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A systematic review and meta-analysis of the association between selenium and osteoarthritis

Hanieh Mollazadeh, **Mansour Salesi***

Department of Rheumatology, Isfahan University of Medical Sciences, Isfahan, Iran

***Correspondence to**
Mansour Salesi, Email: salesi@med.mui.ac.ir, mansour1380@yahoo.com

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Abstract

Introduction: Osteoarthritis is an inflammatory disorder and the most common human joint disease. Considering the anti-inflammatory properties of selenium, we aimed to investigate the relationship between selenium and the risk of osteoarthritis in this study.

Materials and Methods: The present study was a systematic review and meta-analysis based on the PRISMA guidelines, conducted in databases including Web of Science, Cochrane, ProQuest, PubMed, and Google Scholar Search Engine for articles published until December 12, 2023. Data was analyzed using STATA 14 software, and tests with p-values lower than 0.05 were considered statistically significant.

Results: Seven cross-sectional studies with 412998 participants were combined, and results indicated that selenium intake increased the risk of osteoarthritis (OR: 1.26; 95% CI: 1.06, 1.49). However, the risk of osteoarthritis in individuals with low, moderate, and high serum selenium levels was (OR: 1.03; 95% CI: 0.81, 1.31), (OR: 0.97; 95% CI: 0.83, 1.13), and (OR: 0.99; 95% CI: 0.99, 1), respectively. The relationship between serum selenium level and the risk of osteoarthritis in male and female patients were also (OR: 0.99; 95% CI: 0.98, 0.99) and (OR: 0.99; 95% CI: 0.98, 0.99), respectively. Findings showed the relationship between serum selenium level and knee (OR: 1.11; 95% CI: 0.89, 1.38) and hip (OR: 1.23; 95% CI: 0.86, 1.77) osteoarthritis.

Conclusion: Selenium intake increased the risk of osteoarthritis by 26%. However, there was no statistically significant relationship between the serum selenium level and the risk of osteoarthritis. Considering the limited number of reviewed studies, further studies in this field are required.

Registration: This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO (ID: CRD42023494294) and Research Registry (UIN: reviewregistry1762) website.

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Introduction

Osteoarthritis is the most frequent joint disease worldwide, especially among older adults(1). Studies revealed that genetics, obesity, and unhealthy diets are among the risk factors for osteoarthritis (2-4). Clinical symptoms of osteoarthritis include slowly progressing joint pain, tenderness, stiffness, swelling, deformity, and limitation of motion, which seriously disrupt daily functions and reduce the quality of life (5,6). Osteoarthritis mainly involves several joints, including the knee, hip, hand, big toe, and spine. Considering the highest occurrence of osteoarthritis in the knee and hip, it affects motion and increases the demand for total joint replacement and healthcare needs by causing disabilities in patients (7,8). Since osteoarthritis can cause disability, it significantly impacts the patients, care providers, and medical costs (9).

The significant anti-inflammatory, antioxidant, and antiviral properties of selenium have made it vital for human health (10,11). With considerable health benefits, selenium plays critical roles in the metabolism of thyroid hormone, male reproductive system, immune system function, and anti-inflammatory and free radicals detoxification pathways (12-16). Furthermore, selenium level is associated with different disorders, including cardiovascular diseases, type 2 diabetes mellitus, infertility, acute or chronic kidney injury, viral infections, mortality, and neurological diseases (17-19), as the serum selenium level of patients with osteoarthritis is

Key point

This meta-analysis explores the link between selenium and osteoarthritis risk, revealing that selenium intake is associated with a 26% increased risk of osteoarthritis. However, serum selenium levels show no significant correlation with the condition. Further research is needed to fully understand this relationship, given the limited number of studies reviewed.

lower than that of healthy individuals (20). Accordingly, in this study, we aimed to investigate the relationship between selenium and the risk of osteoarthritis using systematic review and meta-analysis methods.

Materials and Methods

The present study used systematic review and meta-analysis methods based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (21). The study protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO).

