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Neutrophil–Lymphocyte Ratio Reflects Inflammation-Related Hypoalbuminemia Rather Than Body Composition Phenotype in Hospitalized Adults

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ABSTRACT:

Introduction: The neutrophil-lymphocyte ratio (NLR) is a simple inflammatory biomarker with potential applications in nutritional assessment. However, its relationship with both visceral proteins and body-composition phenotypes in heterogenous hospitalized populations is unclear.

Objectives: To examine the associations between NLR and serum albumin and to determine whether NLR predicts a low-muscle body-composition phenotype measured by bioelectrical impedance analysis (BIA).

Methods: Cross-sectional study of 120 adults admitted to Hasanuddin University Hospital (median age 44 years; 55% female). NLR was calculated from admission complete blood counts. Physique rating was measured by bioelectrical impedance (Tanita BC-730). Serum albumin was available for 104 patients. We used Spearman correlation and multivariable linear regression adjusted for age, sex, and primary diagnosis to examine associations with albumin; logistic regression tested whether log-transformed NLR predicted a BIA-defined low-muscle phenotype.

Results: Median NLR was 3.75 (IQR 1.92–7.28). Median serum albumin was 34 g/L (IQR 26.3–38.0 g/L); 51% had hypoalbuminemia. NLR correlated negatively with albumin (rho = −0.359, $p < 0.001$). In adjusted regression, each one-unit NLR increase was associated with a −0.42 g/L change in albumin ($p = 0.001$). NLR did not differ between physique rating groups, and log-NLR did not predict low-muscle phenotype.

Conclusions: In hospitalized adults, elevated NLR is independently associated with lower serum albumin levels but was not associated with a BIA-defined low-muscle phenotype after adjustment. These findings suggest that NLR primarily reflects acute inflammation-related nutritional alterations rather than chronic body-composition phenotypes in hospitalized adults.

1. Introduction

Malnutrition affects 30–50% of hospitalized patients worldwide and is associated with increased complications, prolonged hospital stays, and higher mortality rates [1]. The pathophysiology of disease-related malnutrition extends beyond simple caloric deficiency, involving complex interactions between systemic inflammation, metabolic alterations, and nutritional depletion [2]. Identifying patients at nutritional risk early in their hospital course remains a clinical priority, yet conventional nutritional assessment tools can be resource-intensive and time-consuming, particularly in settings with limited healthcare resources [3].

The neutrophil-lymphocyte ratio (NLR), calculated as the ratio of absolute neutrophil count to absolute lymphocyte count from routine complete blood counts, has emerged as a simple, cost-effective biomarker of systemic inflammation [4,5]. Initially utilized in cardiovascular and oncological contexts, NLR has garnered increasing attention in nutritional medicine due to its reflection of both innate immunity (neutrophil

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response) and adaptive immunity (lymphocyte function) [6]. Elevated NLR indicates a pro-inflammatory state characterized by neutrophilia and/or lymphopenia, both hallmarks of stress responses and chronic disease [7,8].

Serum albumin, the most abundant plasma protein synthesized by the liver, serves dual roles as a nutritional marker and an negative acute-phase reactant [1]. While hypoalbuminemia has traditionally been interpreted as a sign of protein-energy malnutrition, contemporary understanding recognizes that albumin levels are profoundly influenced by inflammatory processes through hepatic reprioritization, whereby pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) suppress albumin synthesis while upregulating positive acute-phase proteins [2,3]. This inflammation-driven hypoalbuminemia represents a critical intersection between metabolic stress and nutritional status, making the relationship between NLR and albumin of particular clinical interest.

Beyond biochemical markers, body composition assessment provides essential insights into nutritional status that cannot be captured by body mass index (BMI) alone [12]. The concept of physique rating, a classification system that integrates body fat percentage and skeletal muscle mass measured by bioelectrical impedance analysis (BIA), enables identification of distinct body composition phenotypes ranging from overfat/obese to underfat/lean states [13]. This approach can detect conditions such as sarcopenic obesity (high fat, low muscle) or hidden obesity (normal BMI but excess fat with low muscle), both of which are associated with adverse metabolic and clinical outcomes [14]. The Global Leadership Initiative on Malnutrition (GLIM) criteria emphasize body composition assessment, particularly muscle mass evaluation, as a phenotypic criterion for malnutrition diagnosis [12,15].

