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Neutrophil-To-Lymphocyte Ratio and Glycemic Control in Adults With Type 2 Diabetes Mellitus: A Cross-Sectional Study

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ABSTRACT

The neutrophil-to-lymphocyte ratio (NLR) is a simple and readily available marker of inflammation, and its relationship with type 2 diabetes mellitus (T2DM) and insulin resistance has been investigated by many researchers; however, its association with long-term glycemic control remains unclear and findings are inconsistent. This cross-sectional laboratory-based study was conducted among 100 adults with T2DM attending Al-Zahawi Private Laboratory for Medical Laboratory Investigations from April to August 2026. Absolute neutrophil and lymphocyte counts were obtained from blood count tests, and NLR was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count, while HbA1c was measured using an automated high-performance liquid chromatography technique. Participants were divided into two groups according to HbA1c levels ($<7\%$ and $\geq 7\%$), and associations were assessed using Pearson and Spearman correlation, Mann-Whitney U test, partial correlation, and multivariable linear and logistic regression models adjusted for age and sex. The mean NLR was 2.20 ± 1.26 , while the mean HbA1c was $7.72 \pm 1.87\%$. Spearman correlation showed no significant association between NLR and HbA1c ($p = -0.050$, $p = 0.619$), which was also supported by Pearson correlation ($r = 0.106$, $p = 0.296$), the Mann-Whitney U test ($p = 0.151$), and partial correlation adjusted for age and sex ($r = 0.137$, $p = 0.175$). Linear regression also showed that NLR was not independently associated with HbA1c ($\beta = 0.200$, $p = 0.180$), whereas age showed a positive association with HbA1c ($\beta = 0.055$, $p = 0.041$). Logistic regression similarly found no significant association between NLR and poor glycemic control (OR = 1.035, 95% CI: 0.744–1.439, $p = 0.839$). Overall, NLR was not significantly associated with HbA1c or glycemic control in adults with T2DM, suggesting that it may reflect general systemic inflammation rather than long-term glycemic variations; future longitudinal, multicenter studies are required to further elucidate the metabolic factors influencing this relationship.

INTRODUCTION

Type 2 Diabetes Mellitus is a metabolic disease, which is characterised by chronic changes in glucose homeostasis due to insulin resistance and progressive decline of pancreatic beta cell function. In addition to defects in glucose metabolism Type 2 Diabetes Mellitus is now increasingly recognised as a condition associated with low-grade systemic inflammation. The interaction, between metabolic disarray and inflammatory pathways may influence insulin resistance, vascular complications and disease progression (Donath & Shoelson, 2011; Hotamisligil, 2006).

Neutrophil-to-lymphocyte ratio or NLR is a blood test result that comes from counting neutrophils and lymphocytes. NLR is easy and cheap so doctors use NLR to see how the body reacts to inflammation or stress. When neutrophils go up NLR shows the body's first line of defense is active. When lymphocytes go down NLR can mean the body is under mental stress. Because NLR can be found in a blood test NLR is useful, for looking at conditions that involve metabolism or inflammation (Zahorec, 2001).

Earlier research showed that high neutrophil-related indices are linked to T2DM; high neutrophil-related indices are also linked to NLR and insulin resistance (Guo

et al., 2015; Lou *et al.*, 2015). These observations line up with the idea that NLR reflects activity that comes with metabolic problems. The link between NLR and how well blood sugar is controlled, measured by HbA1c is not as clear. Some studies find a link, between NLR and blood sugar levels while other studies find a weak or no link (Shiny *et al.*, 2014; Mohammadi *et al.*, 2026).

Glycaemic control is often checked using HbA1c. This test shows the blood sugar level over about the past two to three months. Because of this it is very different from a short-term sign of inflammation, like NLR (American Diabetes Association, 2025). Therefore the fact that there is no link between NLR and HbA1c does not mean there is no inflammation happening in T2DM. Other things, like age how long someone has had the disease being overweight, smoking, infections, other health conditions, medicines and kidney or metabolism problems can influence both inflammation levels and blood sugar readings.