Search strategy

The published articles until December 12, 2023, were searched in databases Web of Science, Cochrane, ProQuest, PubMed, and Google Scholar Search Engine. Medical Subject Headings (MeSH) keywords 'Selenium, Osteoarthritis, Arthrosis, Degenerative Arthritis, Osteoarthrosis, Kidney protection.' and their equivalents were used to search the sources. In the advanced search, the keywords were combined using the 'AND - OR' operators. In the manual search, a list of eligible studies was reviewed. The strategy of search in the Web of Science database was as follows: Osteoarthritis OR Arthrosis OR Degenerative Arthritis OR Osteoarthroses (All Fields) AND Selenium (All Fields).

PICO component:

- Population: studies investigating the relationship between selenium and the risk of osteoarthritis. Exposure/Intervention: selenium.
- Comparison: individuals without osteoarthritis.
- Outcomes: the odds ratio for selenium and risk of osteoarthritis.

Inclusion criteria

Observational studies that examined the relationship between selenium and the risk of osteoarthritis.

Exclusion criteria

Exclusion criteria included duplicate studies, in vitro and in vivo studies, narrative reviews, descriptive studies, low-quality studies, studies without accessible full text, and studies that lacked the required data for analysis.

Quality assessment

The quality of the observational studies was examined using the Newcastle-Ottawa Scale (NOS) (22), which included three viewpoints: participant selection, comparability, and result evaluation. Articles that achieved at least six stars entered the present mete-analysis as high-quality studies. Then, the two researchers examined the inconsistencies and reached a similar answer after consultation with each other.

Data extraction

Two researchers extracted the data independently. The extracted data included the author's name, study design, sample size, age of the patients, time and location of the study, the odds ratio between selenium level and risk of osteoarthritis, and its 95% confidence interval. The third researcher reviewed the extracted data of the previous researchers and addressed the errors.

Statistical analysis

The log odds ratio (OR) was used for each article to combine the studies, and the I^2 index was used to investigate the inter study heterogeneity. The I^2 index included three categories (lower than 25%: low heterogeneity; between 25% and 75%: mild heterogeneity; higher than 75%: high heterogeneity). The randomized effects model was used to examine the relationship between serum selenium level and risk of osteoarthritis, and the fixed effects model was used to determine the relationship between selenium intake through diet and risk of osteoarthritis. Data was analyzed using the STATA 14 software, and tests with P values lower than 0.5 were considered statistically significant ($P < 0.05$).

Results

A total of 511 articles were found by searching the databases, 217 of which were duplicates and were removed. Then, the abstracts were reviewed, and 24 studies without accessible full texts were removed from the study. In the next step, 82 studies lacked the required data for analysis, and 118 other articles exited the meta-analysis due to other exclusion criteria. Seven high-quality articles entered the study (Figure 1).

This meta-analysis examined seven cross-sectional studies with 412 998 participants. Table 1 presents some of the information obtained from the reviewed articles.

Calculates indicated the risk of osteoarthritis in individuals with low (OR: 1.03; 95% CI: 0.81, 1.31), mild (OR: 0.97; 95% CI: 0.83, 1.13), and high serum selenium levels (OR: 0.99; 95% CI: 0.99, 1). The relationships were statistically insignificant, and no significant relationship was observed between the serum selenium level and the risk of osteoarthritis (Figure 2).

There was a statistically significant relationship between the serum selenium level in male patients and the risk of osteoarthritis. Reports indicated a significant relationship between the serum selenium level in female individuals and the risk of osteoarthritis. However, note that only a few studies reported the results by sex. On the other hand, there was no significant relationship between the serum selenium level and the osteoarthritis-affected joint (i.e., knee or hip) (Table 2).