Systemic inflammation is known to drive unfavorable changes in body composition through multiple mechanisms. Chronic elevation of pro-inflammatory cytokines activates catabolic pathways, including the ubiquitin-proteasome system, leading to accelerated muscle protein breakdown and suppressed muscle protein synthesis [16,17]. Concurrently, inflammation promotes insulin resistance and metabolic dysfunction that favour ectopic fat deposition, including visceral and intramuscular fat accumulation [18]. This dual process culminates in sarcopenic obesity—a phenotype particularly detrimental to metabolic health and functional capacity[19].

Several studies have documented associations between NLR and nutritional parameters in specific populations. In geriatric inpatients, NLR ≥4.5 predicted malnutrition with 85.2% specificity [20]. Among cancer patients, the combination of albumin and NLR (Albumin/Neutrophil-to-Lymphocyte Ratio Score) demonstrated superior prognostic accuracy compared to either parameter alone [21] . Research at Wahidin Sudirohusodo Hospital, Makassar, showed that NLR, combined with CRP-albumin ratio, significantly predicted ICU mortality [3]. However, most existing evidence derives from specialized populations (geriatric, oncologic, critical care), while data from general medical wards with heterogeneous diagnoses remain limited.

Furthermore, few studies have simultaneously examined NLR relationships with both visceral protein status (albumin) and body composition phenotypes (physique rating) within a single cohort. Understanding these multidimensional relationships is essential for developing integrated nutritional screening algorithms that leverage readily available hematologic biomarkers alongside anthropometric assessments.

2. Objectives

This study aimed to investigate the associations between NLR and two key nutritional parameters—serum albumin and physique rating—in a diverse cohort of hospitalized adults at a tertiary referral centre in Indonesia. We hypothesized that elevated NLR would correlate negatively with albumin levels (reflecting inflammation-driven protein depletion) and positively with alterations in physique rating (reflecting inflammation-associated compositional changes). Identifying these relationships could support the development of cost-effective, laboratory-integrated nutritional screening strategies suitable for resource-limited healthcare settings.

3. Methods

Study Design and Setting

This cross-sectional observational study was conducted at Hasanuddin University Hospital, a tertiary referral

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centre in Makassar, Indonesia, between August and October 2024.

Participants

Consecutive adult patients admitted to general medical wards were screened for eligibility. Inclusion criteria were: (1) age ≥18 years; (2) anticipated hospital stay ≥3 days; (3) alert and oriented mental status; (4) oral feeding capacity; and (5) provision of written informed consent. Exclusion criteria included: (1) surgical or critically ill patients; (2) pregnancy; (3) psychiatric disorders; (4) primary hematologic malignancies (e.g., leukemia, lymphoma); (5) immunosuppressive therapy or high-dose corticosteroids within the preceding two weeks; and (6) severe liver failure. These exclusions aimed to minimize confounding from conditions that directly alter leukocyte counts or hepatic albumin synthesis independent of general inflammatory-nutritional status.

Data Collection and Measurements

Demographic and Clinical Variables

Demographic data (age, sex, education, marital status, occupation) and clinical information (primary diagnosis, comorbidities, smoking history, hospital length of stay) were extracted from medical records. Primary diagnoses were categorized according to major disease groups: oncology/ neoplasms, infectious diseases, renal/ urological disorders, ear-nose-throat/ head and neck conditions, endocrine/ metabolic diseases, gynecology/ obstetrics, and others.

Laboratory Measurements

Venous blood samples were collected at hospital admission for routine complete blood count analysis. NLR was calculated as the ratio of absolute neutrophil count to absolute lymphocyte count. Total lymphocyte count (TLC) and hemoglobin levels were also recorded. Serum albumin (g/L) was measured using the bromocresol green (BCG) method as per hospital laboratory standard protocol. Albumin was treated as a continuous variable for all inferential analyses, including correlation and multivariable linear regression models. For descriptive purposes only, hypoalbuminemia was defined as albumin < 35 g/L according to established clinical thresholds [9]. NLR showed a right-skewed distribution. For linear regression models examining serum albumin, the untransformed NLR provided approximately normally distributed residuals and was therefore retained for clinical interpretability. For logistic regression analyses evaluating the association with physique rating phenotype, log-transformed NLR was used to improve model fit and satisfy the assumption of linearity between the predictor and the logit of the outcome.