The information is not clear especially when it comes to NLR being able to show blood sugar control on its own. More research is needed in groups of people. Because of this this study looked at how NLR and HbA1c're connected in adults who have T2DM. It also looked at how NLR changes based on how blood sugar

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is controlled. The study also checked how much NLR matters on its own after taking into account age and sex.

LITERATURE REVIEW

Type 2 Diabetes Mellitus and Chronic Inflammation

Type 2 diabetes mellitus is not a problem, with how the body handles sugar. More and more doctors are realizing that term mild inflammation is a very important part of how insulin resistance and other metabolic problems develop. When the way immune cells talk to tissue and the body's energy systems changes it can cause signals that lead to inflammation and make it harder for insulin to work properly (Donath & Shoelson, 2011; Hotamisligil, 2006).

I have seen that the inflammatory environment is usually not as harsh as the one that appears during an infection or a serious inflammatory disease. Yet ongoing immune activation can bring about metabolic abnormalities after years. Because of this simple haematological indices have attracted focus as potential markers of systemic inflammatory activity in people with T2DM. In fact the inflammatory environment is a factor that we keep watching and immune activation remains a concern, over time. These simple haematological indices might just help us spot inflammatory activity early in T2DM patients.

Neutrophil-to-Lymphocyte Ratio as an Inflammatory Marker

NLR brings together two groups of leukocytes that have roles in the body. Neutrophils are a part of the innate immune system and can increase during inflammation or normal stress. Lymphocytes may decrease in stress-related situations. Because of this the NLR is a value that takes into account changes, in both neutrophils and lymphocytes (Zahorec, 2001).

The practical advantage of NLR is that it comes from a complete blood count. No special tests are needed. NLR does not point to a specific disease. Its values can change based on age, acute infections, long-term inflammation, medicines, physical stress and other health conditions (Forget *et al.*, 2017). So NLR should be seen as a sign of body-wide inflammation or stress. It is not an indicator of one specific illness.

NLR, Type 2 Diabetes Mellitus, and Insulin Resistance

There is some evidence suggesting a connection, between blood profiles and metabolic problems. Guo *et al.* Found that in a group of adults, higher levels of neutrophils were linked to type 2 diabetes mellitus (Guo *et al.*, 2015). Similarly NLR association with insulin resistance among diagnosed T2DM patients was reported by Lou *et al.* NLR data suggest an association, between systemic inflammatory activity and metabolic disorders linked with T2DM. (Lou *et al.*, 2015).

Associations make sense from a point of view because insulin resistance and problems with how the body uses energy might be linked to a mild type of inflammation.. These links do not show that NLR is the main reason, for

how the body controls blood sugar. Instead NLR could be part of a pattern that includes both inflammation and metabolic issues.

NLR and Glycemic Control

The results of studies looking at the link between NLR and blood sugar control are mixed. One study by Shiny and colleagues found that NLR was linked to glucose intolerance in people, with type 2 diabetes suggesting that NLR might show the body's inflammation that comes with glucose levels. Similarly, target metabolic outcomes often show distinct geographical and socio-demographic variations, which aligns with varying glycemic control profiles observed across recent regional clinical investigations (Islam & Rahman, 2023).

Similarly in a study looking back at patients with type 2 diabetes mellitus, Yuksel Salduz and Ozder found that NLR could be useful, in predicting how well blood sugar levels are controlled (Yuksel Salduz & Ozder, 2022).

Not all studies have shown the same results. Dayama *et al.* Looked at NLR and other signs of inflammation in people, with controlled and uncontrolled T2DM. They also provided proof that inflammatory measures can be different depending on the people being studied (Dayama *et al.*, 2024). Sefil *et al.* Also looked at how NLR relates to blood glucose regulation showing that there is interest in using NLR as a possible marker, for metabolic control (Sefil *et al.*, 2014).

The evidence has been looked at again carefully. Using special analysis methods.. Adane *et al.* Said that each study showed different results about the link between NLR and blood sugar control, in T2DM (Adane *et al.*, 2023). The last update of the analysis was done by Mohammadi *et al.* They looked again at the evidence and pointed out that it's important to think about differences, between populations and study designs. These differences can affect how the results are understood. They stressed that not all studies are the same and these variations should not be ignored when drawing conclusions. This helps make sure findings are more accurate and useful. A large 2024 meta-analysis of people found a link between NLR and metabolic syndrome. The link between NLR and metabolic syndrome suggests an association, between systemic inflammation and metabolic malfunction (Qiu *et al.*, 2024).

