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Association between the hemoglobin, albumin, lymphocyte, and platelet (HALP) score and erectile dysfunction in a clinical population: a cross-sectional study

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Abstract

Background: The present study aimed to evaluate the association between the hemoglobin, albumin, lymphocyte, and platelet (HALP) score and erectile dysfunction (ED), as well as the severity of erectile dysfunction , in a clinical population. **Methods**: Patients presenting to the urology outpatient clinic were included, and erectile function was assessed using the International Index of Erectile Function (IIEF). Participants were grouped according to the presence of ED, and the HALP score was calculated from routine laboratory parameters. The association between the HALP score and ED was analyzed using multivariable logistic regression analysis, while correlation analysis was performed to evaluate the relationship between the HALP score and the IIEF erectile function score. Receiver operating characteristic (ROC) analysis was used to provide exploratory information regarding the ability of the HALP score to distinguish between patients with and without ED. **Results**: The HALP score was significantly lower in patients with ED and was found to be associated with ED after adjustment for relevant clinical variables. A strong positive correlation was observed between the HALP score and the IIEF erectile function score. ROC analysis suggested that the HALP score may have the ability to distinguish between patients with and without ED. **Conclusions**: These findings suggest that the HALP score may have potential clinical relevance as a complementary biomarker reflecting the inflammatory and metabolic background associated with ED; however, it should be considered a supportive tool rather than a diagnostic test. Further prospective and externally validated studies are warranted to confirm these findings.

Keywords

Endothelial dysfunction; Erectile dysfunction; Inflammation; International index of erectile function

Asociación entre la puntuación de hemoglobina, albúmina, linfocitos y plaquetas (HALP) y la disfunción eréctil en una población clínica: un estudio transversal

Resumen

Antecedentes: El presente estudio tuvo como objetivo evaluar la asociación entre la puntuación de hemoglobina, albúmina, linfocitos y plaquetas (HALP) y la disfunción eréctil (DE), así como la gravedad de la función eréctil en una población clínica. **Métodos**: Se incluyeron pacientes que acudieron a la consulta externa de urología. La función eréctil se evaluó mediante el Índice Internacional de Función Eréctil (IIEF). Los participantes se agruparon según la presencia de DE, y la puntuación HALP se calculó a partir de parámetros de laboratorio rutinarios. La asociación entre el puntaje HALP y la DE se analizó mediante análisis de regresión logística multivariable, mientras que se realizó un análisis de correlación para evaluar la relación entre el puntaje HALP y la puntuación de función eréctil del IIEF. El análisis de la curva característica operativa del receptor (ROC) se utilizó para proporcionar información exploratoria sobre la capacidad del puntaje HALP para distinguir entre pacientes con y sin DE. **Resultados**: El puntaje HALP fue significativamente menor en pacientes con DE y se encontró asociado con la DE tras el ajuste por variables clínicas relevantes. Se observó una fuerte correlación positiva entre el puntaje HALP y la puntuación de función eréctil del IIEF. El análisis ROC sugirió que el puntaje HALP podría tener la capacidad de distinguir entre pacientes con y sin DE. **Conclusiones**: Estos hallazgos sugieren que el puntaje HALP puede tener una relevancia clínica potencial como biomarcador complementario que refleja el trasfondo inflamatorio y metabólico asociado con la DE; sin embargo, debe considerarse una herramienta de apoyo y no una prueba diagnóstica. Se requieren estudios prospectivos y con validación externa para confirmar estos hallazgos.

Palabras Clave

Disfunción endotelial; Disfunción eréctil; Inflamación; Índice internacional de función eréctil

1. Introduction

Erectile dysfunction (ED) refers to the ongoing inability to attain or sustain an erection adequate for satisfactory sexual performance and represents the most prevalent form of male sexual dysfunction [1]. Although its prevalence increases with age, ED has also been increasingly reported among younger men in recent years [2]. ED is closely associated with cardiovascular risk factors such as diabetes mellitus, hypertension, dyslipidemia, obesity, and cigarette smoking, and vascular and endothelial dysfunction are considered among the main pathophysiological mechanisms involved [3, 4].