Physique Rating Assessment

Physique rating was assessed by single-frequency bioelectrical impedance analysis (BIA) using the TANITA BC-730 device and scored according to the manufacturer's protocol. The device generates a nine-level "physique rating" score that integrates percent body fat and muscle mass to classify body composition into nine categorical profiles (1 = hidden obese; 2 = obese; 3 = solidly built; 4 = under-exercised; 5 = standard; 6 = standard muscular; 7 = thin; 8 = thin and muscular; 9 = very muscular).

For analytic purposes the physique rating scores were dichotomized a priori into a low-muscle phenotype (scores 1, 4 and 7, characterised by low muscle mass across varying fat levels) and a normal phenotype (scores 2, 3, 5, 6, 8 and 9).

Physique rating derived from bioelectrical impedance analysis reflects the combined profile of muscle mass and body fat percentage. For analytic purposes, scores representing relatively lower muscle phenotype were grouped and compared with scores representing normal muscle phenotype, consistent with the manufacturer's classification framework. This classification was used as a pragmatic body-composition phenotype rather than a diagnostic definition of sarcopenia.

Functional Assessment

Functional assessment included measurement of handgrip strength using a CAMRY EH101 digital dynamometer (Lafayette Instrument Company, USA) with patients seated in a standardized position, and the highest value from three attempts with the dominant hand was recorded.

Dietary Intake

Dietary intake was estimated by trained nutritionists via a 24-hour dietary recall to calculate energy, protein, carbohydrate, and fat intake using Indonesian food composition tables.

Malnutrition Assessment

Nutritional status was determined using the Global Leadership Initiative on Malnutrition (GLIM) criteria,

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which require at least one phenotypic criterion (unintentional weight loss, low BMI, or reduced muscle mass) and one etiologic criterion (reduced food intake/assimilation or disease burden/inflammation) [12], and patients were classified as either well-nourished or malnourished (moderate and severe combined)

Ethical Considerations

Demographic data (age, sex, education Participants received detailed information on study objectives, procedures, and potential benefits prior to enrolment. Written informed consent was obtained from all participants before data collection. Participant confidentiality was maintained throughout the study. The study received ethical approval from the Medical and Health Research Ethics Committee (approval number: KE/FK/0963/EC/2024).

Statistical Analysis

Statistical analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for distribution using visual inspection (histogram and Q–Q plot) and summarized as mean ± standard deviation or median (interquartile range) as appropriate. Categorical variables were presented as frequencies and percentages. Correlations between neutrophil–lymphocyte ratio (NLR) and serum albumin were assessed using Spearman's rank correlation coefficient due to non-normal distribution of NLR. Multivariable linear regression was conducted to evaluate the association between NLR and serum albumin levels. NLR was retained in its original scale in the linear model because residual diagnostics demonstrated acceptable model assumptions and allowed clinically interpretable effect estimates.

For logistic regression analyses examining the association between NLR and low-muscle physique rating, log-transformed NLR was used to improve model fit and to satisfy the assumption of linearity between the predictor and the logit of the outcome. Models were adjusted for clinically relevant covariates, including age, sex, and primary diagnosis. Regression assumptions were evaluated through residual analysis and multicollinearity diagnostics. A two-sided p-value <0.05 was considered statistically significant.

4. Results

A total of 120 hospitalized adults were enrolled in this study. Demographic and clinical characteristics are summarized in Table 1. The median age was 44 years (IQR 29.2–55.7, range 18–88 years), reflecting a diverse adult population. Females comprised 55.0% (n = 66) of the cohort. Educational attainment was relatively high, with 76.7% having completed at least secondary education. Approximately half of the participants (52.5%) were unemployed, and 64.2% were married.

Oncology/neoplastic diseases represented the most common primary diagnosis category (34.2%), followed by infectious diseases (15.8%) and renal/urological conditions (15.0%). Comorbidities were present in 35.8% of patients, and 24.2% reported current or former smoking. The majority (81.7%) had hospital stays of 1–5 days, classified as short-term hospitalization.

