

Article

Not peer-reviewed version

Correlation of Neutrophil-to-Lymphocyte Ratio and Platelet-to-Lymphocyte Ratio with Bone Mineral Density in Postmenopausal Women: A Cross-Sectional Study

Pierpaolo Panebianco , [Gianluca Testa](#) ^{*} , Giulia Barbagallo , [Luciano Costarella](#) , [Alessia Caldaci](#) , [Sveva Condorelli](#) , [Marco Sapienza](#) , [Vito Pavone](#)

Posted Date: 18 March 2025

doi: 10.20944/preprints202503.1285.v1

Keywords: Osteoporosis; inflammation; neutrophil-to-lymphocyte ratio; platelet-to-lymphocyte ratio; bone health



Preprints.org is a free multidisciplinary platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This open access article is published under a Creative Commons CC BY 4.0 license, which permit the free download, distribution, and reuse, provided that the author and preprint are cited in any reuse.

Article

Correlation of Neutrophil-to-Lymphocyte Ratio and Platelet-to-Lymphocyte Ratio with Bone Mineral Density in Postmenopausal Women: A Cross-Sectional Study

Pierpaolo Panebianco, Gianluca Testa *, Giulia Barbagallo, Luciano Costarella, Alessia Caldaci, Sveva Condorelli, Marco Sapienza and Vito Pavone

Department of General Surgery and Medical Surgical Specialties, Section of Orthopaedics, A.O.U. Policlinico Rodolico-San Marco, University of Catania, 95123 Catania, Italy

* Correspondence: gianpavel@hotmail.com

Abstract: Background/Objectives: Osteoporosis is a skeletal disorder characterized by reduced bone mineral density (BMD) and increased fracture risk. Chronic inflammation is implicated in osteoporosis pathogenesis, with inflammatory mediators promoting bone resorption. The neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) are markers of systemic inflammation and have emerged as potential indicators of bone health. This study's aim was to highlight the potential role of NLR and PLR as markers of bone health in postmenopausal women affected by osteoporosis or osteopenia and to evaluate the possible influence of autoimmune disease in this context. **Methods:** This cross-sectional study included 124 postmenopausal women diagnosed with osteopenia or osteoporosis at the Orthopedic Unit of the Policlinico G. Rodolico in Catania, Italy. Demographic, clinical, laboratory, and diagnostic imaging data were collected. NLR and PLR were calculated from complete blood counts, and BMD was measured using dual-energy X-ray absorptiometry (DEXA). Statistical analyses included correlations, group comparisons, and multiple and logistic regressions. **Results:** NLR and PLR did not directly correlate with BMD or fracture incidence. However, PLR weakly correlated with vitamin D levels. Notably, women without Hashimoto's thyroiditis exhibited higher NLR values than those with the condition. Hypertensive women had lower PLR than non-hypertensive women, while euthyroid women had higher PLR than hyperthyroid or hypothyroid women. Multiple regression analysis revealed that age, BMI, CKD stage, vitamin D levels, NLR, PLR, diabetes, and autoimmune diseases significantly predicted BMD at the femur neck, with PLR contributing significantly. Logistic regression confirmed these predictors for osteoporosis or osteopenia, with increased PLR being associated with a higher likelihood of osteoporosis. **Conclusion:** While NLR and PLR may not independently predict bone health, their inclusion in a multifactorial assessment considering age, BMI, vitamin D, and comorbidities could enhance osteoporosis management.

Keywords: Osteoporosis; inflammation; neutrophil-to-lymphocyte ratio; platelet-to-lymphocyte ratio; bone health

1. Introduction

Osteoporosis is a high-impact, chronic, and progressive bone condition that affects over 200 million people worldwide. It is characterized by a loss of bone mass and the deterioration of bone microarchitecture, leading to increased fragility and a higher risk of fractures. The prevalence of osteoporosis continues to rise, primarily due to aging populations and changes in lifestyle [1]. Diagnosis is typically performed using dual-energy X-ray absorptiometry (DEXA), which measures bone mineral density (BMD) at key sites such as the lumbar spine, hip, and forearm. According to the

World Health Organization (WHO), osteoporosis is defined by a T-score of ≤ -2.5 standard deviations (SD) below that of a healthy, young adult, indicating significantly reduced bone density [2].

The development of osteoporosis results from an imbalance in bone remodeling, where the bone resorption carried out by osteoclasts exceeds the bone formation by osteoblasts. Various factors contribute to this imbalance, including hormonal changes, oxidative stress, and chronic low-grade inflammation. Pro-inflammatory cytokines like IL-6 and TNF- α play a critical role by promoting osteoclast activity while inhibiting osteoblast function, ultimately accelerating bone loss [2,3].