According to Figure 3, the relationship between selenium intake through diet and the risk of osteoarthritis was statistically significant. Selenium intake through diet

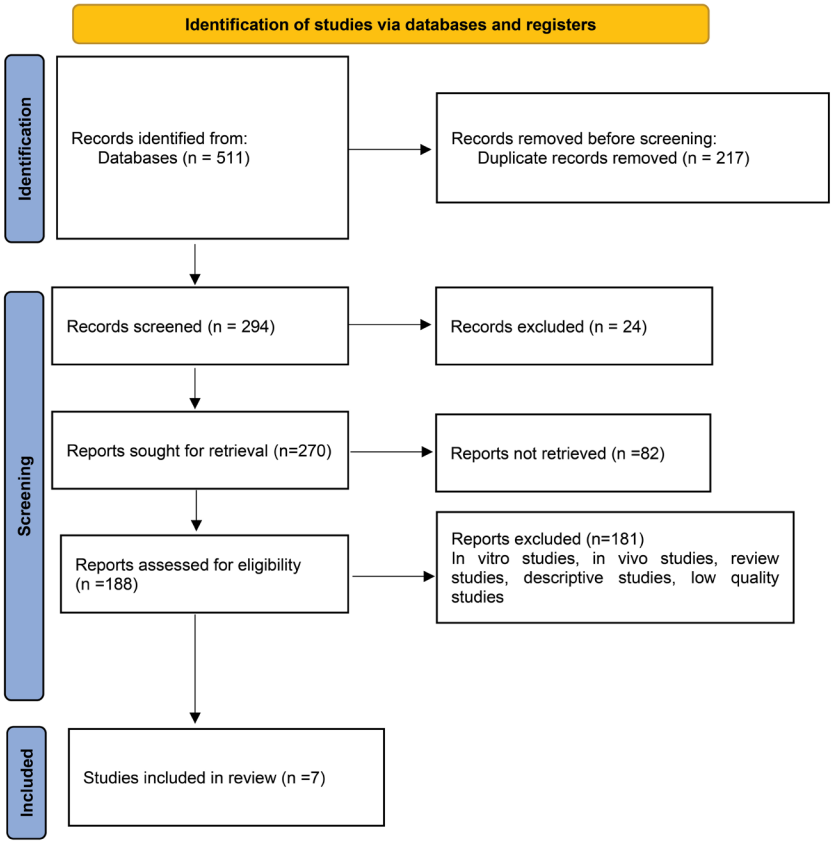

Figure 1. The PRISMA flow chart of study selection.

increased the risk of osteoarthritis by 26% (OR: 1.26; 95% CI: 1.06, 1.49).

The publication bias diagram showed no publication bias during the search process ($P = 0.634$) (Figure 4).

Discussion

Inconsistent with previous studies reporting that higher serum selenium levels or high selenium intake reduced the risk of cancer and osteoporosis, the present study indicated that high serum selenium levels increased the risk of osteoarthritis.

According to a study by Cui et al, the highest serum selenium level decreased the risk of prostate carcinoma compared with the lowest serum selenium level (OR:

Table 1. A summary of the information extracted from the reviewed articles

First Author, Year	Country	Sample Size	Mean Age by Year	Duration of Study	Serum Selenium Levels
Yang WM, 2023 (23)	USA	4200	≥20	2011–2016	Low
Yang WM, 2023 (23)	USA	4200	NR	2011–2016	Moderate
Yang WM, 2023 (23)	USA	4200	NR	2011–2016	High
Zhu Y, 2023 (24)	China	86	NR	January 2020 to December 2022	Moderate
Xia F, 2022 (25)	USA	15234	49.6	2011-2020	Low
Xia F, 2022 (25)	USA	15234	NR	2011-2020	Moderate
Xia F, 2022 (25)	USA	15234	NR	2011-2020	High
Wang N, 2022 (26)	China	1032	≥50	NR	Low
Wang N, 2022 (26)	China	1032	NR	NR	Moderate
Qu Z, 2021 (27)	UK	361141	NR	NR	Moderate
First author, year	Country	Sample size	Mean age by year	Duration of study	Selenium intake
Yang WM, 2023 (23)	USA	4200	>20	2011–2016	128.59 mcg/d
Deng X, 2023 (28)	USA	26620	NR	2003–2016	NR
Li H, 2016 (29)	China	4685	NR	October 2013 to July 2014	66.74 μg/d

NR, not reported.