Nutritional, Anthropometric, and Laboratory Parameters

Nutritional and body composition characteristics are presented in Table 2. According to GLIM criteria, 47.5% (n = 57) of patients were diagnosed with malnutrition (moderate or severe combined). Mean BMI was 22.13 ± 4.07 kg/m^2, falling within the normal range for Asian populations. However, physique rating distribution revealed substantial heterogeneity: 67.5% had normal/standard composition while 32.5% were classified as low muscle composition. Among individual physique rating types, type 5 (standard) was most prevalent (35.0%), followed by type 4 (under-exercised, 25.8%). Mean handgrip strength was 15.5 ± 6.53 kg, indicating reduced muscle function in this hospitalized population.

Dietary intake data showed median energy consumption of 4,642 kJ (1,109.5 kcal) (IQR 2,965–6,064 kJ; 708.7–1,449.2 kcal) and median protein intake of 42.3 g (IQR 24-51.9 g), both substantially below recommended levels for hospitalized adults, suggesting inadequate nutritional intake across the cohort.

Hematologic and biochemical parameters are also shown in Table 2. Median NLR was 3.75 (IQR 1.92-7.28). Among 104 patients with available albumin data, median serum albumin was 34 g/L (IQR 26.3 - 38.0 g/L), and 51.0% had hypoalbuminemia (< 35 g/L). Median total lymphocyte count was 1.735 × 10^9/L (IQR 1.082 -2.453).

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Mean hemoglobin was 119.3 ± 32.1 g/L, indicating mild anemia in this cohort.

Association Between NLR and Serum Albumin

Among the 104 patients with available albumin measurements, Spearman correlation analysis revealed a moderate negative correlation between NLR and serum albumin ($r = -0.359$, $p < 0.001$), indicating that higher NLR values were associated with lower albumin levels (Figure 1). This relationship remained statistically significant after multivariable linear regression adjustment for age, sex, and primary diagnosis category (B= -0.042, SE= 0.013, p= 0.001), demonstrating that each one-unit increase in NLR was independently associated with a 0.42 g/L decrease in serum albumin (Table 3).

Table 1. Demographic and Clinical Characteristics of Hospitalized Adults

Characteristics	Total (N = 120)
Age (year)	44 (29.2-55.7)
Sex	
Male	54 (45.0)
Female	66 (55.0)
Education Level	
No. formal education	4 (3.3)
Primary school	16 (13.3)
Junior high school	8 (6.7)
Senior high school	60 (50.0)
Higher education	32 (26.7)
Marital Status	
Single	34 (28.3)
Married	77 (64.2)
Widowed/divorced	9 (7.5)
Employment Status	
Employed	57 (47.5)
Unemployed	63 (52.5)
Primary Diagnosis	
Oncology/neoplasms	41 (34.2)
Infectious diseases	19 (15.8)
Renal/Urology	18 (15.0)
ENT/ Head & Neck	11 (9.1)
Endocrine/Metabolic	8 (6.7)
Gynecology/Obstetrics	6 (5.0)
Others	9 (7.5)
Comorbidities	
Yes	43 (35.8)
No	77 (64.2)
Smoking status	
Yes	29 (24.2)
No	91 (75.8)
Length of hospital stay	
≤ 5 days	98 (81.7)
> 5 days	22 (18.3)

Notes: Values are presented as median (IQR) for non-normally distributed continuous variables and number (percentage) for categorical variables. Abbreviations: IQR, interquartile range; n, number.

Association Between NLR and Physique Rating

Median Neutrophil–Lymphocyte Ratio (NLR) did not differ significantly between patients classified as low muscle (n = 39) and those with a normal physique rating (n = 81). The median NLR was 4.50 (IQR 2.39–6.79) in the low-muscle group and 3.56 (IQR 1.77–7.52) in the normal group; the Mann–Whitney U test yielded p = 0.394, indicating no statistically significant difference (Table 4).

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In multivariable logistic regression evaluating the odds of being classified as low muscle, log-transformed NLR was not a significant predictor after adjustment for covariates. In the initial model (NLR [log], age, sex, oncologic diagnosis) no variable reached statistical significance; in the final adjusted model the association between NLR (log) and low-muscle phenotype remained non-significant (adjusted OR 1.19, 95% CI 0.79–1.79, p = 0.405).