Osteoblasts originating from mesenchymal stem cells are responsible for producing and mineralizing the bone matrix while also regulating osteoclast function through factors such as RANKL and OPG. On the other hand, osteoclasts derived from monocyte/macrophage lineages break down bone tissue. In osteoporosis, this delicate balance is disrupted, often due to increased osteoclast activity or impaired osteoblast function. For example, postmenopausal osteoporosis is closely associated with estrogen deficiency, which leads to decreased OPG levels and increased RANKL expression, which ultimately drives excessive bone resorption [4–6].

Cytokines and immune dysregulation amplify this imbalance through chronic inflammation. Age-related low-grade inflammation (termed “inflammaging”) promotes osteoclast activation and osteoblast dysfunction via release of pro-inflammatory cytokines by senescent bone cells. It has long been known that chronic inflammatory diseases such as rheumatoid arthritis increase systemic inflammation, which directly enhances bone resorption. Glucocorticoid therapy can control inflammation but also suppresses osteoblast activity, thereby worsening bone loss. Emerging treatments targeting interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF- α), and receptor activator of nuclear factor-kappa B ligand (RANKL) have shown promising results in reducing inflammation-related bone loss. Additionally, lifestyle modifications such as a healthy diet, regular exercise, and stress management can complement these therapies by helping to lower systemic inflammation [4–6].

Various systemic inflammation markers have been investigated in their role as possible osteoporotic risk factors, particularly the neutrophil-to-lymphocyte ratio (NLR) and the platelet-to-lymphocyte ratio (PLR). High NLR and PLR have been linked with increased states of systemic inflammation, and most recent studies show that they may also be associated with lower bone density and increased risk of fracture [7]. Information regarding NLR and PLR as clinical biomarkers has shown potential relevance in the pathogenesis and progression of osteoporosis. Both NLR and PLR are derived from botanical parameters and represent different aspects of the inflammatory milieu. NLR reflects the balance between innate and adaptive immunity by comparing absolute neutrophil and absolute lymphocyte counts, while PLR emphasizes the role of platelets as mediators of inflammation and bone metabolism.

As an innate immune response, neutrophils secrete inflammatory mediators including interleukin-1 (IL-1), IL-6, and TNF- α . These cytokines stimulate RANKL, which is important for osteoclast differentiation and activation, hence increasing bone resorption [2]. Concurrent lymphopenia marked by high NLR contributes to a reduced adaptive immune response, which may subsequently compromise bone repair and remodeling. The association between such parameters and therapeutic approaches is also relevant due to the use of NLR and PLR as biomarkers. Cytokine inhibitors of IL-6 or TNF- α , which are known to be biomarkers of high NLR and PLR, might represent potential anti-inflammatory treatments that could ameliorate their negative effect on bone health [2–7].

The use of NLR and PLR in research is growing. However, the reference values vary in different studies and populations, and broad limits have been set to interpret these ratios clinically. The normal value of NLR is between 1.0 and 3.0. Levels over 3.0 are often indicative of potential systemic inflammation, stress, or worse, immune dysregulation [8]. Low ratios can suggest an immune dysfunction rather than a systemic inflammatory state. Low NLR values (≤ 1) may indicate either lymphocytosis (high percentage of lymphocytes in blood) or neutropenia (lower percentage of

neutrophils in blood). These may arise in the setting of viral infections, selected autoimmune diseases, bone marrow suppression, or some hematologic disorders.

Low NLR may also reflect an enhanced adaptive immune response that might be protective in specific settings but could also be a signal of disturbed immune regulation. In a similar vein, a PLR below the reference range (generally <100) might be due to thrombocytopenia as either a primary process related to bone marrow dysfunction or a secondary process due drugs or systemic diseases interfering with platelet production or survival [8,9]. In osteoporosis, low NLR or PLR values are rarely studied as attention has been focused on elevated levels as inflammation markers. However, abnormally low ratios can imply an impaired inflammatory response that may restrict their potential to repair microdamage of bone tissue. Nevertheless, one must always take into account the clinical background as the values might differ according to age, comorbidities, and different methodologies among studies.