Due to the small diameter of the penile arteries, ED may represent one of the earliest clinical manifestations of endothelial dysfunction compared with systemic vascular diseases [5]. Therefore, ED is regarded not only as a localized urological condition but also as an early indicator of systemic vascular diseases [6]. Current literature has demonstrated that inflammation and oxidative stress lead to functional impairment in the penile vascular bed by reducing nitric oxide bioavailability [7].

In recent years, various hematological and inflammatory markers have been investigated to elucidate the role of inflammation in the pathogenesis of ED. Parameters such as the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), C-reactive protein (CRP), and the CRP-to-albumin ratio have been reported to be associated with the presence and severity of ED [8–10]. These observations further suggest that inflammatory processes may contribute substantially to the pathophysiology of ED.

The hemoglobin, albumin, lymphocyte, and platelet (HALP) score is a combined biomarker that simultaneously reflects nutritional status, immune response, and systemic inflammation [11]. Initially described as a prognostic index in oncological patients, the HALP score has subsequently been associated with cardiovascular and inflammatory diseases [12, 13]. Low HALP scores have been associated with malnutrition, chronic inflammation, and immune suppression and have been found to be related to adverse clinical outcomes [11–13].

Within this biological framework, studies investigating the association between the HALP score and ED are quite limited. In the present study, we aimed to investigate the relationship between the HALP score and the presence of ED in a clinical population, in which erectile function was evaluated using the International Index of Erectile Function (IIEF-15) among patients presenting to a urology outpatient clinic. Thus, we sought to elucidate the potential clinical utility of the HALP score as an easily accessible biomarker based on routine laboratory data that may reflect the inflammatory and nutritional background of ED.

2. Materials and methods

This cross-sectional observational study was conducted between April 2024 and June 2025, following approval from the Ethics Committee of the University of Health Sciences Bursa Yüksek İhtisas Training and Research Hospital (approval number: 2024-TBEK 2024/02-12) and in compliance with the ethical principles outlined in the Declaration of Helsinki.

The study included consenting individuals presenting to the urology outpatient clinic with complaints of erectile dysfunction. Erectile function was assessed using the validated 15-item International Index of Erectile Function (IIEF-15) questionnaire. Based on the erectile function domain score of the IIEF (questions 1, 2, 3, 4, 5, and 15), participants with a score of 26 or higher were considered to have normal erectile function. In contrast, those with a score of 25 or lower

were classified as having ED. The control group consisted of voluntary participants who presented to our outpatient clinic for reasons other than ED, had normal erectile function with an IIEF-15 score of 26 or higher, and did not meet any exclusion criteria. Control participants were selected consecutively from individuals presenting to the outpatient clinic during the study period who met the inclusion criteria and did not report erectile dysfunction. Patients with ED were categorized as Group 1, and participants in the control group were categorized as Group 2.

Individuals under 18 years of age or older than 75 years were excluded from the study. Additional exclusion criteria included endocrine disorders other than diabetes mellitus (such as hyperprolactinemia, hypogonadism, and thyroid dysfunction), neurological, hematological, or psychiatric diseases, use of medications or substances potentially affecting erectile function, active malignancy, connective tissue disorders, Peyronie's disease or other penile deformities, previous pelvic or penile surgery, trauma or radiotherapy, and chronic kidney disease. Comprehensive medical histories were obtained from all participants, followed by physical examination. The IIEF-15 questionnaire was completed individually by each participant, and clarification was provided only when necessary, without influencing the responses. Anthropometric measurements, including height and weight, were recorded, and body mass index (BMI) was calculated accordingly. Smoking habits were also documented.

Blood samples were collected from all participants after at least 8 hours of fasting between 7:00 and 11:00 AM. The following laboratory parameters were analyzed: complete blood count, fasting blood glucose, glycated hemoglobin (HbA1c), triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, very low-density lipoprotein cholesterol, total cholesterol, albumin, total testosterone, and total prostate-specific antigen (PSA) in patients older than 45 years.

The hemoglobin, albumin, lymphocyte, and platelet (HALP) score was calculated using the following formula:

HALP = (hemoglobin [g/L] × albumin [g/L] × absolute lymphocyte count [10^9/L])/platelet count [10^9/L] [11].