Table 2. Nutritional Status, Body Composition, Dietary Intake, and Laboratory Parameters

Variables	Total (N = 120)
Nutritional Status (GLIM)	
Well-nourished	63 (52.5)
Malnourished (moderate & severe)	57 (47.5)
Physique rating score	
Score 1	0 (0.0)
Score 2	12 (10.0)
Score 3	13 (10.8)
Score 4	31 (25.8)
Score 5	42 (35.0)
Score 6	1 (0.8)
Score 7	8 (6.7)
Score 8	6 (5.0)
Score 9	7 (5.8)
Physique rating category	
Low muscle	39 (32.5)
Normal (Standard + High)	81 (67.5)
BMI (kg/m^2)	22.13 ± 4.07
Handgrip Strength (kg)	15.5 ± 6.53
24-hour dietary recall	
Energy kJ (kcal)	4,642 kJ (1,109.5 kcal) (IQR 2,965–6,064 kJ; 708.7–1,449.2 kcal)
Protein (g)	42.3 (24,-51.9)
Carbohydrate (g)	187.1 ± 87.14
Fat (g)	15.9 (9.5-23.6)
Laboratory parameters	
NLR	3.75 (1.92-7.28)
Serum Albumin (g/L), n = 104	34.0 (26.3 – 38.0)
TLC **(**10^9 cells/L**)**	1.735 (1.082 – 2.453)
Hemoglobin (g/L)	119.3 ± 32.1
Albumin category (n = 104)	
Normal	51 (49.0)
Low	53 (51.0)

Notes: Values are presented as median (IQR) for non-normally distributed continuous variables and number (percentage) for categorical variables. Abbreviations: IQR, interquartile range (Q1, Q3); n, number; TLC, total lymphocyte count, BMI: body mass index

Table 3. Multivariable linear regression: association between NLR and serum albumin (n=104)

Variables	B	Std. Error	β	95% CI	p-value
Intercept	3.421	0.116	–	3.194 to 3.648	<0.001
Neutrophil–lymphocyte ratio	–0.042	0.013	–0.312	–0.067 to –0.017	0.001

Dependent variable**:** serum albumin (g/L). Model adjusted for age, sex, and primary diagnosis.

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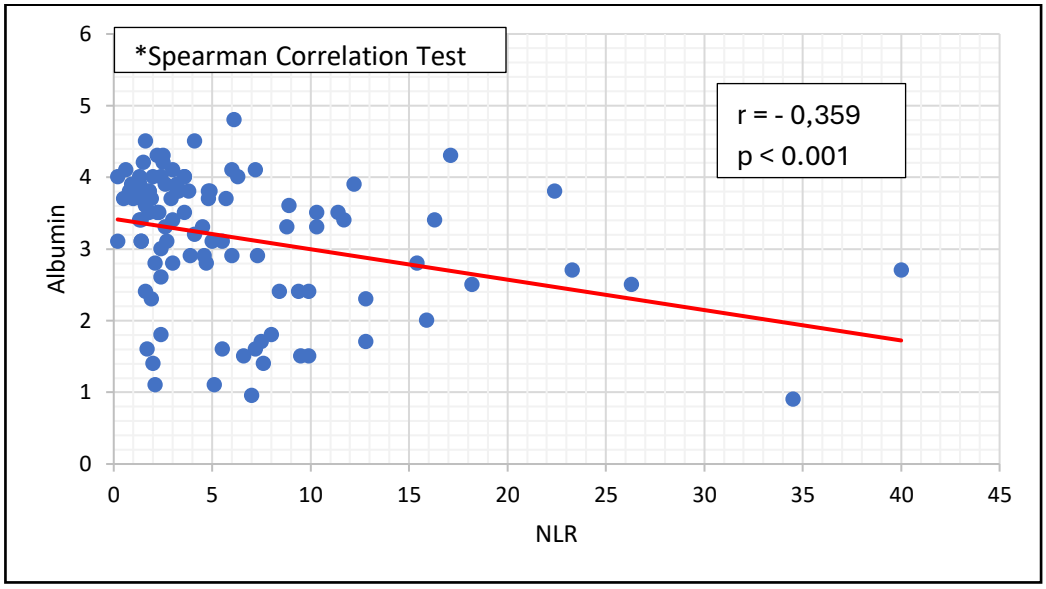

Notes: Dots represent individual NLR values and the line indicates the linear regression fit.