2. Materials and Methods

2.1. Declarations, Study Design, Setting, and Participants

Informed consent was obtained from all patients for the publication of all their data and images. We conducted a cross-sectional study from November 2023 to November 2024 and recruited 124 consecutive patients from the osteoporosis service of the Orthopedic Unit of the Policlinico G. Rodolico in Catania, Italy. The inclusion criteria included postmenopausal women with a diagnosis of osteopenia or osteoporosis based on the BMD T-score at the femur neck or lumbar spine (T-score of at least ≤ -1.5). This study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the ethics committee of Policlinico G. Rodolico.

2.2. Data Collection and Measures

We collected demographic, clinical, laboratory, and diagnostic imaging data from the patients. EGFR was calculated using the 2021 CKD-EPI creatinine formula. The NLR was calculated by dividing the number of neutrophils by the number of lymphocytes, and the PLR was calculated by dividing the platelet count by the number of lymphocytes. The lumbar spine and femur neck BMD were measured by DEXA.

2.3. Statistical Analysis

Data were expressed as the mean $\pm$ standard deviation (SD) for parametric variables, the median and inter-quartile range (IQR) for nonparametric variables, and percentages for categorical variables. All the variables were tested for normal distributions by visual representation and via the Shapiro-Wilk test. To test relationships between two or more variables, we applied Pearson's product-moment correlation for parametric variables and Spearman's rank-order correlation for nonparametric variables. The independent-samples t-test and the Mann-Whitney U test were respectively conducted to compare differences of parametric and nonparametric variables between two independent groups.

One-way ANOVA and the Kruskal-Wallis H test were respectively used to compare differences of parametric and nonparametric variables across three or more independent groups. To predict the value and the categorization of a variable, we respectively used multiple and binomial logistic regression. Statistical significance was considered for $P \leq 0.05$. Statistical analysis was performed using SPSS software version 29.0 (IBM Corp. Released 2023. IBM SPSS Statistics for Macintosh, Version 29.0.2.0 Armonk, NY: IBM Corp).

3. Results

We included 124 postmenopausal women, of which 70.2% were osteoporotic and 29.8% were osteopenic. The mean age of the patients was 64.5 ± 10.4 years, and the mean BMI was 24.8 ± 4.2

kg/m². BMD T-scores in our series were -2.3 ± 0.78 at the femur neck and -2.5 ± 0.84 at the lumbar spine. Among the participants, 23.4% had experienced fractures, and 71.8% were using medication. The prevalence of autoimmune diseases was 34.7%, with coeliac disease being the most common at 22.6%, followed by Hashimoto’s thyroiditis at 6.5%.

Table 1. Main characteristics of participants.

Category	Details	Value(s)
Sample Size	Total participants	124
Age	Mean ± SD	64.6 ± 10.4 years
BMI	Mean ± SD	24.8 ± 4.2 kg/m²
	Underweight	1.7%
	Healthy weight	58.6%
	Overweight	26.7%
	Obesity	12.9%
NLR	Median (IQR)	1.7 (1.26–2.09)
PLR	Median (IQR)	125.1 (96.9–152.7)
BMD T-Score	Femur neck (Mean ± SD)	-2.3 ± 0.78 SD
	Lumbar spine (Mean ± SD)	-2.5 ± 0.84 SD
	Osteoporosis	70.2%
	Osteopenia	29.8%
	Fractures	23.4%
Comorbidities	Hypertension	31.1%
	Diabetes	12.2%
	Dyslipidemia	18.9%
	Cancer	5.6%
Pharmacological Therapies	Any therapy	71.8%
	Vitamin D	64.5%
	Calcium	13.6%
	Bisphosphonates	28.2%
	Denosumab	3.6%
	Teriparatide	1.8%
	Raloxifene	0.8%
Autoimmune Diseases	Any autoimmune disease	34.7%
	Coeliac disease	22.6%
	Hashimoto’s thyroiditis	6.5%
	Others	5.6%
Number of Autoimmune Diseases	1	81
	2	36
	3	6
	4	1
Chronic Kidney Disease (CKD)	Stage 1	23.6%
	Stage 2	52.8%
	Stage 3a	17.0%
	Stage 3b	4.7%
	Stage 4	0.9%
	Stage 5	0.9%
Thyroid Function	Euthyroidism	89.5%
	Hyperthyroidism	7.9%

Vitamin D Status	Hypothyroidism	2.6%
	Serum levels (Mean ± SD)	33.3 ± 13.6
	Normal	55.7%
	Insufficiency	31.1%
	Deficiency	13.1%

No statistically significant direct correlation was observed between NLR and PLR with any index of bone health, demographic factors, or laboratory results. However, PLR showed a slight association with vitamin D levels ($\rho=0.17$, $P<0.05$) (Table2). The median values of NLR and PLR did not differ statistically between individuals with osteoporosis or osteopenia, nor between those with or without fractures ($P>0.05$).