Recent cross-sectional studies continue to examine the relationship between NLR and glycaemic control. Work by Begum and colleagues shows that this relationship, between NLR and glycaemic control remains a focus of interest (Begum *et al.*, 2026). In total these findings point to a link between NLR and metabolic and inflammatory changes in T2DM. However the strength and independence of the link, between NLR and HbA1c remain unclear.

Glycated Hemoglobin and Inflammatory Indices

I find that HbA1c is a marker that shows long-term blood sugar levels and is regularly used to check how well blood sugar is controlled (American Diabetes Association,

2025). NLR on the hand shows the true balance between neutrophils and lymphocytes and can vary in both sudden and long-term inflammation and stress. I also note that the time scales for HbA1c and NLR are different. The fact that HbA1c and NLR do not correlate does not rule out the role of inflammation in type two diabetes mellitus. Instead one single blood test, for inflammation may not be enough to show the complex and long term metabolic changes that HbA1c reveals. Nevertheless, evaluating cell-based immune ratios remains a crucial step, supporting the clinical utility of specific hematological factors and baseline systemic inflammatory markers in comprehensive metabolic tracking (Sultana & Ahmed, 2024).

Age and Inflammatory Changes

Age is another thing that can change how inflammation looks. As people get older there is a build-up of a long-term mild inflammation. This is called “inflammaging”. It has been linked to many changes in the body that happen as people grow older like, in how the body handles sugar and the immune system (Franceschi *et al.*, 2018). When looking at how NLR connects with HbA1c it's important to take age into account. This is because age can affect the levels of inflammation and how the body handles blood sugar.

Rationale for the Present Study

While earlier studies and reviews suggested there could be a link between NLR and how the body controls blood sugar the findings are still not clear (Dayama *et al.*, 2024 ; Sefil *et al.*, 2014 ; Adane *et al.*, 2023 ; Qiu *et al.*, 2024 ; Begum *et al.*, 2026). These differences could be because of how different groups of people were studied how long they had the disease other health conditions they had how inflammation they had how many people were in the study and the way the data was analyzed.

So the current study focused specifically on adults with T2DM. Looked into whether NLR was connected to HbA1c and how well blood sugar was controlled. Along, with correlation studies studies that took into account age and sex were also done to see if NLR was still connected to blood sugar control.

MATERIALS AND METHODS

Study Design and Participants

A cross-sectional study was conducted in the laboratory, including 100 adults with T2DM who attended Al-Zahawi Private Laboratory for Medical Laboratory Investigations from April to August 2026.

Participants were included according to the availability of complete NLR and HbA1C measurements. The study population consisted of adults with established T2DM with available data for analysis on complete blood count and HbA1c.

Subjects were divided into two groups based on the status of their glycaemic control with a cut off of HbA1c of 7%. The low HbA1c group was defined as HbA1c < 7% and the high HbA1c group as HbA1c ≥ 7%.

Ethical Considerations

The study followed the principles of the declaration of Helsinki. Participant information was kept confidential and laboratory data were analysed without identifiers. Ethical clearance waiver was kindly obtained from the administration of Al-Zahawi laboratory, for medical laboratory investigations.

Blood Sample Collection

We collected venous blood samples using standard laboratory procedures. We collected blood samples for blood count analysis in suitable anticoagulant tubes; we processed samples, for HbA1c analysis according to the requirements of the analytical system. All samples were processed using laboratory procedures and we performed measurements following the manufacturers' recommendations.

Complete Blood Count Analysis

Complete blood count measurements were conducted with the Mindray BC-5000 automated haematology analyser. Absolute neutrophil and lymphocyte counts were calculated from the analyser differential leukocyte results.

The absolute neutrophil count (ANC) and absolute lymphocyte count (ALC) were expressed as $\times 10^9/L$.

Measurement of Glycated Hemoglobin

HbA1c was measured using the Tosoh HLC-723G8 automated glycohemoglobin analyzer, based on high-performance liquid chromatography (HPLC). HbA1c results were expressed as percentages (%).