Figure 1. Correlation between Neutrophil–Lymphocyte Ratio (NLR) and Serum Albumin Levels in Hospitalized Patients (n = 104)

Table 4. Association Between Neutrophil–Lymphocyte Ratio (NLR) and Physique Rating Categories

Physique Rating	n	Median (IQR, Q1-Q3)	p-value
Low muscle	39	4.50 (2.39-6.79)	0.394*
Normal	81	3.56 (1.77-7.52)	

*Mann-Whitney Test

Table 5. Logistic Regression Analysis of the Association Between NLR and Physique Rating

Variables	Adjusted Odds Ratio (95% CI)	p-value
Intercept	0.74 (0.23 - 2.40)	0.610
Age	0.98 (0.96 -1.01)	0.205
Neutrophil–lymphocyte ratio	1.19 (0.79 - 1.79)	0.405

5. Discussion

This cross-sectional study of 120 hospitalized adults at a tertiary referral centre in Indonesia demonstrates that neutrophil-lymphocyte ratio (NLR) is independently associated with serum albumin levels, but not with BIA-derived body composition phenotype. Specifically, we found a moderate negative correlation between NLR and albumin ($r = -0.359$, $p < 0.001$), indicating that elevated systemic inflammation is associated with lower visceral protein status.

The inverse relationship between NLR and albumin observed in our cohort aligns with the pathophysiological understanding of inflammation-driven hypoalbuminemia. Elevated NLR reflects systemic inflammation characterized by neutrophilia (driven by granulocyte colony-stimulating factor and pro-

NLR did not discriminate patients with a BIA-defined low-muscle phenotype. Median NLR values were similar between the low-muscle and normal physique rating groups ($p = 0.394$), and multivariable logistic regression showed no significant association between log-transformed NLR and the low-muscle phenotype (adjusted OR 1.19; 95% CI 0.79–1.79; $p = 0.405$). These results indicate that a single cross-sectional NLR measurement should not be interpreted as a surrogate for BIA-derived low muscle mass in a heterogeneous inpatient population.

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inflammatory cytokines) and/or lymphopenia (resulting from lymphocyte redistribution and stress-induced apoptosis) [6,22]. This inflammatory milieu is mediated by cytokines such as IL-6, TNF-α, and IL-1β, which exert profound effects on hepatic protein synthesis[10,23].

The phenomenon of hepatic reprioritization whereby inflammatory signals suppress albumin synthesis while upregulating acute-phase proteins like CRP and fibrinogen explains the albumin reduction in inflamed states [11,24]. Additionally, inflammation increases vascular permeability, leading to albumin redistribution from the intravascular to interstitial compartments, and accelerates albumin catabolism [9]. Our finding that each unit increase in NLR corresponds to a 0.42 g/L decrease in albumin quantifies this relationship and suggests that even modest elevations in inflammatory biomarkers can have clinically meaningful effects on protein status.

Our results are consistent with previous studies demonstrating NLR-albumin correlations in various clinical contexts. Kaya et al. reported a similar negative correlation ($r = -0.42$, $p < 0.001$) in geriatric inpatients [25]. Sue et al. showed that albumin < 38 g/L modified the prognostic value of NLR in cancer patients receiving immunotherapy [26]. In our heterogeneous hospitalized population, the correlation was strongest in oncology and infectious disease patients, likely reflecting the higher inflammatory burden characteristic of these conditions.

Hypoalbuminemia (< 35 g/L) affected 51% of our cohort and is a well-established predictor of adverse clinical outcomes including increased complications, prolonged hospitalization, and mortality [27]. While albumin's utility as a pure nutritional marker is debated due to its status as a negative acute-phase protein, its prognostic value remains robust [11]. The integration of NLR, a parameter readily available from routine complete blood counts with albumin assessment could enhance early identification of patients at high risk for poor outcomes, enabling timely nutritional and medical interventions.

In this study, both univariate and multivariable analyses failed to demonstrate a statistically significant association between the Neutrophil–Lymphocyte Ratio (NLR) and the "low muscle" phenotype as assessed by the Tanita physique rating system. Specifically, the median NLR did not differ significantly between patients categorized as having "low muscle" and those with a "normal" phenotype ($p = 0.394$). Furthermore, after adjusting for potential confounders such as age and primary diagnosis in the final regression model, the NLR remained a non-significant predictor of physique rating (Adjusted OR 1.19; 95% CI 0.79–1.79; $p = 0.405$).