Table 2. Correlations between NLR/PLR and factors.

Parameter	Correlation with Bone Health	Correlation with Vitamin D	Correlation with Fractures
NLR	Not significant	Not significant	Not significant
PLR	Not significant	$\rho=0.17$, $P<0.05$	Not significant

No correlations were found between NLR, PLR, and bone health, even when stratifying the sample by age quartiles ($P>0.05$), and there were no differences in PLR and NLR values among fractured subjects based on the type of fracture ($P>0.05$). Median NLR values were notably higher in women without Hashimoto’s thyroiditis compared to those with the condition (1.76, 1.29–2.24 vs. 1.18, 1.09–1.55; $P=0.028$). Women with diabetes also had higher median NLR values compared to non-diabetic participants (2.14, 1.65–2.5 vs. 1.69, 1.15–2.07; $P=0.028$). PLR values were elevated in women without hypertension compared to hypertensive individuals (135.76, 99.84–166.15 vs. 101.43, 82.16–131.99; $P=0.003$). Similarly, euthyroid women had significantly higher PLR values compared to hyperthyroid and hypothyroid participants (124.28, 100.43–148.87 vs. 112.95, 101.08–124.81 vs. 81.40, 66.67–96.30; $P=0.004$) (Table 3).

Table 3. Comparison of NLR and PLR values in specific groups.

Group Comparison	Values	P-value
NLR: Women without Hashimoto’s vs. with Hashimoto’s	1.76 (1.29–2.24) vs. 1.18 (1.09–1.55)	0.028
NLR: Diabetic vs. Non-diabetic women	2.14 (1.65–2.5) vs. 1.69 (1.15–2.07)	0.028
PLR: Women without Hypertension vs. with Hypertension	135.76 (99.84–166.15) vs. 101.43 (82.16–131.99)	0.003
PLR: Euthyroid vs. Hyperthyroid vs. Hypothyroid	124.28 (100.43–148.87) vs. 112.95 (101.08–124.81) vs. 81.40 (66.67–96.30)	0.004

No significant differences were observed between groups based on the presence or absence of other autoimmune diseases, comorbidities, bone-targeting medications, number of autoimmune diseases, vitamin D status, or CKD stage ($P>0.05$). Similarly, the mean BMD T-score values did not differ significantly regarding the autoimmune status of postmenopausal women ($P>0.05$). There was also no correlation between the number of comorbidities and NLR or PLR values, and no significant differences in median NLR and PLR values were found when patients were grouped by their total number of comorbidities ($P>0.05$).

Multiple regression analysis indicated that BMD T-score values at the femur neck could be predicted by a model incorporating factors such as age, BMI, CKD stage, vitamin D levels, NLR and PLR values, diabetes, and autoimmune disease ($R^2=0.41$, $P<0.001$). Notably, PLR contributed significantly to this prediction ($B=-0.006$, $P=0.022$) (Table 4). Logistic regression analysis was performed to ascertain the effects of age, BMI, CKD stage, vitamin D levels, NLR, PLR, presence of diabetes, and autoimmune disease on the likelihood that patients have osteoporosis or osteopenia ($R^2=0.54$, $P=0.002$). The model correctly classified 100% of osteoporosis cases, and increased PLR was associated with an increased likelihood of having osteoporosis ($B=0.035$, $P=0.025$) (Table 4).

Table 4. Regression analysis summary.

Model	Predictors	Significant Factor	R ²
Multiple Regression (BMD T-score)	Age, BMI, CKD stage, Vitamin D, NLR, PLR, Diabetes, Autoimmune disease	PLR ($B=-0.006$, $P=0.022$)	0.41
Logistic Regression (Osteoporosis likelihood)	Age, BMI, CKD stage, Vitamin D, NLR, PLR, Diabetes, Autoimmune disease	PLR ($B=0.035$, $P=0.025$)	0.54

4. Discussion

The results of the study provide further insights into the relationship between systemic inflammation represented by NLR and PLR and bone-health indices. While the connection between chronic inflammation and bone metabolism is well established, this study highlights that neither NLR nor PLR shows a straightforward correlation with bone-health indices, demographic data, or most laboratory findings. An exception is the weak but statistically significant correlation observed between PLR and vitamin D levels. This indicates a modest relationship between platelet-mediated inflammation and vitamin D status, which is a key factor in bone health.