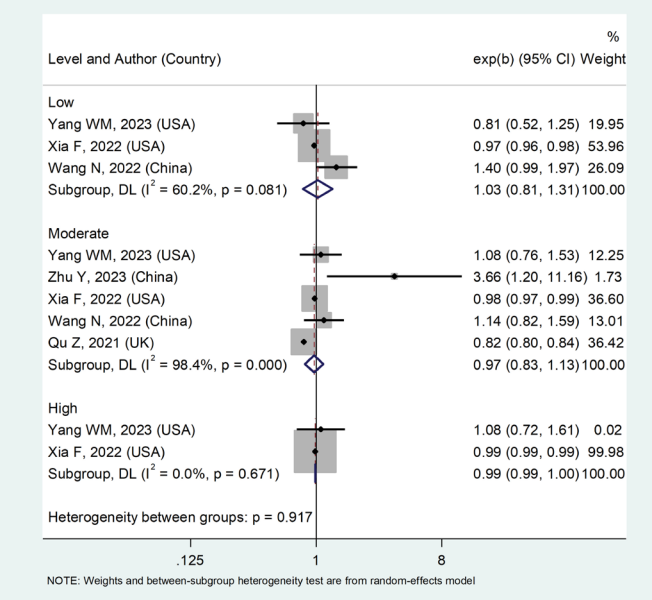

Figure 2. Examining the relationship between serum selenium level and the risk of osteoarthritis, along with its 95% confidence interval.

0.76; 95% CI: 0.64, 0.91) (30). Reports of another meta-analysis by Gong et al investigating the relationship between selenium and the risk of gastric cancer indicated that high selenium levels decreased the risk of gastric neoplasms in case-control (OR: 0.62; 95% CI: 0.44, 0.89) and cohort (OR: 0.87; 95% CI: 0.78, 0.97) studies (31). A previous meta-analysis by He et al showed that higher serum selenium levels were a protective factor against cervical carcinoma (OR: 0.55; 95% CI: 0.42, 0.73) (32). Based on the results of another meta-analysis by Xie et al, individuals with higher selenium intake faced a lower risk of osteoporosis (OR: 0.47; 95% CI: 0.31, 0.72), and patients with osteoporosis had significantly lower serum selenium levels compared with healthy individuals (WMD: -2.01; 95% CI: -3.91, -0.1) (33). Results of a meta-analysis by Ma et al examining trace metals common in rheumatoid arthritis demonstrated lower serum selenium levels (SMD: -1.04; 95% CI: -1.58, -0.50) in rheumatoid arthritis patients (34). The results of the cited studies were inconsistent with our study. The mentioned studies reported that high serum selenium levels play a protective role against the incidence of diseases including rheumatoid arthritis,

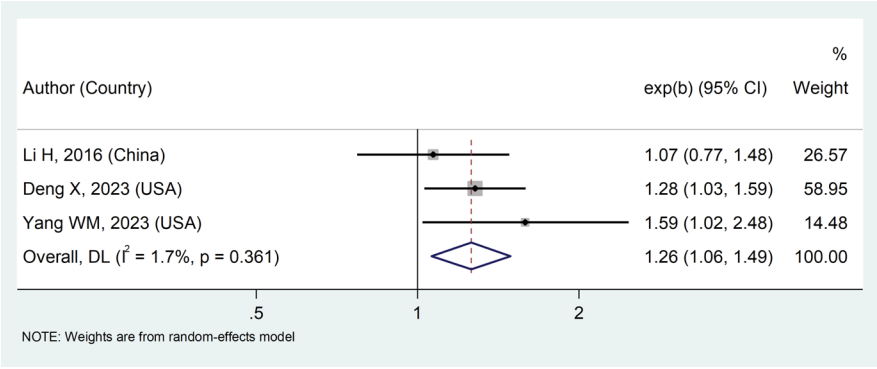

Figure 3. Examination of the relationship between dietary selenium intake and the risk of osteoarthritis, along with its 95% confidence interval.