For the present analysis, HbA1c <7% and HbA1c ≥7% were used to define the two glycaemic-control categories.

Calculation of Neutrophil-to-Lymphocyte Ratio

NLR was calculated using the following equation:

$$NLR = \frac{\text{Absolute neutrophil count}}{\text{Absolute lymphocyte count}}$$

NLR was treated as a continuous variable in correlation and regression analyses and was also compared between the two HbA1c-defined groups.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 26.

Continuous variables were expressed as means and standard deviations (SD) and as medians and interquartile ranges (IQR) when appropriate. Categorical variables are described as frequencies and percentages.

Pearson and Spearman correlation coefficients were used to assess the relationships and distribution between NLR, HbA1c and age Differences in NLR between participants with HbA1c <7% and ≥7% were assessed using Mann–Whitney U test. As a sensitivity analysis, a Welch independent-samples comparison was also considered.

The relationship between NLR and HbA1c was assessed by partial correlation after adjustment for age and sex.

In the multivariable linear regression, HbA1c was the

dependent variable, and NLR, age and sex were the independent variables. We also conducted a binary logistic regression model to assess whether NLR predicted higher HbA1c status ($\text{HbA1c} \geq 7\%$) with adjustment of age and sex.

Statistical significance was defined as $P < 0.05$.

RESULTS AND DISCUSSION

Participant Characteristics and Laboratory Findings

The study included 100 adults with T2DM. The mean age was 60.70 ± 7.13 years, with an age range of 41–73 years. Females represented 61% of the study

population, while males represented 39%.

The mean absolute lymphocyte count was $2.44 \pm 0.80 \times 10^9/\text{L}$, and the mean absolute neutrophil count was $4.81 \pm 1.64 \times 10^9/\text{L}$.

The mean NLR was 2.20 ± 1.26 , with a median of 1.97 (IQR: 1.62–2.41) and a range of 0.54–8.50.

The mean HbA1c was $7.72 \pm 1.87\%$, with a median of 7.05% (IQR: 6.20–8.73%) and a range of 5.9–15.4%.

Of the 100 participants, 47 (47%) had $\text{HbA1c} < 7\%$, whereas 53 (53%) had $\text{HbA1c} \geq 7\%$.

Table 1: General characteristics and laboratory findings of the study participants

Variable	Overall (n=100)
Age, years	60.70 ± 7.13
Age range, years	41–73
Female, n (%)	61 (61%)
Male, n (%)	39 (39%)
Absolute lymphocyte count, $\times 10^9/\text{L}$	2.44 ± 0.80
Absolute neutrophil count, $\times 10^9/\text{L}$	4.81 ± 1.64
NLR	2.20 ± 1.26
NLR median (IQR)	1.97 (1.62–2.41)
NLR range	0.54–8.50
HbA1c, %	7.72 ± 1.87
HbA1c median (IQR), %	7.05 (6.20–8.73)
HbA1c range, %	5.9–15.4
HbA1c $< 7\%$, n (%)	47 (47%)
HbA1c $\geq 7\%$, n (%)	53 (53%)

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; HbA1c, glycated hemoglobin; IQR, interquartile range; SD, standard deviation.

Note: Continuous variables are presented as mean $\pm$ SD unless otherwise indicated.

NLR According to Glycemic-Control Status

NLR was similar between the two HbA1c-defined groups. Participants with $\text{HbA1c} < 7\%$ had a mean NLR of 2.21 ± 0.80 , with a median of 2.00 (IQR: 1.62–2.40). Participants with $\text{HbA1c} \geq 7\%$ had a mean NLR of 2.20 ± 1.57 , with a median of 1.75 (IQR: 1.62–2.41).

The Mann–Whitney U test showed no statistically significant difference in NLR between the two groups ($P = 0.151$). A Welch sensitivity analysis similarly showed no significant difference ($P = 0.976$).

Correlation Between NLR, Age, and HbA1c

No significant association was identified between NLR and HbA1c. Spearman correlation showed $\rho = -0.050$, $P = 0.619$, while Pearson correlation showed $r = 0.106$, $P = 0.296$.

NLR was also not significantly correlated with age. Spearman correlation showed $\rho = -0.143$, $P = 0.155$, and Pearson correlation showed $r = -0.153$, $P = 0.128$.