The HALP score was calculated as previously described using hemoglobin and albumin levels measured in g/L and lymphocyte and platelet counts measured in $\times 10^9$/L, resulting in a unitless composite index reflecting nutritional, immunological, and inflammatory status. This methodology is consistent with previously published prognostic studies evaluating the HALP score in oncological populations.

Statistical analyses were performed using IBM SPSS Statistics version 21 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as mean, standard deviation (SD), minimum, maximum, number, and percentage values. Data distribution patterns were evaluated using the Kolmogorov-Smirnov test. Variables showing normal distribution were compared with the independent samples *t*-test, whereas non-parametric variables were analyzed using the Mann-Whitney U test. Normally distributed variables were presented as mean ± standard deviation (SD), while non-normally distributed variables were reported as median and interquartile range (IQR). Categorical data were compared using the chi-square test. Associations between HALP scores and clinical variables were examined through Pearson correlation analysis. Multivariable logistic regression analysis was performed to evaluate the association between the HALP score and erectile dysfunction while adjusting for clinically relevant confounders, including age, smoking status, hypertension, diabetes mellitus, and cardiovascular disease. Receiver operating characteristic (ROC) analysis was performed to evaluate the ability of the HALP score to distinguish between patients with and without erectile dysfunction and to determine an optimal cutoff value. A p-value < 0.05 was considered statistically significant.

3. Results

A total of 137 voluntary participants were included in the study, comprising 84 patients with erectile dysfunction (ED) and 53 controls without ED. Participants with a score of 25 or lower based on their responses to questions 1, 2, 3, 4, 5, and 15 of the IIEF-15 questionnaire were classified as having ED.

Demographic features, comorbidities, IIEF scores, and laboratory parameters of the erectile dysfunction group (Group 1) and the control group (Group 2) are summarized in Table 1. As expected, the IIEF score was significantly lower in the erectile dysfunction group compared to the control group ($p < 0.001$). In Group 1, age and platelet levels were found to be significantly higher. In contrast, hemoglobin, hematocrit, lymphocyte count, albumin level, and HALP score were significantly lower in Group 1. No statistically significant differences were observed between the two groups regarding the other variables presented in Table 1 ($p > 0.05$).

When the correlation analysis between the HALP score and the IIEF erectile function scores of the participants was performed, a significant positive correlation was identified between the IIEF score and the HALP score (Table 2).

Multivariate logistic regression analysis was performed to identify factors associated with erectile dysfunction. The revised model included clinically relevant variables (age, smoking status, hypertension, diabetes mellitus, and cardiovascular disease) together with the HALP score, while excluding the individual components of the HALP score to avoid collinearity. In this model, the HALP score remained significantly associated with erectile dysfunction (OR: 0.82, 95% CI (confidence interval): 0.75–0.89, $p < 0.001$), whereas none of the other variables reached statistical significance (Table 3).

Receiver operating characteristic (ROC) analysis was performed to evaluate the ability of the HALP score to distinguish between patients with and without erectile dysfunction. The area under the curve (AUC) was 0.958 (95% CI: 0.926–0.989, $p < 0.001$). A cutoff value of 73.4 was identified, corresponding to a sensitivity of 85% and a specificity of 96% (Fig. 1). Nevertheless, because both the cutoff threshold and diagnostic performance measures were generated from the same study cohort, these results should be regarded as preliminary and interpreted cautiously.

Correlation analysis was also conducted to examine the association between HALP values and IIEF scores. A strong positive relationship was identified between these parameters (Spearman's $r = 0.81$, $p < 0.001$), indicating that higher HALP scores were associated with better erectile function (Fig. 2).

TABLE 1. Comparison of clinical and laboratory data between the patient and control groups.

