritis	0.000 (-0.017, 0.018) 0.9733	0.010 (-0.007, 0.027) 0.2599	0.014 (-0.003, 0.031) 0.1074
Psoriatic arthritis	0.005 (-0.039, 0.049) 0.8177	0.020 (0.000, 0.039) 0.0445	0.024 (0.005, 0.043) 0.0133
Don't know or refused	0.000 (-0.015, 0.015) 0.9712	0.008 (-0.006, 0.023) 0.2665	0.011 (-0.004, 0.026) 0.1350

Model 1: no covariates were adjusted.

Model 2: age, gender, race were adjusted.

Model 3: age, gender, race, educational level, body mass index, ratio of family income to poverty, vigorous recreational activities, smoked at least 100 cigarettes in life, blood urea nitrogen, total protein, total cholesterol, alkaline phosphatase, serum uric acid, serum sodium, serum potassium, serum phosphorus, and serum calcium were adjusted.

Table 3 Subgroup analyses stratified by gender.

	Model 1 β (95% CI, P)	Model 2 β (95% CI, P)	Model 3 β (95% CI, P)
Male			
Non- Arthritis	Reference	Reference	Reference
Osteoarthritis or degenerative arthritis	0.045 (0.026, 0.065) <0.0001	0.053 (0.034, 0.072) <0.0001	0.047 (0.028, 0.066) <0.0001
Rheumatoid arthritis	0.010 (-0.016, 0.036) 0.4569	0.021 (-0.005, 0.046) 0.1139	0.023 (-0.003, 0.048) 0.0776
Female			
Non- Arthritis	Reference	Reference	Reference
Osteoarthritis or degenerative arthritis	-0.012 (-0.026, 0.003) 0.1158	0.005 (-0.010, 0.020) 0.4922	0.007 (-0.008, 0.021) 0.3526
Rheumatoid arthritis	-0.010 (-0.034, 0.013) 0.3941	0.001 (-0.022, 0.024) 0.9418	0.008 (-0.015, 0.031) 0.5157

Associations were adjusted for age, race, educational level, body mass index, ratio of family income to poverty, vigorous recreational activities, smoked at least 100 cigarettes in life, blood urea nitrogen, total protein, total cholesterol, alkaline phosphatase, serum uric acid, serum sodium, serum potassium, serum phosphorus, and serum calcium.

Table 4 Subgroup analyses stratified by race.

	Model 1 β (95% CI, P)	Model 2 β (95% CI, P)	Model 3 β (95% CI, P)
Non-Hispanic White			
Non- Arthritis	Reference	Reference	Reference
Osteoarthritis or degenerative arthritis	0.009 (-0.009, 0.026) 0.3439	0.018 (-0.000, 0.036) 0.0501	0.019 (0.001, 0.037) 0.0382
Rheumatoid arthritis	-0.015 (-0.045, 0.015) 0.3222	-0.007 (-0.036, 0.023) 0.6699	0.001 (-0.028, 0.031) 0.9232
Non-Hispanic Black			
Non- Arthritis	Reference	Reference	Reference
Osteoarthritis or degenerative arthritis	-0.020 (-0.050, 0.009) 0.1806	0.003 (-0.027, 0.034) 0.8340	0.007 (-0.024, 0.037) 0.6611
Rheumatoid arthritis	0.008 (-0.031, 0.046) 0.6947	0.032 (-0.007, 0.071) 0.1105	0.032 (-0.007, 0.071) 0.1035
Mexican American			
Non- Arthritis	Reference	Reference	Reference
Osteoarthritis or degenerative arthritis	0.015 (-0.025, 0.056) 0.4579	0.032 (-0.008, 0.073) 0.1189	0.017 (-0.023, 0.057) 0.4103
Rheumatoid arthritis	-0.022 (-0.061, 0.018) 0.2899	-0.004 (-0.044, 0.036) 0.8602	-0.006 (-0.046, 0.033) 0.7621

Associations were adjusted for age, gender, educational level, body mass index, ratio of family income to poverty, vigorous recreational activities, smoked at least 100 cigarettes in life, blood urea nitrogen, total protein, total cholesterol, alkaline phosphatase, serum uric acid, serum sodium, serum potassium, serum phosphorus, and serum calcium.

Table 5 Associations between disease duration of arthritis and lumbar bone mineral density.

Disease duration of arthritis (years)	Model 1 β (95% CI) P value	Model 2 β (95% CI) P value	Model 3 β (95% CI) P value
Osteoarthritis or degenerative arthritis	0.0005 (-0.0021, 0.0011) 0.5312	-0.0003 (-0.0020, 0.0013) 0.6746	-0.0001 (-0.0017, 0.0015) 0.8619
Rheumatoid arthritis	0.0013 (-0.0005, 0.0032) 0.1596	0.0013 (-0.0005, 0.0032) 0.1649	0.0006 (-0.0012, 0.0025) 0.4979

Associations were adjusted for age, race, educational level, body mass index, ratio of family income to poverty, vigorous recreational activities, smoked at least 100 cigarettes in life, blood urea nitrogen, total protein, total cholesterol, alkaline phosphatase, serum uric acid, serum sodium, serum potassium, serum phosphorus, and serum calcium.