



RESEARCH ARTICLE

STUDY OF SERUM CALCIUM, PHOSPHORUS, MAGNESIUM AND IRON LEVELS IN THE OSTEOARTHRITIS PATIENTS

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ABSTRACT

Background: Osteoarthritis (OA) is a common degenerative joint disease in the elderly, causing pain and stiffness due to cartilage loss and bone changes. Essential minerals like calcium, phosphorus, magnesium and iron are crucial for joint health, but their role in OA progression remains unclear.

Objectives:

- To determine and compare the serum levels of calcium, phosphorus, magnesium and iron levels in patients with and without osteoarthritis.
- To assess the Calcium and Phosphorus ratio in patients with Osteoarthritis.

Materials and Methods: A total of 138 subjects were included in the study. This includes 69 with osteoarthritis and 69 without Osteoarthritis in patients. Subjects with and without osteoarthritis in the age group 40-70 years of all genders after obtaining informed consent were included in the study. Patients with Rheumatoid arthritis, History of joint surgery, History of inflammatory joint disease, History of renal failure, Patients with parathyroid disease were excluded from study. **Results:** OA patients have significantly calcium, phosphorus and iron levels but magnesium, levels not significantly compar. The calcium-to-phosphorus ratio is significantly OA patients. **Conclusion:** OA patients exhibit significantly serum calcium ($p = 0.00090$), phosphorus levels ($p = 0.02652$) magnesium ($p = 0.025613$) and iron ($p = 0.00295$) levels,. The calcium-to-phosphorus ratio is significantly ($p = 0.00590$).

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INTRODUCTION

Osteoarthritis is a degenerative, non-inflammatory joint disorder. Risk factors include aging, weight-bearing stress, joint damage, obesity, and local trauma. It is characterized by the gradual deterioration of cartilage, leading to pain, stiffness, and reduced joint function. (1). Women, particularly postmenopausal women, experience a higher prevalence due to hormonal changes associated with menopause. The decline in estrogen levels after menopause may negatively impact joint health, contributing to the increased occurrence of osteoarthritis in this group. In the United States, osteoarthritis is the second leading cause of work incapacity among men over the age of 50. (2)

Calcium: Is a vital mineral involved in blood clotting, muscle contraction, nerve transmission, and hormone secretion.(3) It also plays a key role in bone health and cellular signaling through the calcium-calmodulin complex, which regulates

enzymes like glycogen synthase and phospholipase C. In osteoarthritis, cartilage degradation is a primary concern, but disruptions in bone metabolism, including calcium and vitamin D deficiencies, may contribute to disease progression (9).

Phosphorus: A key mineral in bones and teeth, supports bone health, cartilage function, and joint stability. In osteoarthritis, phosphate imbalance can contribute to cartilage degradation, bone changes, and inflammation. Along with calcium, phosphorus is essential for bone mineralization, and any imbalance may accelerate disease progression and worsen symptoms.(5)

Magnesium: Plays a vital role in inflammation control, enzymatic activity, and bone metabolism, helping maintain cartilage integrity. Lower magnesium levels in osteoarthritis patients are associated with increased inflammation, reduced proteoglycan production, and cartilage degradation. Studies suggest that magnesium deficiency may promote calcium

crystal formation in cartilage, damaging chondrocytes and accelerating OA progression (6,7).

Iron: Is essential for oxygen transport, cellular respiration, immune function, nitric oxide metabolism, and DNA synthesis. Its deficiency can lead to anemia, weakened immunity, and impaired growth. In osteoarthritis, elevated serum ferritin levels, indicating iron stores, are linked to increased joint inflammation and pain severity (8). The present research study is undertaken to compare the serum calcium, phosphorus, magnesium and iron levels in osteoarthritis patients.

Objectives

- To determine and compare the serum levels of calcium, phosphorus, magnesium and iron levels in patients with and without osteoarthritis.
- To assess the Calcium and Phosphorus ratio in patients with Osteoarthritis.