Table 2. Investigating the relationship between serum selenium level and the risk of osteoarthritis based on the gender of the patients and the joint involved with osteoarthritis

Subgroups		OR	Low limit	Upper limit	*P* value	I^2 (%)
Gender	Male	0.990	0.986	0.993	0.370	4.7
	Female	0.990	0.985	0.994	0.513	0
Joint	Hip	1.230	0.860	1.770	0.537	0
	Knee	1.110	0.890	1.380	0.362	1.6

OR: Odds ratio.

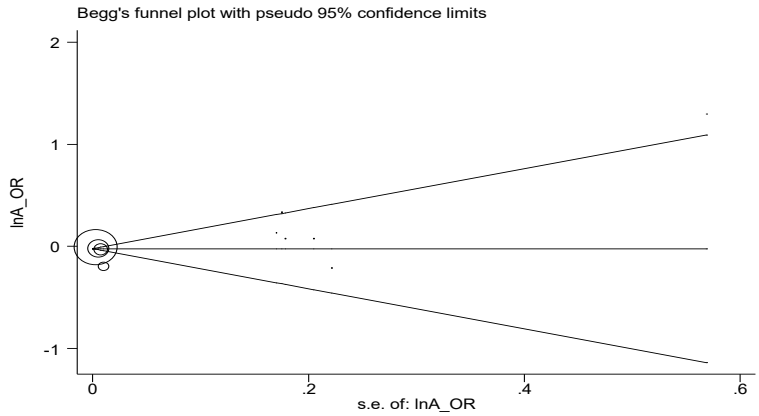

Figure 4. Publication bias diagram.

prostate, cervical, and gastric cancers, and osteoporosis, which are acceptable considering the anti-inflammatory and antioxidant properties of selenium reports.

A recent meta-analysis by Cai et al showed that exposure to high selenium levels protected individuals against cancer (R: 0.78; 95% CI: 0.73, 0.83) (35). Similarly, Wang et al demonstrated that high selenium intake significantly reduced the risk of pancreatic cancer compared with low selenium intake (RR: 0.65; 95% CI: 0.48, 0.88) (36). In a study by Peng et al with 3250 participants, the authors reported that compared with the lowest selenium intake, the highest selenium intake was associated with reduced risk of osteoporosis (OR: 0.63; 95% CI: 0.41–0.96) (37). A cross-sectional study by Grili et al showed that the odds ratio of osteoporosis in postmenopausal women in the highest selenium intake quartile compared with the lowest quartile was (OR: 0.02; 95% CI: 0.001–0.41) (38). The results of these studies were inconsistent with the current meta-analysis as in the cited studies, selenium intake reduced the risk of diseases including pancreatic carcinoma and osteoporosis. In contrast, in our study, selenium intake was a risk factor for osteoarthritis.

Based on a cohort study by Konstari et al on 4953 individuals, the risk ratio of knee osteoarthritis for low magnesium intake was (R: 1.28; 95% CI: 0.78–2.10). Low magnesium intake through diet did not affect the risk of knee arthritis (39). The results of our study, however, showed that high selenium intake considerably increased the risk of osteoarthritis. Accordingly, we recommend reducing the selenium intake through diet in patients with osteoarthritis.

Limitations of the study

Limitation of the number of reviewed studies; all the studies were cross-sectional, and the studies were not diversified; the cut-off point of serum selenium level in the reviewed studies was not similar; examining the relationship between the serum selenium level and the risk of osteoarthritis based on the age of the patients was not possible; investigating the relationship between the selenium intake through diet and the risk of osteoarthritis based on the dosage was not possible.

Conclusion

The present study indicated that selenium intake increased the risk of osteoarthritis by 26%. However, there was no statistically significant relationship between the serum selenium level and the risk of osteoarthritis. In fact, low serum selenium level was not a risk factor for osteoarthritis, and high serum selenium levels did not prevent osteoarthritis. However, considering the limited number of reviewed studies, further studies in this field are required.