	Group 1 (n = 84)	Group 2 (n = 53)	*p*-value
Variables	Median (IQR)	Median (IQR)	
IIEF score	15.5 (8–20)	28 (28–30)	<0.001
Age (yr)	46 (38–57)	42 (28.5–52.5)	0.020
BMI (kg/m^2)	27.17 (25.57–29.90)	26.89 (25.35–28.73)	0.425
Hgb (g/dL)	14.7 (14–15.5)	15.4 (15–16.1)	<0.001
Hct (%)	43.85 (42.12–46.77)	45.7 (44.25–47.65)	0.004
WBC (mcL)	6.94 (6.18–8.52)	7.83 (6.32–9.32)	0.086
Plt (mcL)	262 (223.25–300.50)	211 (196.5–252)	<0.001
Neu (mcL)	4.23 (3.38–5.04)	4.3 (3.36–5.69)	0.540
Lym (mcL)	2 (1.73–2.37)	2.6 (2.11–3.16)	<0.001
FBG (mg/dL)	96 (85–113.75)	89 (83–106)	0.244
HbA1c (%)	5.69 (5.32–6.09)	5.59 (5.19–5.99)	0.187
TG (mg/dL)	143.5 (94.25–221.75)	130 (90.5–177)	0.331
HDL cholesterol (mg/dL)	39.35 (35.42–48.65)	41.8 (35.8–48.8)	0.524
VLDL cholesterol (mg/dL)	29 (18.85–44.35)	26 (18.1–35.4)	0.246
Total Testosterone (ng/dL)	433.35 (365.52–531.38)	413.5 (372–531)	0.952
Total PSA (ng/mL)	0.78 (0.48–1.71)	0.69 (0.46–1.36)	0.558
Albumin (g/L)	46 (42.32–48.17)	47.6 (45.8–49.9)	<0.001
HALP score	54.12 (43.41–64.53)	91.04 (77.90–104.98)	<0.001
Variables	Mean ± SD	Mean ± SD	
LDL (mg/dL)	117.74 ± 35.43	113.91 ± 38.95	0.550
Total cholesterol (mg/dL)	189.84 ± 37.63	186.69 ± 45.22	0.660
Variables	n (%)	n (%)	
Smoking	36 (42.9%)	21 (39.6%)	0.560
Hypertension	13 (15.5%)	3 (5.7%)	0.100
Diabetes mellitus	10 (11.9%)	7 (13.2%)	0.990
Cardiovascular disease	8 (9.5%)	2 (3.8%)	0.310

IIEF: International Index of Erectile Function; IQR: Interquartile range; BMI: Body mass index; Hgb: Hemoglobin; Hct: Hematocrit; WBC: White blood cell; Plt: Platelet; Neu: Neutrophil; Lym: Lymphocyte; FBG: Fasting blood glucose; HbAlc: Glycated hemoglobin; TG: Triglycerides; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low-density lipoprotein; PSA: Prostate Specific Antigen; HALP: hemoglobin, albumin, lymphocyte, and platelet; SD: standard deviation.

TABLE 2. Correlation analysis between the IIEF score and the HALP score in the study participants.

	Pearson correlation coefficient (*r*)	*p*-value
IIEF erectile function score	+0.809	<0.001

IIEF: International Index of Erectile Function.

TABLE 3. Multivariate logistic regression analysis for erectile dysfunction.

Variable	OR (95% CI)	*p* value
Age (yr)	1.06 (0.99–1.13)	0.085
Smoking	0.70 (0.18–2.75)	0.615
Hypertension	22.35 (0.27–1836.94)	0.167
Diabetes mellitus	0.06 (0.00–9639.85)	0.644
Cardiovascular disease	1.50 (0.00–297,938.30)	0.948
HALP score	0.82 (0.75–0.89)	<0.001

OR: Odds ratio; CI: confidence interval; HALP: hemoglobin, albumin, lymphocyte, and platelet.