MATERIALS AND METHODS

Source of data and study design: It is a comparative cross sectional study, conducted at the National Institute of Medical Sciences & Hospital (NIMS Hospital), Jaipur (Rajasthan) in the Department of Biochemistry in association with the Department of Orthopaedics and General Medicine. Samples were analyzed for biochemical investigations in the Department of Biochemistry, National Institute of Medical Sciences & Research (NIMS&R) and NIMS Hospital, Jaipur.

Inclusion Criteria: Subjects with and without osteoarthritis in the age group 40-70 years of all genders after obtaining informed consent were included in the study.

Exclusion Criteria: patients with following conditions were excluded from the study.

- Patients with Rheumatoid arthritis.
- History of joint surgery.
- History of inflammatory joint disease.
- History of renal failure.
- Patients with parathyroid disease.

Sample collection: After anthropometric data collection 3ml fasting venous blood samples were taken from subjects; under aseptic precaution with a clot activator tube. Serum was separated by centrifugation and using photo colorimeter biochemical analyzer.

RESULTS

A total of 138 subjects were included in the study. This includes 69 with Osteoarthritis and 69 without Osteoarthritis in patients. Subjects with and without Osteoarthritis in the age group 40-70 years of all genders were included in the study. Table No.1 shows the descriptive statistics for calcium, phosphorus, magnesium, and iron levels in both the Controls and Osteoarthritis (OA) groups.

Control Group: Calcium: Ranges from 5.4 to 12.3 mg/dL, with a median (IQR) of 8.9(8.4-9.7) and a mean \pm SD of 8.99 ± 1.20 .

Phosphorous: Ranges from 1.2 to 8 mg/dL, with a median (IQR) is 3.2 (2.2-4.4), and the mean \pm SD of 3.51 ± 1.66 . Magnesium falls between 0.56 to 3.4 mg/dL, the Control Group exhibits a median (IQR) of 1.9(1.4-2.1) and a mean \pm SD of 1.77 ± 0.53 .

Iron: Ranges from 10 to 96 (μ g/dL); the median (IQR) is 42 (23-64), and the mean \pm SD is 46.61 ± 26.6 . Calcium/phosphorous ratio: Spans from 0.916 to 9.08, the median(IQR) is 2.82 (1.93-4.39) and the mean \pm SD is 3.27 ± 1.80

OA Group: Calcium: Ranges from 6 to 11.5 mg/dL, a median (IQR) of 8.1(7-9.2) and a mean \pm SD of 8.26 ± 1.34 . phosphorus: Ranges from 1.15 to 7.8 mg/dL, with a median (IQR) is 3.9 (3-5), and the mean \pm SD of 4.11 ± 1.51 . magnesium: varies from 0.43 to 3.5 mg/dL, the OA Group exhibits a median (IQR) of 1.8(1.1-2.8) and a mean \pm SD of 1.92 ± 0.93 . iron ranges from 10 to 96 μ g/dL, the median (IQR) is 28 (15-45), and the mean \pm SD to 33.77 ± 23.12 . Calcium/phosphorus ratio: Spans from 0.923 to 9.565, the median(IQR) is 2 (1.7-2.71) and the mean \pm SD to 2.45 ± 1.64 . Table No.2, shows a comparative analysis of calcium, phosphorous, magnesium, and iron levels between the Controls and Osteoarthritis (OA) groups, utilizing the t-test to determine statistical significance.

The mean calcium level was significantly lower in Osteoarthritis patients (8.26 ± 1.11 mg/dL) compared to the control group (8.99 ± 1.13 mg/dL) with a significant difference (t-test = 3.395, p = 0.00090). Phosphorus levels were significantly higher in the Osteoarthritis group (4.11 ± 1.51 mg/dL) compared to the Controls group (3.51 ± 1.66 mg/dL) with a significant difference (t-test = -2.243, p = 0.02652). Magnesium levels were significantly lower in Osteoarthritis patients (1.92 ± 0.93 mg/dL) compared to the Controls group (1.77 ± 0.53 mg/dL) with a significant difference (t-test = -1.140, p = 0.25613). Iron levels were also significantly lower in the Osteoarthritis group (33.77 ± 23.12 μ g/dL) compared to the Controls group (46.61 ± 26.6 μ g/dL) with a highly significant difference (t-test = 3.028, p < 0.00295). Additionally, the calcium/phosphorus ratio was significantly lower in Osteoarthritis patients (2.45 ± 1.64) compared to the Controls group (3.27 ± 1.80) with a highly significant difference (t-test = 2.797, p 0.00590).