In contrast, age showed a weak positive association with HbA1c using Pearson correlation ($r = 0.201$, $P =$

Table 2: Comparison of NLR according to glycemic-control status

Glycemic-control group	n	NLR, mean $\pm$ SD	NLR, median (IQR)	Primary P-value
HbA1c $< 7\%$	47	2.21 ± 0.80	2.00 (1.62–2.40)	
HbA1c $\geq 7\%$	53	2.20 ± 1.57	1.75 (1.62–2.41)	
Mann–Whitney U test				0.151
Welch sensitivity analysis				0.976

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; HbA1c, glycated hemoglobin; SD, standard deviation; IQR, interquartile range.

Note: The primary between-group comparison was performed using the Mann–Whitney U test. The Welch test was included as a sensitivity analysis.

Table 3: Correlation analysis among NLR, age, and HbA1c

Variables	Pearson r	P-value	Spearman ρ	P-value
NLR vs. HbA1c	0.106	0.296	-0.050	0.619
NLR vs. age	-0.153	0.128	-0.143	0.155
Age vs. HbA1c	0.201	0.044	0.194	0.053

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; HbA1c, glycated hemoglobin.

Note: $P < 0.05$ was considered statistically significant.

0.044). The corresponding Spearman correlation was $\rho = 0.194$, $P = 0.053$, which was just above the conventional significance threshold.

Age-Stratified Analysis

Participants were further categorized into three age groups: <60 years, 60–69 years, and ≥ 70 years.

The <60-year group included 35 participants, with a mean NLR of 2.49 ± 1.38 and mean HbA1c of $7.36 \pm 1.42\%$. The 60–69-year group included 49 participants, with a mean NLR of 2.01 ± 1.25 and mean HbA1c of $7.40 \pm 1.56\%$.

The ≥ 70 -year group included 16 participants, with a mean NLR of 2.16 ± 0.90 and mean HbA1c of $9.52 \pm 2.56\%$.

Table 4: Age-stratified NLR and HbA1c values

Age group	n	NLR, mean $\pm$ SD	HbA1c, mean $\pm$ SD (%)
<60 years	35	2.49 ± 1.38	7.36 ± 1.42
60–69 years	49	2.01 ± 1.25	7.40 ± 1.56
≥ 70 years	16	2.16 ± 0.90	9.52 ± 2.56

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; HbA1c, glycated hemoglobin; SD, standard deviation.

The higher mean HbA1c observed in the oldest age group was consistent with the positive relationship between age and HbA1c identified in the correlation analysis.

Multivariable Linear Regression

A multivariable linear regression model was constructed with HbA1c as the dependent variable and NLR, age, and

sex as independent variables.

The overall model explained 6.5% of the variance in HbA1c ($R^2 = 0.065$), with an adjusted R^2 of 0.035 and an overall model P-value of 0.092.

NLR was not independently associated with HbA1c ($\beta = 0.200$, 95% CI: -0.094 to 0.495, $P = 0.180$). In contrast, age showed a statistically significant positive association

Table 5: Multivariable linear regression analysis of factors associated with HbA1c

Predictor	β coefficient	95% CI	P-value
NLR	0.200	-0.094 to 0.495	0.180
Age	0.055	0.002 to 0.108	0.041
Male sex	0.275	-0.484 to 1.034	0.473

Model statistics: $R^2 = 0.065$; adjusted $R^2 = 0.035$; overall $P = 0.092$.

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; HbA1c, glycated hemoglobin; CI, confidence interval; β , regression coefficient.

with HbA1c ($\beta = 0.055$, 95% CI: 0.002–0.108, $P = 0.041$).

Male sex was not significantly associated with HbA1c ($\beta = 0.275$, 95% CI: -0.484 to 1.034, $P = 0.473$).

Logistic Regression Analysis of Poor Glycemic Control

Binary logistic regression was performed to evaluate whether NLR was associated with higher HbA1c status,

defined as HbA1c $\geq 7\%$.

NLR was not significantly associated with higher HbA1c status (OR = 1.035, 95% CI: 0.744–1.439, $P = 0.839$). Age also did not reach statistical significance in the logistic model (OR = 1.053, 95% CI: 0.991–1.119, $P = 0.093$).