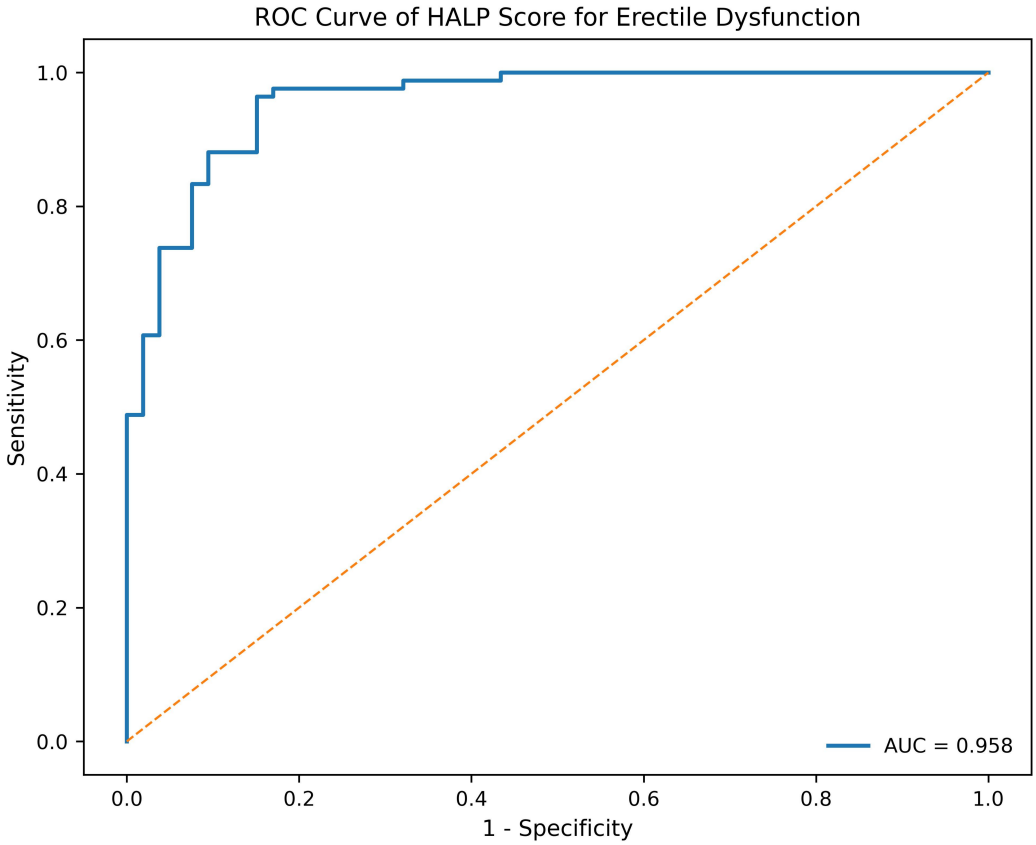

FIGURE 1. ROC curve of the HALP score in patients with erectile dysfunction. ROC: Receiver operating characteristic; HALP: hemoglobin, albumin, lymphocyte, and platelet; AUC: area under the curve.