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Authors' contribution

Conceptualization: Mansour Salesi, Hanieh Mollazadeh.
Data curation: Mansour Salesi, Hanieh Mollazadeh.
Formal analysis: Mansour Salesi, Hanieh Mollazadeh.
Funding acquisition: Mansour Salesi, Hanieh Mollazadeh.
Investigation: Mansour Salesi.
Methodology: Mansour Salesi, Hanieh Mollazadeh.
Project administration: Mansour Salesi.
Resources: Mansour Salesi, Hanieh Mollazadeh.
Software: Mansour Salesi, Hanieh Mollazadeh.
Supervision: Mansour Salesi, Hanieh Mollazadeh.
Validation: Mansour Salesi, Hanieh Mollazadeh.
Visualization: Mansour Salesi, Hanieh Mollazadeh.
Writing–original draft: Mansour Salesi, Hanieh Mollazadeh.
Writing–review & editing: Mansour Salesi, Hanieh Mollazadeh.

Conflicts of interest

The authors declare that they have no competing interests.

Ethical issues

This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO (International Prospective Register of Systematic Reviews) website (ID: CRD42023494294) and Research Registry website (Unique Identifying Number (UIN): reviewregistry1762). The institutional ethical committee of Isfahan University of Medical Sciences, Isfahan, Iran, approved all study

protocols (ethical code # IR.MUI.MED.REC.1402.476). This study was extracted from rheumatology subspecialty thesis, of Hanieh Mollazadeh at this university. Besides, ethical issues (including plagiarism, data fabrication and double publication) have been completely observed by the authors.

