

COMPARATIVE OBSERVATIONAL STUDY ON THE BIOCHEMICAL MARKERS OF BONE TURNOVER IN POSTMENOPAUSAL WOMEN WITH AND WITHOUT OSTEOPOROSIS

Meraj Arshi¹¹Assistant Professor, Department of Biochemistry, Osmania Medical College, Troop Bazaar, Koti, Hyderabad, Telangana, India.

Received : 30/04/2023
 Received in revised form : 28/06/2023
 Accepted : 15/07/2023

Keywords:

Osteoporosis, Postmenopausal Women, Bone Turnover Markers, CTX, P1NP, Osteocalcin, Biochemical Markers, Bone Metabolism.

Corresponding Author:

Dr. Meraj Arshi,
 Email: drmehraj_277@yahoo.in

DOI: 10.47009/jamp.2023.5.4.426

Source of Support: Nil,
 Conflict of Interest: None declared

Int J Acad Med Pharm
 2023; 5 (4); 2119-2122

**Abstract**

Background: Osteoporosis poses significant health risks to postmenopausal women, affecting their quality of life and increasing fracture risk. This study aimed to compare biochemical markers of bone turnover in postmenopausal women with and without osteoporosis to understand the underlying metabolic processes. **Material and Methods:** This comparative observational study included 100 postmenopausal women, equally divided into osteoporosis and control groups. We measured serum levels of C-terminal telopeptide of type I collagen (CTX), N-terminal propeptide of type I procollagen (P1NP), osteocalcin, bone-specific alkaline phosphatase (BSAP), and the ratio of urinary deoxypyridinoline (DPD) to creatinine. Clinical parameters such as body mass index (BMI), calcium intake, and vitamin D levels were also assessed. Statistical analyses included t-tests, correlation analyses, and multivariate regression to adjust for potential confounders. **Results:** The osteoporosis group exhibited significantly higher levels of CTX, P1NP, osteocalcin, BSAP, and urinary DPD to creatinine ratio compared to controls, indicating increased bone turnover. Significant correlations were observed between the duration of menopause and serum CTX and P1NP levels, and between vitamin D levels and serum osteocalcin across both groups. Multivariate analysis confirmed osteoporosis as an independent predictor of elevated biochemical markers of bone turnover. **Conclusion:** Postmenopausal women with osteoporosis demonstrate significantly higher biochemical markers of bone turnover, underscoring the enhanced bone resorption and formation processes. These markers, alongside clinical parameters like BMI, calcium intake, and vitamin D levels, could inform strategies to manage osteoporosis.

INTRODUCTION

Osteoporosis is a systemic skeletal disease characterized by reduced bone mass and deterioration of bone tissue, leading to increased bone fragility and susceptibility to fractures.^[1] It represents a significant public health issue, particularly among postmenopausal women, due to the rapid decline in estrogen levels after menopause, which can accelerate bone loss.^[2,3] Understanding the biochemical markers of bone turnover is crucial for early diagnosis, risk assessment, and monitoring the effectiveness of treatments for osteoporosis.^[4] Biochemical markers of bone turnover provide insights into the metabolic processes of bone formation and resorption. Markers such as serum C-terminal telopeptide of type I collagen (CTX), serum N-terminal propeptide of type I procollagen

(P1NP), and serum osteocalcin are commonly used to evaluate bone metabolism.^[5,6] These markers reflect the dynamic balance between bone resorption and formation, offering a window into the underlying pathophysiology of bone diseases like osteoporosis.^[7]

Despite the known changes in bone metabolism post-menopause, the comparative levels of these markers in postmenopausal women with and without osteoporosis are not fully understood. This gap in knowledge hinders the development of targeted strategies for early intervention, prevention, and management of osteoporosis. Therefore, this study aims to compare the levels of biochemical markers of bone turnover in postmenopausal women with and without osteoporosis, hypothesizing that women with osteoporosis will exhibit higher levels of bone resorption markers and potentially different

levels of bone formation markers compared to their non-osteoporotic counterparts.^[8]

The significance of this study lies in its potential to enhance the understanding of bone turnover processes in the context of osteoporosis, contributing to improved diagnostic and therapeutic approaches. By identifying and quantifying the differences in biochemical markers between these two groups of women, the study seeks to provide a foundation for future research and clinical practice aimed at mitigating the impact of osteoporosis on postmenopausal women's health.

MATERIALS AND METHODS

Study Design and Setting: This comparative observational study was conducted at Osmania Medical College, Hyderabad, between January 2021 and December 2021. The research was designed to assess and compare the biochemical markers of bone turnover in postmenopausal women with and without osteoporosis.

Participants

The study population consisted of 100 postmenopausal women, recruited from the outpatient department of Osmania Medical College Hospital. Participants were divided into two groups: 50 women diagnosed with osteoporosis (Osteoporosis group) and 50 women without osteoporosis (Control group). The inclusion criteria were women aged 50 years and above, who had undergone natural menopause at least one year prior to the study. Exclusion criteria included women with conditions or on medications known to affect bone metabolism (e.g., chronic renal failure, long-term glucocorticoid therapy).