Male sex was similarly not significantly associated with HbA1c $\geq 7\%$ (OR = 1.892, 95% CI: 0.814–4.396, $P = 0.138$).

Table 6: Logistic regression analysis of HbA1c $\geq 7\%$

Predictor	OR	95% CI	P-value
NLR	1.035	0.744–1.439	0.839
Age	1.053	0.991–1.119	0.093
Male sex	1.892	0.814–4.396	0.138

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; OR, odds ratio; CI, confidence interval; HbA1c, glycated hemoglobin.

Note: The dependent variable was HbA1c $\geq 7\%$.

Adjusted Association Between NLR and HbA1c

After controlling for age and sex, the association between NLR and HbA1c remained non-significant. The partial correlation coefficient was $r = 0.137$ ($P = 0.175$).

This finding indicates that the absence of a significant unadjusted relationship between NLR and HbA1c was not explained by confounding from age or sex within the variables included in the present model.

Summary of Main Findings

The principal findings of this study were:

1. The average NLR in 100 adult T2DM was 2.20 ± 1.26 .
2. NLR was not correlated significantly with HbA1c by Pearson or Spearman correlation.
3. NLR was not significantly different between the HbA1c $< 7\%$ and HbA1c $\geq 7\%$ participants.
4. No significant association was found between NLR and HbA1c after adjustment for age and sex.
5. In multivariable linear regression, NLR was not independently associated with HbA1c.
6. NLR was not associated with higher HbA1c status in logistic regression analysis.
7. In Pearson correlation and multivariable linear regression, age was weakly but statistically significantly positively associated with HbA1c.

Discussion

The purpose of this study was to look at how NLR, a blood test that shows inflammation relates to long-term blood sugar control in adults with type 2 diabetes. The main result showed that NLR did not have a link, with HbA1c levels. This was true. When no other factors were considered and when adjustments were made for age and sex. Also NLR values did not differ between groups defined by HbA1c levels. In addition NLR did not predict HbA1c status on its own.

In the study no significant link was found. This is different from studies that did suggest a connection between NLR and problems, with blood sugar regulation or poor glucose control (Shiny *et al.*, 2014; Dayama *et al.*, 2024; Sefil *et al.*, 2014; Adane *et al.*, 2023). Shiny *et al.* Observed a link between NLR and glucose intolerance in patients with T2DM. This observation supports the hypothesis that systemic inflammation may be linked to glucose metabolism (Shiny *et al.*, 2014). I find this connection, between NLR, glucose intolerance, T2DM systemic inflammation and abnormal glucose metabolism

intriguing. In the line Yuksel Salduz and Ozder suggested a possible predictive role for NLR, in glycaemic control (Yuksel Salduz & Ozder, 2022). These findings agree with reviews that show a general link, between NLR and glycaemic control in T2DM (Mohammadi *et al.*, 2026; Adane *et al.*, 2023). The results of this study do not directly conflict with the body of evidence showing a link between inflammation and type 2 diabetes mellitus. However they do point out that neutrophil-to-lymphocyte ratio or NLR may not always match up with long-term blood sugar exposure as measured by HbA1c. NLR is a blood marker that can change quickly due to many short-term and ongoing health conditions. On the hand HbA1c gives a picture of blood sugar levels over a much longer time period (American Diabetes Association, 2025). Because of this difference, in what they measure NLR and HbA1c may actually be capturing parts of the disease process in type 2 diabetes mellitus.