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References

1. Sun X, Zhen X, Hu X, Li Y, Gu S, Gu Y, et al. Osteoarthritis in the middle-aged and elderly in China: prevalence and influencing factors. Int J Environ Res Public Health. 2019;16:4701. doi: 10.3390/ijerph16234701.
2. Ratneswaran A, Kapoor M. Osteoarthritis year in review: genetics, genomics, epigenetics. Osteoarthritis Cartilage. 2021;29:151-60. doi: 10.1016/j.joca.2020.11.003.
3. Kulkarni K, Karssiens T, Kumar V, Pandit H. Obesity and osteoarthritis. Maturitas. 2016;89:22-8. doi: 10.1016/j.maturitas.2016.04.006.
4. Zhang Y, Ye M, Zhao Y, Xiong Y, Shen S, Yu Q, et al. Higher dietary Se intake is associated with the risk of new-onset fracture: a national longitudinal study for 20 years. Front Nutr. 2021;8:719147. doi: 10.3389/fnut.2021.719147.
5. Lin Z, Fu C, Yan Z, Wu Y, Zhan J, Lou Z, et al. The protective effect of hesperetin in osteoarthritis: an in vitro and in vivo study. Food Funct. 2020;11:2654-66. doi: 10.1039/c9fo02552a.
6. Park DR, Kim J, Kim GM, Lee H, Kim M, Hwang D, et al. Osteoclast-associated receptor blockade prevents articular cartilage destruction via chondrocyte apoptosis regulation. Nat Commun. 2020;11:4343. doi: 10.1038/s41467-020-18208-y.
7. Neogi T, Zhang Y. Epidemiology of osteoarthritis. Rheum Dis Clin North Am. 2013;39:1-19. doi: 10.1016/j.rdc.2012.10.004.
8. United States Bone and Joint Initiative (USBJI). The Burden of Musculoskeletal Diseases in the United States. 3rd ed. USBJI; 2014.
9. Cross M, Smith E, Hoy D, Nolte S, Ackerman I, Fransen M, et al. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. Ann Rheum Dis. 2014;73:1323-30. doi: 10.1136/annrheumdis-2013-204763.
10. Wrobel JK, Power R, Toborek M. Biological activity of selenium: revisited. IUBMB Life. 2016;68:97-105. doi: 10.1002/iub.1466.
11. Malhotra S, Welling MN, Mantri SB, Desai K. In vitro and in vivo antioxidant, cytotoxic, and anti-chronic inflammatory arthritic effect of selenium nanoparticles. J Biomed Mater Res B Appl Biomater. 2016;104:993-1003. doi: 10.1002/jbm.b.33448.
12. Schoenmakers E, Agostini M, Mitchell C, Schoenmakers N, Papp L, Rajanayagam O, et al. Mutations in the selenocysteine insertion sequence-binding protein 2 gene lead to a multisystem selenoprotein deficiency disorder in humans. J Clin Invest. 2010;120:4220-35. doi: 10.1172/jci43653.
13. Andrade GRG, Gorgulho B, Lotufo PA, Bensenor IM, Marchioni DM. Dietary selenium intake and subclinical hypothyroidism: a cross-sectional analysis of the ELSA-Brasil study. Nutrients. 2018;10:693. doi: 10.3390/nu10060693.
14. Zamamiri-Davis F, Lu Y, Thompson JT, Prabhu KS, Reddy PV, Sordillo LM, et al. Nuclear factor-kappaB mediates over-expression of cyclooxygenase-2 during activation of RAW 264.7 macrophages in selenium deficiency. Free Radic Biol Med. 2002;32:890-7. doi: 10.1016/s0891-5849(02)00775-x.
15. Hozyen HF, Khalil HMA, Ghandour RA, Al-Mokaddem AK, Amer MS, Azouz RA. Nano selenium protects against deltamethrin-induced reproductive toxicity in male rats. Toxicol Appl Pharmacol. 2020;408:115274. doi: 10.1016/j.taap.2020.115274.
16. Tang KK, Li HQ, Qu KC, Fan RF. Selenium alleviates cadmium-induced inflammation and meat quality degradation via antioxidant and anti-inflammation in chicken breast muscles. Environ Sci Pollut Res Int. 2019;26:23453-9. doi: 10.1007/s11356-019-05675-0.
17. Wang XL, Yang TB, Wei J, Lei GH, Zeng C. Association between serum selenium level and type 2 diabetes mellitus: a non-linear dose-response meta-analysis of observational studies. Nutr J. 2016;15:48. doi: 10.1186/s12937-016-0169-6.
18. Shahar A, Patel KV, Semba RD, Bandinelli S, Shahar DR, Ferrucci L, et al. Plasma selenium is positively related to performance in neurological tasks assessing coordination and motor speed. Mov Disord. 2010;25:1909-15. doi: 10.1002/mds.23218.
19. Iglesias P, Selgas R, Romero S, Díez JJ. Selenium and kidney disease. J Nephrol. 2013;26:266-72. doi: 10.5301/jn.5000213.
20. Wang L, Yin J, Yang B, Qu C, Lei J, Han J, et al. Serious selenium deficiency in the serum of patients with Kashin-Beck disease and the effect of nano-selenium on their chondrocytes. Biol Trace Elem Res. 2020;194:96-104. doi: 10.1007/s12011-019-01759-7.
21. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4:1. doi: 10.1186/2046-4053-4-1.
22. Peterson J, Welch V, Losos M, Tugwell PJ. The Newcastle-Ottawa Scale (NOS) for Assessing the Quality of Non-Randomized Studies in Meta-Analyses. Ottawa: Ottawa Hospital Research Institute; 2011. p. 1-2.
23. Yang WM, Lv JF, Wang YY, Xu YM, Lin J, Liu J, et al. The daily intake levels of copper, selenium, and zinc are associated with osteoarthritis but not with rheumatoid arthritis in a cross-sectional study. Biol Trace Elem Res. 2023;201:5662-70. doi: 10.1007/s12011-023-03636-w.
24. Zhu Y. A cross-sectional analysis between plasma trace elements and osteoarthritis. Res Sq [Preprint]. September 9, 2023. doi: 10.21203/rs.3.rs-3270418/v1.
25. Xia F, Li Q, Luo X, Wu J. Identification for heavy metals exposure on osteoarthritis among aging people and Machine learning for prediction: a study based on NHANES 2011-2020. Front Public Health. 2022;10:906774. doi: 10.3389/fpubh.2022.906774.
26. Wang N, Xie M, Lei G, Zeng C, Yang T, Yang Z, et al. A cross-sectional study of association between plasma selenium levels and the prevalence of osteoarthritis: data from the Xiangya osteoarthritis study. J Nutr Health Aging. 2022;26:197-202. doi: 10.1007/s12603-022-1739-2.
27. Qu Z, Yang F, Hong J, Wang W, Li S, Jiang G, et al. Causal relationship of serum nutritional factors with osteoarthritis: a Mendelian randomization study. Rheumatology (Oxford). 2021;60:2383-90. doi: 10.1093/rheumatology/keaa622.
28. Deng X, Tan Y. A national cross-sectional analysis of selenium intake and risk of osteoarthritis: NHANES 2003-2016. Front Public Health. 2022;10:1047605. doi: 10.3389/fpubh.2022.1047605.
29. Li H, Zeng C, Wei J, Yang T, Gao SG, Li YS, et al. Associations between dietary antioxidants intake and radiographic knee osteoarthritis. Clin Rheumatol. 2016;35:1585-92. doi: 10.1007/s10067-016-3177-1.
30. Cui Z, Liu D, Liu C, Liu G. Serum selenium levels and prostate cancer risk: a MOOSE-compliant meta-analysis. Medicine (Baltimore). 2017;96:e5944. doi: 10.1097/md.0000000000005944.
31. Gong HY, He JG, Li BS. Meta-analysis of the association