This finding aligns with the work of Akbas et al., who reported that PLR and NLR were significantly associated with 25(OH)D levels. They also noted an inverse relationship between vitamin D levels and inflammation. However, this weak correlation alone does not point to a direct effect of PLR on bone density or fracture risk [10].

4.1. NLR, PLR, and Bone-Health Outcomes

There was no significant difference in the median values of NLR and PLR between individuals with osteoporosis and those with osteopenia, nor between those with and without fractures. Furthermore, stratifying by fracture type revealed no variations in NLR and PLR values, suggesting that the inflammatory response may not significantly differ based on the type of fracture. Multivariate regression analysis identified age, BMI, CKD stage, vitamin D levels, NLR, PLR, diabetes, and autoimmune diseases as significant predictors of BMD at the femur neck. In logistic regression models predicting osteoporosis or osteopenia, systemic factors demonstrated strong predictive power, with increased PLR linked to a higher likelihood of osteoporosis.

While PLR contributed significantly to these models, its overall impact was modest, indicating a nuanced role of platelet activity in bone metabolism. This suggests that PLR might serve as a biomarker for assessing osteoporosis risk, although further research is needed for validation. Lee et al. [11] investigated the relationship between BMD and the NLR and PLR in Korean postmenopausal women and found that the NLR was related to BMD, but the PLR was not. In this study, the sample was bigger and included only postmenopausal women with or without osteoporosis. Moreover, the study was conducted on a geographically distinct population compared to ours.

A meta-analysis performed by Liu et al. [12] demonstrated that both NLR and PLR are higher in individuals with osteoporosis in comparison to those with normal BMD. This suggests associations

of these two inflammatory biomarkers with osteoporosis. The difference in the findings of these two studies from ours could be explained by the fact that we did not include women with normal BMD.

4.2. Autoimmune Diseases and Comorbidities

Interestingly, our data highlighted certain subgroup differences. Women without Hashimoto's thyroiditis showed significantly higher NLR values than those with the condition, suggesting that Hashimoto's may suppress systemic neutrophilic inflammation. Hypertension also influenced PLR values, with hypertensive women having lower PLR compared to non-hypertensive women. Thyroid function had a distinct effect as euthyroid women had significantly higher PLR values than hyperthyroid and hypothyroid women. This hints at a potential connection between thyroid homeostasis and platelet-mediated inflammatory activity. This is supported by the study conducted by Erinc et al., where PLR values were found to be higher in patients with Hashimoto's thyroiditis and non-immunogenic hypothyroidism compared to healthy controls [13].

4.3. Implications and Future Research

In light of the evidence, it can be concluded that the examined markers are not specific but are influenced by a wide range of conditions and comorbidities. This highlights their sensitivity to various systemic factors rather than serving as exclusive indicators of a single pathological state. This observation is further supported by the heterogeneity of results reported in the current literature on the subject.

These findings suggest that while routine inflammatory markers such as NLR and PLR may not directly reflect bone health, their association with conditions such as diabetes, hypertension, and thyroid dysfunction could have an indirect effect on bone metabolism. The identification of PLR as a potential predictor of osteoporosis risk introduces a new dimension to the study of systemic inflammation in bone diseases. However, there is currently no evidence to support its use in clinical practice. Future research should focus on longitudinal studies to further elucidate the causal pathways between systemic inflammation and bone health and on assessment of patient outcomes and prognosis. Additionally, integrating other inflammatory biomarkers and genetic predispositions could enhance the predictive accuracy of models involving NLR and PLR.

4.3. Limitations

The limitations of our study include a small sample size and its cross-sectional design. These limitations precluded the possibility of conducting follow-up assessments to evaluate NLR and PLR as prognostic indices or to monitor the response to pharmacological therapy. Furthermore, the study focused exclusively on osteoporotic and osteopenic women without including a control group of healthy women. It should also be noted that some participants were not undergoing osteoporosis/osteopenia treatment.

5. Conclusions

In conclusion, while NLR and PLR may not independently predict bone-health outcomes, their integration into a broader clinical context alongside factors such as age, BMI, vitamin D levels, and comorbidities could enhance the understanding and management of bone-related diseases. Future research should focus on validating these markers through longitudinal studies on larger cohorts and exploring their role as components of multifactorial predictive models for bone health.