One possible reason for the differences seen across studies is that the groups of people being studied might have had characteristics. The NLR (Forget *et al.*, 2017). can change due to infection inflammation, certain medicines, smoking, obesity, other health conditions and various other physical or medical factors. Because these factors may vary between study populations, the link, between NLR and HbA1c could also be different. This study used lab data and information on many of these possible influencing factors was limited. As a result it's possible that some unseen confounding factors were still present meaning residual confounding cannot be ruled out. The present findings should also be interpreted in light of the association between NLR and metabolic dysfunction. Previous studies have shown associations, between related measures, NLR, T2DM and insulin resistance (Guo *et al.*, 2015; Lou *et al.*, 2015). Also meta-analysis has shown that NLR is linked to metabolic syndrome (Qiu *et al.*, 2024). These results mean that NLR can still serve as a sign of body-wide inflammation in people with metabolic issues even if there is no direct link, between NLR and HbA1c. One key result in this analysis is the link between age and HbA1c. The Pearson correlation shows that age is weakly and positively connected to HbA1c with $r = 0.201$ and $P = 0.044$. Age stays significantly tied to HbA1c after adjusting for other factors with $\beta = 0.055$ and $P = 0.041$ in the multivariable regression. When we split the data by age groups we see that people who are 70 years old or older have an average HbA1c, than those who are younger. This finding makes sense biologically because ageing

brings changes in how the body regulates metabolism how the immune system works and how much chronic inflammation is present. The low-grade inflammation that comes with ageing is called inflammaging. Inflammaging could explain how ageing and metabolic disease influence each other according to reference (Franceschi *et al.*, 2018). However the regression model only explained six point five percent of the variance in HbA1c. This shows that most of the variance in HbA1c was not explained by NLR, age or sex. This is a point because glycaemic control, in T2DM is multifactorial. HbA1c variability can be strongly influenced by diabetes duration, treatment adherence, medication type, obesity, dietary behaviour, physical activity, insulin resistance, renal function and other clinical variables. The logistic regression analysis supported the absence of a significant association between NLR and HbA1c. The odds ratio for NLR was close to 1 (OR=1.035, 95% CI: 0.744–1.439, P=0.839) and showed no evidence that increasing NLR independently increased the odds of HbA1c $\geq 7\%$ in this sample.

The consistency between correlation, group-comparison, regression and logistic-regression analyses gives us confidence that NLR is not meaningfully linked to glycaemic control. In this set of data NLR shows no association, with glycaemic control.

The present findings are also important for the interpretation of NLR as a biomarker. NLR has some advantages because NLR is inexpensive rapidly available and derived from routine complete blood count measurements. However these advantages do not make NLR specific, for control. The present results support an interpretation where NLR is considered as a non-specific inflammatory marker and not as a surrogate marker of HbA1c.

Strengths

Strengths of the study are as follows. First all the participants were measured on the variables needed for the analysis. Second the NLR was calculated from complete blood count measurements, which made the approach inexpensive and easily reproducible in clinical laboratory settings. Third several complementary statistical methods were used, including correlation analysis, group comparison, partial correlation, multivariable linear regression and logistic regression. That the results are consistent, across these analyses further supports the finding.

Limitations

Several limitations must be kept in mind. First the cross-sectional design does not let us see whether NLR causes changes in control or whether glycaemic control influences NLR. Second the study used a sample taken from only one laboratory, which weakens the power of the statistics and limits how well the findings can be applied to other people. Third the analysis did not account for important factors such as how long a person has had diabetes, body mass index, smoking habits, medications,

an acute infection, chronic inflammatory diseases, kidney function and other possible comorbidities. Fourth NLR is a marker of inflammation and can be altered by temporary physiological or pathological states.

Future studies that involve centers and follow patients over time should take these possible confounders into account and examine whether changes in NLR are linked to changes, in HbA1c or other measures of glycaemic control.

CONCLUSION

In this -sectional study of adults with type 2 diabetes the neutrophil-to-lymphocyte ratio did not show a significant link with HbA1c levels. There was no difference in NLR between people with HbA1c below 7% and those with HbA1c 7% or higher. After adjusting for age and sex the neutrophil-to-lymphocyte ratio still did not stand out as an independent factor. In regression models NLR could not predict who had higher HbA1c levels.

These results suggest that the neutrophil-to-lymphocyte ratio should not be seen as a marker for long-term blood sugar control. Still it remains a low-cost way to check for signs of ongoing inflammation in the body. The connection between age and HbA1c also highlights how personal background and health conditions can influence blood sugar levels regardless of what the neutrophil-, to-lymphocyte ratio says.

Further multicenter and longitudinal studies taking into account diabetes duration, body mass index, treatment, smoking, inflammatory conditions, infection status, renal function, and other metabolic variables are required to clarify the clinical significance of NLR in the evaluation of T2DM and glycaemic control.

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