between selenium and gastric cancer risk. Oncotarget. 2016;7:15600-5. doi: 10.18632/oncotarget.7205.
32. He D, Wang Z, Huang C, Fang X, Chen D. Serum selenium levels and cervical cancer: systematic review and meta-analysis. Biol Trace Elem Res. 2017;179:195-202. doi: 10.1007/s12011-017-0982-6.
33. Xie H, Wang N, He H, Yang Z, Wu J, Yang T, et al. The association between selenium and bone health: a meta-analysis. Bone Joint Res. 2023;12:423-32. doi: 10.1302/2046-3758.127.bjr-2022-0420.r1.
34. Ma Y, Zhang X, Fan D, Xia Q, Wang M, Pan F. Common trace metals in rheumatoid arthritis: a systematic review and meta-analysis. J Trace Elem Med Biol. 2019;56:81-9. doi: 10.1016/j.jtemb.2019.07.007.
35. Cai X, Wang C, Yu W, Fan W, Wang S, Shen N, et al. Selenium exposure and cancer risk: an updated meta-analysis and meta-regression. Sci Rep. 2016;6:19213. doi: 10.1038/srep19213.
36. Wang L, Wang J, Liu X, Liu Q, Zhang G, Liang L. Association between selenium intake and the risk of pancreatic cancer: a meta-analysis of observational studies. Biosci Rep. 2016;36:e00395. doi: 10.1042/bsr20160345.
37. Peng S, Zhang G, Wang D. Association of selenium intake with bone mineral density and osteoporosis: the national health and nutrition examination survey. Front Endocrinol (Lausanne). 2023;14:1251838. doi: 10.3389/fendo.2023.1251838.
38. da Fonseca Grili PP, Vidigal CV, da Cruz GF, Albergaria BH, Marques-Rocha JL, Pereira TS, et al. Dietary consumption of selenium inversely associated with osteoporosis in postmenopausal women. Front Nutr. 2022;9:997414. doi: 10.3389/fnut.2022.997414.
39. Konstari S, Sares-Jäske L, Heliövaara M, Rissanen H, Knekt P, Arokoski J, et al. Dietary magnesium intake, serum high sensitivity C-reactive protein and the risk of incident knee osteoarthritis leading to hospitalization-a cohort study of 4,953 Finns. PLoS One. 2019;14:e0214064. doi: 10.1371/journal.pone.0214064.