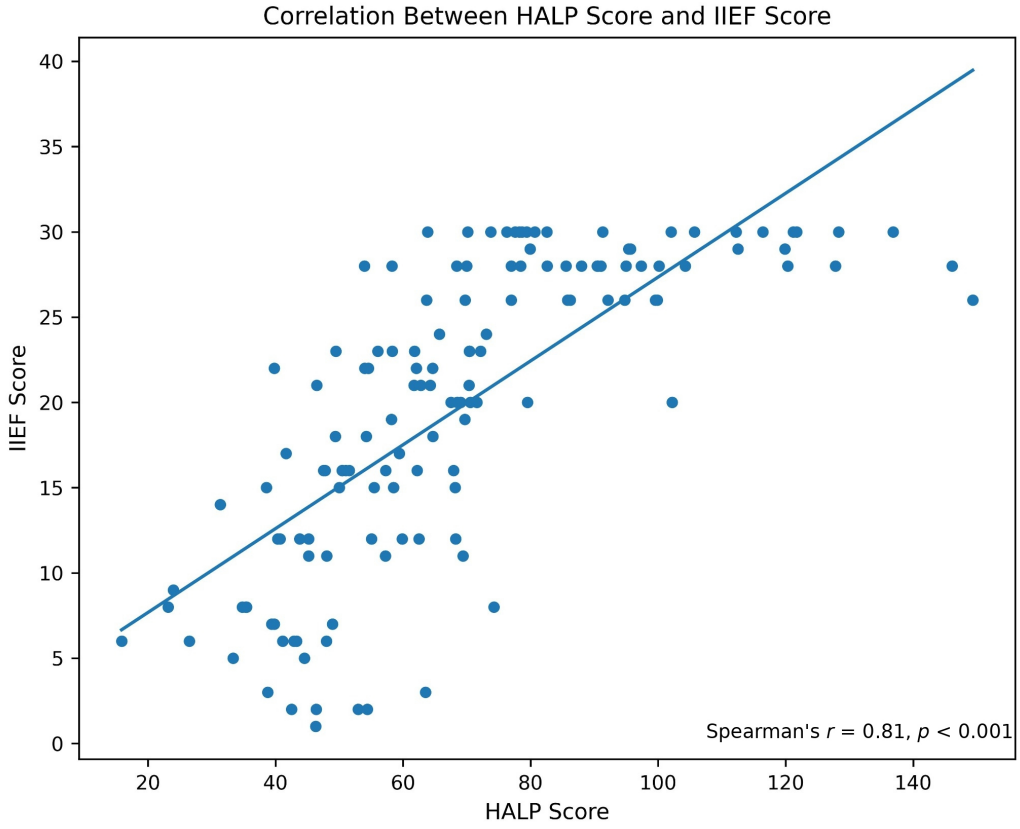

FIGURE 2. Correlation between HALP score and IIEF score. HALP: hemoglobin, albumin, lymphocyte, and platelet; IIEF: International Index of Erectile Function.

4. Discussion

The current study demonstrated a significant relationship between HALP scores and the presence of erectile dysfunction. The markedly lower HALP scores observed in patients diagnosed with ED suggest that the inflammatory, nutritional, and immunological components reflected by this score are closely related to the pathophysiology of ED. Furthermore, the persistence of this association after adjustment for age and other clinically relevant factors in multivariable analysis indicates that the HALP score may have potential value in the clinical evaluation of erectile dysfunction. The significant positive correlation identified between the HALP score and the IIEF erectile function score further supports the notion that low HALP values are associated not only with the presence of ED but also with the degree of erectile function. In addition, ROC analysis provided exploratory information regarding the ability of the HALP score to distinguish between individuals with and without erectile dysfunction. It should be noted that the ROC analysis was conducted within a single dataset without internal or external validation. Therefore, the reported cutoff value and performance estimates may be optimistic and should be interpreted as preliminary findings requiring confirmation in larger and independent cohorts. Taken together, these findings suggest that the HALP score may represent an easily accessible and clinically applicable biomarker associated with the inflammatory and nutritional background of erectile dysfunction.

The association between the HALP score and erectile dysfunction may be interpreted within a broader biological context. The components of the HALP score have been individually linked to inflammatory status, immune function, and metabolic reserve [5, 7]. In this regard, the HALP score may reflect an underlying systemic condition characterized by inflammation and metabolic imbalance, which have been associated with vascular dysfunction and impaired nitric oxide bioavailability in previous studies [14–16]. Nevertheless, endothelial function and inflammatory biomarkers were not directly evaluated in this study; therefore, these interpretations should be regarded as speculative and hypothesis-generating rather than definitive conclusions. Accordingly, the proposed biological links between the HALP score and erectile dysfunction should be interpreted cautiously and within the context of existing literature rather than as direct evidence from the present study. The present study did not investigate the relative diagnostic value of the HALP score compared with its individual laboratory components, which may represent an important area for future investigation.

Although well-established risk factors such as smoking, hypertension, diabetes mellitus, and cardiovascular disease are known to be associated with erectile dysfunction, these variables were not found to be statistically significant in our multivariable analysis. This may be related to the relatively limited sample size, the specific characteristics of the study population, and the potential overlap between these clinical factors and the components of the HALP score.

In our study, the finding of higher platelet levels and lower lymphocyte and albumin levels in the ED group is consistent with the concept that erectile dysfunction develops on a systemic vascular and inflammatory background rather than being merely a localized condition [5–7]. An increase in platelet count may represent part of a broader biological spectrum reflecting platelet activation and a prothrombotic tendency; particularly when considered together with endothelial dysfunction at the microvascular level, this may indicate an environment that could contribute to impaired perfusion and vascular responsiveness in penile tissue [6, 7]. On the other hand, the relative decrease in lymphocyte count accompanied by elevated platelet levels suggests a disruption of the inflammatory balance that may be associated with ED through the hematological manifestations of systemic inflammation. Indeed, findings in the literature demonstrating associations between ED presence and/or severity and hematological ratios such as the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) provide a framework that is consistent with our results [8, 9]. The higher albumin levels observed in the control group further suggest a more pronounced inflammatory and metabolic stress state in the ED group, given that albumin, as a negative acute-phase reactant, conveys indirect information regarding inflammatory burden and metabolic reserve [17]. Similarly, studies linking ED and inflammation have shown that composite markers such as the C-reactive protein-to-albumin ratio are independently associated with ED, providing additional evidence supporting the relevance of albumin in this context [10]. Therefore, rather than interpreting differences in platelet, lymphocyte, and albumin levels as independent mechanisms, it appears more appropriate to consider the combined components of the HALP score as a holistic reflection of the inflammatory and vascular milieu in which erectile dysfunction develops.