Calcium/Phosphorous Ratio Distribution:

0.0 - 1.00:

Controls Group: 2 (2.90%)

Osteoarthritis Group: 3 (4.35%)

1.01 - 2.00:

Controls Group: 19(27.54.%)

Osteoarthritis Group: 32(46.38%)

2.01 - 3.00:

Controls Group: 17(24.64%)

Osteoarthritis Group: 20(28.99%)

3.01 - 4.00:

Controls Group: 12(17.39%)

Osteoarthritis Group: 9 (13.04%)

4.01 - 5.00:

Controls Group: 9(13.04 %)

Osteoarthritis Group: 2 (2.90%)

> 5.00: Controls Group: 10 (14.49%) Osteoarthritis Group: 3(4.35%)

Table 1. Descriptive statistics of calcium, phosphorus, magnesium and iron of patients of Controls and Osteoarthritis groups

	Variables	Minimum	Maximum	Median (IQR)	Mean \pm SD
Controls Group	Calcium	5.4	12.3	8.9 (8.4-9.7)	8.99 \pm 1.20
	Phosphorus	1.2	8	3.2 (2.2-4.4)	3.51 \pm 1.66
	Magnesium	0.56	3.4	1.9 (1.4-2.1)	1.77 \pm 0.53
	Iron	10	133	42 (23-64)	46.61 \pm 26.6
	Calcium/Phosphorous ratio	0.916	9.08	2.82 (1.93-4.39)	3.27 \pm 1.80
Osteoarthritis	Calcium	6	11.5	8.1 (7-9.2)	8.26 \pm 1.34
	Phosphorus	1.15	7.8	3.9 (3-5)	4.11 \pm 1.51
	Magnesium	0.43	3.5	1.8 (1.1-2.8)	1.92 \pm 0.93
	Iron	10	96	28 (15-45)	33.77 \pm 23.12
	Calcium/Phosphorus ratio	0.923	9.565	2 (1.7-2.71)	2.45 \pm 1.64

Table 2. Comparing calcium, phosphorus, magnesium and iron between Controls and Osteoarthritis group of patients by using t-test

Variables	Control Group	Osteoarthritis Group	t-test	P - Value	Significance
Calcium	8.99 \pm 1.20	8.26 \pm 1.34	3.395	0.00090	Significant
Phosphorus	3.51 \pm 1.66	4.11 \pm 1.51	-2.243	0.02652	
Magnesium	1.77 \pm 0.53	1.92 \pm 0.93	-1.140	0.25613	Not Significant
Iron	46.61 \pm 26.6	33.77 \pm 23.12	3.028	0.00295	Significant
Calcium/Phosphorus ratio	3.27 \pm 1.80	2.45 \pm 1.64	2.797	0.00590	

Table 3. Frequency distribution of calcium/phosphorus ratio of patients

Calcium/Phosphorus	Control Group		Osteoarthritis	
	n = 69	In %	n = 69	In %
0.0 - 1.00	2	2.90%	3	4.35%
1.01 - 2.00	19	27.54%	32	46.38%
2.01 - 3.00	17	24.64%	20	28.99%
3.01 - 4.00	12	17.39%	9	13.04%
4.01 - 5.00	9	13.04%	2	2.90%
> 5.00	10	14.49%	3	4.35%

Table 4. Correlation between calcium and phosphorus by using Karl Pearson's Correlation coefficient

Groups	Corr (r)	t-test	P - Value	Significance
Control	-0.4	-3.572	0.00066	Both are significant
Osteoarthritis	-0.296	-2.534	0.01359	

Table No. 4, shows the correlation between calcium and phosphorous levels using Karl Pearson's correlation coefficient. In the Controls Group, there is a correlation ($r = -0.4$) with a p-value of 0.00066, indicating significant relationship. The osteoarthritis group, a positive correlation ($r = 0.296$) is observed, with a p-value of 0.01359, which is also not significant. These results suggest that calcium and phosphorous levels have a meaningful correlation in either group.