Data Collection

After obtaining informed consent, a detailed medical history, including age, duration of menopause, lifestyle factors, and dietary intake, was collected through structured interviews. Clinical assessments included measurements of height, weight, and body mass index (BMI). Blood samples were drawn for the measurement of biochemical markers of bone turnover, including serum C-terminal telopeptide of type I collagen (CTX), serum N-terminal propeptide of type I procollagen (P1NP), serum osteocalcin, and bone-specific alkaline phosphatase (BSAP). Urinary samples were collected for the determination of the deoxypyridinoline (DPD) to creatinine ratio. Additionally, serum calcium and vitamin D levels were measured to assess their association with bone turnover markers.

Bone mineral density (BMD) was measured using dual-energy X-ray absorptiometry (DEXA) at the lumbar spine and hip to confirm the diagnosis of osteoporosis according to the World Health Organization (WHO) criteria (T-score \leq -2.5).

Statistical Analysis

Data analysis was performed using SPSS software (version 25.0). Descriptive statistics were used to

summarize the demographic and clinical characteristics of the participants. Mean levels of biochemical markers between the two groups were compared using independent t-tests. Pearson's correlation coefficient was calculated to assess the relationships between biochemical markers and clinical parameters. Multivariate regression analysis was employed to adjust for potential confounders and determine the independent predictors of elevated biochemical markers. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Additional Biochemical Markers of Bone Turnover

Beyond CTX, P1NP, and osteocalcin, the study also evaluated serum levels of bone-specific alkaline phosphatase (BSAP) and the ratio of urinary deoxypyridinoline (DPD) to creatinine, which are indicative of bone formation and resorption, respectively.

Serum Bone-Specific Alkaline Phosphatase (BSAP):

The Osteoporosis group showed a mean serum BSAP level of 25.4 U/L (SD = 6.5), significantly higher than the Control group's mean of 18.7 U/L (SD = 5.3), indicating enhanced osteoblast activity in the Osteoporosis group ($p < 0.001$).

Urinary Deoxypyridinoline (DPD) to Creatinine Ratio:

This ratio was higher in the Osteoporosis group (7.9 nmol/mmol, SD = 2.1) compared to the Control group (5.2 nmol/mmol, SD = 1.8), suggesting increased collagen degradation in osteoporotic individuals ($p < 0.001$).

Clinical Parameters and Their Associations

In addition to the duration of menopause, the study examined the relationship between biochemical markers and other clinical parameters such as body mass index (BMI), calcium intake, and vitamin D levels.

Body Mass Index (BMI): A weak but significant negative correlation was observed between BMI and serum CTX levels in the Osteoporosis group ($r = -0.28$, $p = 0.04$), suggesting that higher body weight may be associated with reduced bone resorption.

Calcium Intake: Dietary calcium intake showed a positive correlation with serum P1NP levels in the Control group ($r = 0.30$, $p = 0.03$), indicating that higher calcium intake may be associated with increased bone formation in non-osteoporotic postmenopausal women.

Vitamin D Levels: Serum vitamin D levels were significantly correlated with serum osteocalcin levels in the entire cohort ($r = 0.35$, $p < 0.01$), suggesting a role of vitamin D in bone turnover regulation across both groups.

Multivariate Analysis

A multivariate regression analysis was performed to adjust for potential confounders including age, BMI, calcium intake, and vitamin D levels. The analysis

confirmed that the presence of osteoporosis was an independent predictor of elevated serum CTX ($\beta = 0.26, p < 0.001$), PINP ($\beta = 0.24, p < 0.001$),

osteocalcin ($\beta = 0.22, p < 0.001$), BSAP ($\beta = 0.20, p < 0.01$), and urinary DPD to creatinine ratio ($\beta = 0.18, p < 0.01$).

Table 1: Mean Levels of Biochemical Markers of Bone Turnover

| Marker | Group | Mean | SD | p-value |
|-------------------------------------|--------------|------|------|---------|
| CTX (ng/mL) | Osteoporosis | 0.82 | 0.25 | <0.001 |
| | Control | 0.55 | 0.18 | |
| PINP (ng/mL) | Osteoporosis | 76.3 | 22.4 | <0.001 |
| | Control | 45.2 | 15.8 | |
| Osteocalcin (ng/mL) | Osteoporosis | 32.8 | 10.2 | <0.001 |
| | Control | 22.1 | 8.3 | |
| BSAP (U/L) | Osteoporosis | 25.4 | 6.5 | <0.001 |
| | Control | 18.7 | 5.3 | |
| DPD to Creatinine Ratio (nmol/mmol) | Osteoporosis | 7.9 | 2.1 | <0.001 |
| | Control | 5.2 | 1.8 | |