In the existing literature, the clinical significance of the HALP score has predominantly been evaluated in the context of oncological and metabolic diseases, and this score has been shown to represent a comprehensive biomarker reflecting systemic inflammation, immune status, and metabolic reserve [11–13]. Evidence from large-scale population cohorts showing relationships between HALP values and both cardiovascular and overall mortality further highlights the potential connection of this index with vascular integrity and metabolic status [12]. Considering that erectile dysfunction similarly represents an early clinical manifestation of systemic vascular and inflammatory processes, the association between the HALP score and ED appears biologically plausible [5, 6, 17]. In line with this perspective, a recent large population-based analysis derived from the National Health and Nutrition Examination Survey (NHANES) 2001–2004 dataset demonstrated that lower HALP scores were associated with a higher likelihood of self-reported erectile dysfunction [18]. However, the reliance on simplified questionnaire responses for ED assessment and the absence of clinically validated erectile function scales in that study limit the direct generalizability of its findings to routine urological practice. In contrast, in the present study, erectile dysfunction was assessed in patients presenting to a urology outpatient clinic using the widely accepted and clinically validated International Index of Erectile Function (IIEF-15) questionnaire, allowing the evaluation of its association with the HALP score. Moreover, the identification of the HALP score as an independently associated factor in multivariable analyses and the confirmation of its discrimi-

native ability through ROC analysis place the clinical utility of this biomarker on a stronger and more practical foundation compared with previous population-based studies.

While previous studies, particularly those based on large population datasets such as NHANES, have explored the association between the HALP score and erectile dysfunction, the present study differs in several important aspects [18]. First, our study was conducted in a clinical population presenting to a urology outpatient clinic, which may better reflect real-life clinical practice. Second, erectile dysfunction was assessed using the validated International Index of Erectile Function (IIEF-15) questionnaire, rather than self-reported single-question assessments. Therefore, our findings provide complementary evidence by evaluating the association between the HALP score and erectile dysfunction in a more clinically characterized population.

The findings of our study suggest that the HALP score may have clinical relevance as a complementary biomarker reflecting the systemic inflammatory and metabolic background accompanying erectile dysfunction, rather than serving as a direct diagnostic tool for ED. The fact that the parameters constituting the HALP score can be easily obtained from routine laboratory tests allows this index to be calculated without additional cost or invasive procedures. Moreover, the significant correlation observed between the HALP score and the IIEF erectile function score may indicate that this index is associated not only with the presence of ED but also with the level of erectile function. Particularly in cases with low HALP scores, erectile dysfunction should be considered as part of a broader metabolic and inflammatory disturbance rather than an isolated symptom. Nevertheless, the HALP score should be regarded as a supportive biomarker in the evaluation of ED and should not be interpreted as a diagnostic tool that replaces vascular imaging or physiological testing.

Certain limitations of the present study should be considered. Most importantly, the cross-sectional nature of the study prevents any definitive conclusions regarding a causal relationship between HALP scores and ED. In addition, the control group consisted of individuals presenting to the urology outpatient clinic for reasons other than erectile dysfunction, rather than a completely healthy population. Therefore, these individuals may have had underlying inflammatory or metabolic conditions, which could have influenced the HALP score and potentially reduced the observed difference between the groups.