DISCUSSION

The present study was conducted in the Department of Biochemistry, in association with the Department of Orthopaedics and Department of General Medicine at National Institute of Medical Sciences & Research Jaipur (Rajasthan). The study included an aggregate of 138 patients who were divided into 69 clinically diagnosed OA patients and 69 Healthy control subjects at the National Institute of Medical Sciences & research, Jaipur, Rajasthan, India. In this investigation, the analysis of serum calcium, phosphorus, magnesium, and iron in OA revealed noteworthy patterns, shedding light on the association compare serum calcium, phosphorus, magnesium and iron levels. Calcium levels are significantly lower in the osteoarthritis group (8.26 ± 1.34 mg/dL) compared to the control group (8.99 ± 1.20 mg/dL, $p = 0.00090$). Ding *et al.* (2008) report that reduced calcium levels

contribute to cartilage degradation and impair bone remodeling in osteoarthritis patients. Reginster *et al.* (2013) state that inadequate calcium intake weakens subchondral bone, accelerating joint degeneration. Misra *et al.* (2020) explain that calcium deficiency affects bone mineral density, increasing the risk of osteoarthritis. Hannan *et al.* (1993)¹² suggest that elevated phosphorus levels disrupt bone mineralization, contributing to osteoarthritis progression. Ilich *et al.* (2014) report that excessive phosphorus intake, especially from processed foods, depletes calcium, weakens bone structure, and accelerates cartilage wear. Magnesium levels are slightly higher in osteoarthritis patients compared to the control group, but the difference is not statistically significant ($p = 0.25613$). Zeng *et al.* (2015) suggest that magnesium plays a crucial role in regulating inflammation and maintaining cartilage health. Rosanoff *et al.* (2016) report that magnesium deficiency is linked to increased inflammatory markers, such as C-reactive protein (CRP), which are often elevated in osteoarthritis patients. De Souza *et al.* (2020) propose that adequate magnesium intake supports collagen synthesis and chondrocyte function, potentially slowing osteoarthritis progression. Garner *et al.* (2001)¹⁷ associate low iron levels with oxidative stress and inflammation, both of which play a crucial role in osteoarthritis pathogenesis. Hochberg *et al.* (2018) highlight that iron deficiency impairs hemoglobin synthesis, reducing oxygen transport to joint tissues and potentially worsening cartilage damage. Eisenstein *et al.* (2021) suggest that iron

supports mitochondrial function in chondrocytes, and its deficiency contributes to joint cell apoptosis. The calcium-to-phosphorus ratio is significantly lower in the osteoarthritis group (2.45 ± 1.64) compared to the control group (3.27 ± 1.80 , $p = 0.00590$). Reginster *et al.* (2013) highlight that an altered calcium-to-phosphorus ratio contributes to decreased bone density and increased joint degeneration. Parfitt *et al.* (2015)²⁰ suggest that maintaining an optimal Ca/P ratio is crucial for bone mineralization and cartilage stability. Heaney and Nordin (2002)²¹ find that a low Ca/P ratio accelerates osteoarthritis progression by disrupting hydroxyapatite formation in bones.

CONCLUSION

In the present study, we found altered OA parameters (Serum calcium, phosphorus, magnesium and iron) in subjects with OA as compared to the controls and case subjects. The comparative analysis of age is not significant, BMI, and waist circumference between the Healthy Controls and Osteoarthritis(OA) groups indicates significant differences in BMI and waist circumference, emphasizing the importance of these parameters in distinguishing individuals with OA. The significant findings regarding BMI, waist circumference, and other metabolic parameters underscore the complexity of OA and the need for tailored approaches to address this multifaceted health condition within the Indian population. The elevation in these parameters (serum calcium, phosphorus, & iron) is statically highly significant and there was no statically significant elevation in serum magnesium levels in subjects with OA compared to case group. Calcium and phosphorus ratio is statistically significant (p -value 0.00590) in case groups and correlation between calcium and phosphorus by using karl pearson's correlation coefficient is both are significant. Our study suggests that all RA patients should undergo regular monitoring of mineral levels to improve disease management and prevent complications.

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