Author Contributions: Conceptualization, G.T.; methodology, P.P.; software, S.C.; validation, L.C.; formal analysis, M.S.; investigation, S.C.; resources, P.P.; data curation, A.C.; writing—original draft preparation, G.B.; writing—review and editing, G.T.; visualization, V.P.; supervision, V.P.; project administration, V.P.; funding acquisition, V.P. All authors have read and agreed to the published version of the manuscript.

Funding: No funding source to disclose.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of A.O.U. Policlinico Rodolico – San Marco (n. 160/2020/PO).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Yes.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Compston, J.E.; McClung, M.R.; Leslie, W.D. Osteoporosis. *Lancet*. **2019**, 393(10169), 364-376. doi: 10.1016/S0140-6736(18)32112-3.
2. Rachner, T.D.; Khosla, S.; Hofbauer, L.C. Osteoporosis: now and the future. *Lancet*. **2011**, 377(9773), 1276-87. doi: 10.1016/S0140-6736(10)62349-5.
3. Dong, Q.; Wu, J.; Zhang, H.; Luo, L.; Wu, W. The causal role of circulating inflammatory markers in osteoporosis: a bidirectional Mendelian randomized study. *Front Immunol*. **2024**, 15, 1412298. doi: 10.3389/fimmu.2024.1412298.
4. Cui, Y.; Lv, B.; Li, Z.; Ma, C.; Gui, Z.; Geng, Y.; Liu, G.; Sang, L.; Xu, C.; Min, Q.; Kong, L.; Zhang, Z.; Liu, Y.; Qi, X.; Fu, D. Bone-Targeted Biomimetic Nanogels Re-Establish Osteoblast/Osteoclast Balance to Treat Postmenopausal Osteoporosis. *Small*. **2024**, 20(6), e2303494. doi: 10.1002/sml.202303494.
5. Franceschi, C.; Campisi, J. Chronic inflammation (inflammaging) and its potential contribution to age-associated diseases. *J Gerontol A Biol Sci Med Sci*. **2014**, 69 Suppl 1, S4-9. doi: 10.1093/gerona/glu057.
6. Weitzmann, M.N.; Pacifici, R. Estrogen deficiency and bone loss: an inflammatory tale. *J Clin Invest*. **2006**, 116(5), 1186-94. doi: 10.1172/JCI28550.
7. Tang, Y.; Peng, B.; Liu, J.; Liu, Z.; Xia, Y.; Geng, B. Systemic immune-inflammation index and bone mineral density in postmenopausal women: A cross-sectional study of the national health and nutrition examination survey (NHANES) 2007-2018. *Front Immunol*. **2022**, 13, 975400. doi: 10.3389/fimmu.2022.975400.
8. Forget, P.; Khalifa, C.; Defour, J.P.; Latinne, D.; Van Pel, M.C.; De Kock, M. What is the normal value of the neutrophil-to-lymphocyte ratio? *BMC Res Notes*. **2017**, 10(1), 12. doi: 10.1186/s13104-016-2335-5.
9. Zahorec, R. Ratio of neutrophil to lymphocyte counts--rapid and simple parameter of systemic inflammation and stress in critically ill. *Bratisl Lek Listy*. **2001**, 102(1), 5-14. PMID: 11723675.
10. Akbas, E.M.; Gungor, A.; Ozcicek, A.; Akbas, N.; Askin, S.; Polat, M. Vitamin D and inflammation: evaluation with neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio. *Arch Med Sci*. **2016**, 12(4), 721-7. doi: 10.5114/aoms.2015.50625.
11. Lee, S.H.; Ryu, S.Y.; Park, J.; Shin, M.H.; Han, M.A.; Choi, S.W. The Relationship of Neutrophil-Lymphocyte Ratio and Platelet-Lymphocyte Ratio with Bone Mineral Density in Korean Postmenopausal Women. *Chonnam Med J*. **2019**, 55(3), 150-155. doi: 10.4068/cmj.2019.55.3.150.
12. Liu, Y.C.; Yang, T.I.; Huang, S.W.; Kuo, Y.J.; Chen, Y.P. Associations of the Neutrophil-to-Lymphocyte Ratio and Platelet-to-Lymphocyte Ratio with Osteoporosis: A Meta-Analysis. *Diagnostics (Basel)*. **2022**, 12(12), 2968. doi: 10.3390/diagnostics12122968.
13. Erinc, O.; Yesilyurt, S.; Senat, A. A comprehensive evaluation of hemogram-derived inflammatory indices in hashimoto thyroiditis and non-immunogenic hypothyroidism. *Acta Endocrinol (Buchar)*. **2023**, 19(4), 435-440. doi: 10.4183/aeb.2023.435.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.