These results suggest that a single, cross-sectional measurement of NLR lacks the necessary sensitivity and specificity to serve as a reliable surrogate marker for muscle-related body composition phenotypes in a heterogeneous inpatient population,. Biologically, while NLR is a recognized indicator of systemic inflammation, it is highly non-specific and can be acutely altered by various factors including infection, acute stress, and medications. Such acute variability likely attenuates or obscures any potential relationship with chronic changes in muscle mass[6,7]. Taken together, our results support the concept that NLR functions as a dynamic inflammatory–nutritional marker reflecting short-term metabolic stress rather than long-term changes in muscle-related body composition.

Furthermore, the nature of the assessment tool must be considered. Physique rating is a classification of body types based on the relative ratio of body fat to skeletal muscle mass, rather than a direct quantitative measure of absolute muscle mass [15]. Consequently, systemic inflammatory signals reflected by an elevated NLR may not be sensitive enough to differentiate between the specific "low muscle" and "normal" categories within this classification framework, especially in a population with a diverse spectrum of clinical diagnoses. While NLR remains a relevant indicator of systemic inflammation, these findings indicate it cannot currently be used to predict body composition phenotypes as defined by physique rating in a general hospital setting. Inflammation is just one of many determinants of body composition. Genetic factors, dietary intake, physical activity, hormonal status, comorbidities, and medications also play crucial roles [28]. Furthermore, BIA-derived physique rating has limitations in acutely ill populations due to potential hydration status alterations that affect impedance measurements [29].

The findings of this study have several practical implications for clinical nutritional management.

Integrated Screening. NLR, routinely available from complete blood counts, can complement conventional

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nutritional screening tools. Patients with elevated NLR should prompt heightened awareness of potential hypoalbuminemia.

Risk Stratification. The combination of high NLR and low albumin identifies a particularly high-risk phenotype characterized by inflammation-driven protein depletion. Such patients may benefit from aggressive nutritional support incorporating anti-inflammatory strategies (e.g., omega-3 fatty acids, antioxidants) alongside traditional protein-calorie supplementation [30,31].

Resource optimization. In resource-limited settings where advanced nutritional assessment tools (e.g., DXA, CT imaging for muscle mass) are unavailable, leveraging readily accessible biomarkers like NLR and albumin from routine laboratory panels can facilitate timely identification of at-risk patients without additional costs; and 4) monitoring Response: Serial NLR measurements alongside albumin and body composition reassessment could monitor responses to nutritional interventions, with declining NLR potentially indicating reduced inflammatory burden and improved metabolic status.

Our findings contribute to the growing body of evidence linking inflammatory biomarkers with nutritional parameters. Avci et al. demonstrated that NLR ≥4.5 predicted malnutrition in geriatric inpatients with 85.2% specificity [24], supporting NLR thresholds around 4–5 as clinically relevant. In our cohort, median NLR was 3.75, with 58.3% exceeding normal ranges, consistent with the high inflammatory burden in hospitalized populations.

Studies integrating NLR with albumin have shown enhanced prognostic accuracy. Hsueh et al. developed an Albumin/NLR Score (ANS) that outperformed either parameter alone in predicting treatment completion in esophageal cancer patients [21]. Similarly, the CRP-albumin ratio combined with NLR predicted ICU mortality in a local Indonesian cohort [5]. Our study extends these findings to general medical inpatients, demonstrating that NLR-albumin relationships are robust across diverse diagnostic categories. Few published studies have examined NLR in relation to body-composition phenotypes outside disease-specific cohorts (e.g., cancer, cirrhosis) [32]. In our heterogeneous inpatient sample, we found no significant difference in NLR between BIA-defined low-muscle and normal phenotype groups overall. These observations therefore remain hypothesis-generating and require confirmation in larger, prospective cohorts with validated muscle-mass measures.

The dissociation between albumin and physique-rating findings highlights that inflammatory biomarkers and body composition capture different biological domains, and therefore should be interpreted as complementary rather than interchangeable components of nutritional assessment.