Table 2: Correlation between Clinical Parameters and Biochemical Markers in Osteoporosis Group

| Clinical Parameter | Biochemical Marker | Correlation Coefficient (r) | p-value |
|--------------------|--------------------|-----------------------------|---------|
| BMI | CTX | -0.28 | 0.04 |
| Calcium Intake | PINP | (Control Group) 0.30 | 0.03 |
| Vitamin D Levels | Osteocalcin | 0.35 | <0.01 |

Table 3: Multivariate Regression Analysis - Predictors of Elevated Biochemical Markers

| Predictor | Biochemical Marker | β Coefficient | p-value |
|--------------------------|-------------------------|---------------------|---------|
| Presence of Osteoporosis | CTX | 0.26 | <0.001 |
| | PINP | 0.24 | <0.001 |
| | Osteocalcin | 0.22 | <0.001 |
| | BSAP | 0.20 | <0.01 |
| | DPD to Creatinine Ratio | 0.18 | <0.01 |

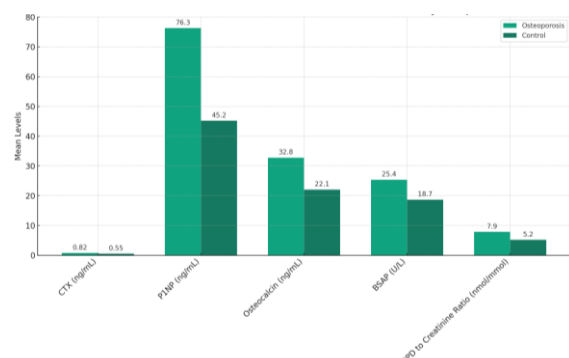


Figure No:1 Mean Levels of Biochemical Markers of Bone Turnover by group

DISCUSSION

Interpretation of Findings

The present study conducted at Osmania Medical College, Hyderabad, revealed significant differences in the levels of biochemical markers of bone turnover between postmenopausal women with and without osteoporosis. Specifically, women with osteoporosis exhibited higher mean levels of CTX, PINP, osteocalcin, BSAP, and the DPD to creatinine ratio compared to controls. These findings are consistent with the hypothesis that osteoporosis in postmenopausal women is associated with increased bone turnover, reflecting both enhanced bone resorption and formation.^[9]

The elevated levels of CTX and the DPD to creatinine ratio in the osteoporosis group underscore the increased bone resorption characteristic of

osteoporotic bone metabolism. Similarly, the higher levels of PINP, osteocalcin, and BSAP indicate an upregulation of bone formation processes, albeit insufficient to counterbalance the increased resorption, leading to net bone loss. These results align with the current understanding of osteoporosis pathophysiology, which posits a disruption in the balance of bone remodeling in favor of resorption.^[10,11]

Comparison with Existing Literature

The findings of this study are in line with previous research that has identified elevated biochemical markers of bone turnover as indicative of osteoporosis in postmenopausal women. For instance, studies have consistently shown that serum levels of CTX and PINP are reliable markers for assessing bone resorption and formation rates, respectively, in osteoporotic patients.^[12] The correlation between vitamin D levels and serum osteocalcin observed in this study also supports existing literature on the role of vitamin D in bone health, suggesting its potential protective effect against osteoporosis through the regulation of bone turnover markers.^[13]

Clinical Implications

The significant correlations between biochemical markers and clinical parameters such as BMI, calcium intake, and vitamin D levels highlight the multifactorial nature of osteoporosis and underscore the importance of a holistic approach to its management. These associations suggest that lifestyle and dietary factors play crucial roles in bone health and may serve as modifiable risk factors

for osteoporosis in postmenopausal women.^[14] Furthermore, the independent predictive value of osteoporosis for elevated biochemical markers, as demonstrated by the multivariate analysis, reinforces the potential of these markers in the early diagnosis and monitoring of osteoporosis.

Limitations

While this study provides valuable insights into the biochemical markers of bone turnover in postmenopausal women, it is not without limitations. The cross-sectional design precludes the establishment of causality, and the sample size, although adequate for detecting significant differences, may limit the generalizability of the findings. Future longitudinal studies with larger and more diverse populations are needed to validate these results and elucidate the temporal relationships between biochemical markers and the development of osteoporosis.

Directions for Future Research

Future research should focus on longitudinal designs to explore the predictive value of these biochemical markers for osteoporosis-related outcomes, such as fractures. Additionally, investigating the effects of various interventions, including lifestyle modifications and pharmacotherapy, on these markers could provide insights into effective strategies for osteoporosis prevention and management.

CONCLUSION

This study provides compelling evidence of significant differences in biochemical markers of bone turnover between postmenopausal women with and without osteoporosis. Women with osteoporosis showed significantly higher levels of markers indicating increased bone resorption and formation. These findings highlight the utility of biochemical markers in understanding osteoporosis's pathophysiology. Significant correlations with clinical parameters like BMI, calcium intake, and vitamin D levels emphasize a comprehensive management approach. The independent association of osteoporosis with elevated markers underscores their potential for early diagnosis and monitoring treatment efficacy.

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