In addition, erectile function was assessed using the International Index of Erectile Function (IIEF), a clinically validated questionnaire widely used in clinical practice, without support from vascular imaging methods or physiological tests. Furthermore, subclinical inflammatory conditions and recent infections were not systematically assessed, and detailed medication histories, including the use of drugs that may affect hematological parameters (such as antiplatelet agents), were not recorded. These variables may have affected HALP measurements and should therefore be taken into account during interpretation of the findings. Nevertheless, this approach allows the study to reflect a clinical practice setting within a urology outpatient population. Although we adjusted for major clinical confounders such as age, smoking status, hypertension, diabetes mellitus, and cardiovascular disease in the multivariable analysis, residual confounding cannot be completely excluded due to the observational cross-sectional design of the study. Therefore, the observed association between the HALP score and erectile dysfunction should be interpreted with caution.

In addition, the relationship between the HALP score and different severity categories of erectile dysfunction was not evaluated. In our dataset, the HALP score did not demonstrate a consistent or monotonic trend across erectile dysfunction severity categories; therefore, erectile dysfunction was analyzed as a binary variable (presence *vs.* absence). Future studies with larger sample sizes may further explore this relationship in more detail. Furthermore, the etiological classification of erectile dysfunction (*e.g.*, psychogenic *vs.* organic) was not specifically evaluated in this study. Given that younger patients were also included, it is possible that a proportion of participants had psychogenic erectile dysfunction. This heterogeneity in ED etiology may have influenced the observed associations, particularly considering that the HALP score is more closely related to systemic inflammatory and metabolic conditions.

In addition, nutritional status was assessed only using body mass index (BMI), without more detailed evaluations such as waist circumference, recent weight changes, or specific nutritional assessments. Therefore, the HALP score in this study may reflect overall health status rather than a specific pathophysiological mechanism related to erectile dysfunction.

Moreover, the modest sample size may have reduced the statistical strength of the analyses and contributed to potential overfitting in the multivariable models. For this reason, the reliability of the regression estimates should be interpreted carefully and confirmed in studies with larger patient populations.

Additionally, advanced modeling approaches such as restricted cubic spline analysis were not performed due to the relatively limited sample size. In the initial analyses, some regression estimates showed wide confidence intervals, suggesting potential model instability. However, this issue was addressed by revising the multivariable model to reduce collinearity and improve interpretability. Despite these refinements, the findings should be evaluated carefully, and future investigations involving larger populations, advanced analytical approaches, and independent model validation are necessary.

In addition, the performance of the full multivariable model was not formally assessed using calibration or global fit measures. Therefore, although the ROC analysis of the HALP score alone provided exploratory information, the overall predictive performance of the multivariable model and the incremental contribution of HALP beyond the included clinical variables could not be fully determined.

Furthermore, the study population consisted of patients presenting to a urology outpatient clinic, which may limit the generalizability of the findings to the broader population. In addition, the findings of this study were not validated in an independent external cohort. Accordingly, caution is required when interpreting the external applicability and reliability of these findings, and larger studies incorporating independent validation cohorts are needed.

On the other hand, the strengths of the study include its con-

duct in a clinical population presenting to a urology outpatient clinic and the evaluation of erectile function using a validated questionnaire (IIEF-15). In addition, the HALP score was analyzed within a multivariable framework, allowing assessment of its association with erectile dysfunction in the context of clinically relevant variables.

5. Conclusions

In this study, the HALP score was shown to be significantly associated with the presence of erectile dysfunction and the level of erectile function. Our findings obtained from a clinical population suggest that the HALP score may represent a complementary biomarker reflecting the inflammatory and metabolic background accompanying ED and can be easily calculated from routine laboratory parameters. However, the HALP score should be considered not as a diagnostic test but as a supportive tool in the comprehensive evaluation of patients with erectile dysfunction. Further well-designed longitudinal and mechanism-based studies are required for these findings to be translated into clinical practice.

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

SZ and AG—designed the research study. SZ, AG and CB—performed the research. AG and AO—analyzed the data. All authors wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Clinical Research Ethics Committee of the University of Health Sciences Bursa Yüksek İhtisas Training and Research Hospital (Approval No: 2024-TBEK 2024/02-12). All study procedures were conducted in compliance with the ethical principles established by the institutional and national research committees, as well as the Declaration of Helsinki and its subsequent revisions. All participants were informed about the study, and written informed consent was obtained from each individual.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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