Strengths and Limitations

This study has several strengths. First, we enrolled a relatively large sample (n = 120) from diverse diagnostic categories, enhancing generalizability to general hospitalized adults. Second, we utilized validated, widely accepted methods including GLIM criteria for malnutrition diagnosis and standardized BIA for body composition assessment. Third, multivariable regression analyses adjusted for key confounders (age, sex, diagnosis), strengthening inference regarding independent associations. Fourth, we integrated multiple nutritional dimensions (biochemical, anthropometric, compositional) within a single cohort, providing a holistic perspective.

Several limitations warrant acknowledgment. First, the cross-sectional design precludes causal inference; while inflammation likely drives albumin reduction and compositional changes, reverse causality wherein malnutrition exacerbates inflammation cannot be excluded. Longitudinal studies tracking NLR dynamics alongside nutritional interventions are needed. Second, albumin data were unavailable for 13.3% of participants, potentially introducing selection bias if these patients differed systematically. Third, BIA accuracy can be affected by hydration status, which is frequently altered in hospitalized patients due to illness, medications, or fluid therapy [38]. The physique rating provided by BIA is device-specific and may not fully correspond to gold-standard assessments of muscle mass. Fourth, we lacked data on other inflammatory markers (CRP, IL-6) that would provide more comprehensive inflammatory profiling. Fifth, single-centre recruitment may limit external validity, though our referral centre's diverse patient population mitigates this concern. Sixth, residual confounding from unmeasured variables (e.g., specific medications, illness severity scores, renal function) remains possible despite multivariable adjustment.

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Future studies should address several key questions: 1) Longitudinal Design: Prospective cohorts monitoring NLR changes during hospitalization alongside nutritional interventions could elucidate temporal relationships and responsiveness to treatment; 2) Cut-point Determination: Receiver operating characteristic (ROC) curve analysis to establish optimal NLR thresholds for predicting hypoalbuminemia, malnutrition, or adverse clinical outcomes in our local population; 3) External Validation: Replication in independent cohorts from other centres and geographic regions to confirm generalizability; 4) Mechanistic Studies: Investigating inflammatory cytokine profiles (IL-6, TNF-α, CRP) alongside NLR and nutritional parameters to clarify pathophysiologic mechanisms; 5) Intervention Trials: Randomized controlled trials comparing standard nutritional care versus NLR-guided enhanced nutritional support to determine whether biomarker-integrated screening improves patient outcomes; 6) Integration with Other Biomarkers: Exploring combinations of NLR with prealbumin, transferrin, or retinol-binding protein (shorter half-life markers) to improve sensitivity for acute nutritional changes; 7) Disease-Specific Sub-analyses: Larger studies enabling adequately powered subgroup analyses by diagnosis (oncology, infection, renal disease) to identify disease-specific NLR-nutrition relationships.

Conclusions

In this cross-sectional study of hospitalized adults, elevated neutrophil–lymphocyte ratio (NLR) was independently associated with lower serum albumin after adjustment for key covariates (consistent with NLR as a readily available marker of systemic inflammation and inflammation-related hypoalbuminemia). By contrast, NLR did not discriminate patients with a BIA-defined low-muscle phenotype: median NLR values were similar between low-muscle and normal physique rating groups ($p = 0.394$) and log-transformed NLR was not a significant predictor of low muscle phenotype in multivariable analysis (adjusted OR 1.19; 95% CI 0.79–1.79; $p = 0.405$). Therefore, a single cross-sectional NLR measurement should not be used as a surrogate for BIA-derived muscle quantification in a heterogeneous inpatient population. Clinically, NLR can serve as an adjunctive inflammatory signal that prompts further nutritional and functional assessment (including direct measures of muscle mass and performance), but it should not replace objective muscle assessment. Prospective studies using serial NLR measurements, validated muscle-quantification methods (e.g., DXA, CT or rigorous BIA protocols accounting for hydration), and disease-specific subgroup analyses are needed to clarify whether NLR can play a role in targeted nutritional screening or monitoring.

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Author Contributions

YMM, NAT, and AYS were responsible for conceptualization, methodology, and writing the original draft. AM, NA, and NS handled visualization, supervision, data management, coordination of manuscript preparation, critical review, and revisions.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT (OpenAI) to support grammar and language clarity. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Conflicts of Interest

The authors declare that there are no conflicts of interest associated with this study, its authorship, or its publication.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request, subject to institutional data sharing policies and ethical approvals.

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