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Association of Neutrophil-to-Lymphocyte Ratio (NLR) with Hypertension in US Diabetic Populations: Insights from NHANES Database (2005-2018)

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Abstract: *The neutrophil-lymphocyte ratio (NLR) has been identified as an inflammation-related predictor of cardiovascular disease, and its association with hypertension has been reported. However, the relationship between NLR and hypertension in diabetic patients remains insufficiently explored. This study aimed to investigate the relationship between NLR and hypertension in diabetic patients using data obtained from the National Health and Nutrition Examination Survey (NHANES) database from 2005 to 2018. After excluding participants with missing data on NLR and hypertension, the baseline characteristics of diabetic patients aged 18 years and older were analyzed. The relationship between NLR and hypertension was assessed using weighted multiple regression models and restricted cubic spline (RCS) analysis. A total of 6,472 participants were included in the study. The weighted multiple regression analysis revealed that higher NLR quartiles were positively associated with hypertension. In Model 3, after adjusting for covariates, the positive correlation remained significant (Q3: OR = 1.39, 95% CI [1.08, 1.80], p = 0.011; Q4: OR = 1.35, 95% CI [1.06, 1.71], p = 0.017), indicating that the risk of hypertension increased by 39% and 35% for participants in the middle and high NLR quartiles, respectively, compared to those in the low NLR quartile. Additionally, RCS analysis demonstrated a significant non-linear relationship between NLR levels and the risk of hypertension in diabetic patients. Specifically, lower NLR levels were associated with a higher risk of hypertension, while the risk escalated once NLR exceeded a certain threshold. The study suggests that elevated NLR is a significant risk factor for hypertension in diabetic patients, with a non-linear relationship observed. These findings highlight the potential utility of NLR as a biomarker for identifying hypertension risk in this population.*

Keywords: *Hypertension, Diabetes, NLR, NHANES*

1. Introduction

Hypertension, a prevalent condition characterized by elevated blood pressure, stands as a leading risk factor for cardiovascular diseases (CVD) worldwide[1]. It is well-established that hypertension contributes significantly to the global burden of CVD, which is a major cause of morbidity and mortality[2]. Hypertension is caused by the close interaction of different causes, such as sodium intake, immunity, inflammation, oxidative stress and endothelial cell dysfunction[3, 4]. The level of inflammation may explain the increased incidence of hypertension[3].

NLR, the ratio of neutrophil to lymphocyte count, has gradually been considered as a potential inflammatory biomarker related to the prognosis of cardiovascular disease in recent years[5]. The association between NLR and hypertension has been explored in various populations, with a study has highlighted that elevated NLR values are associated with an increased risk of hypertension[6]. In addition, a large number of studies have reported that NLR is associated with increased CVD risk and increased cardiovascular mortality in diabetic patients[7-9]. However, no one has independently explored the association between NLR and hypertension in diabetic patients.

The National Health and Nutrition Examination Survey (NHANES) provides a rich source of data for examining the relationship between NLR and health outcomes, including hypertension[1]. The NHANES is a nationally representative survey conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC), collecting comprehensive health and nutritional information from non-institutionalized civilian residents of the United States[10].

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In this study, we aimed to explore the association between neutrophil-to-lymphocyte ratio (NLR) and hypertension in American diabetic patients using NHANES data from 2005 to 2018. We hypothesized that NLR may be a biomarker for predicting the risk of hypertension in this population, thus providing a new perspective on the role of inflammation in the development and management of hypertension in diabetic patients.

2. Methods

2.1 Source of study population

Our study data were extracted from the National Health and Nutrition Examination Survey (NHANES) database. NHANES is carried out by the National Centre for Health Statistics and all data collection procedures are approved by the National Institute of Health Statistics. National Center for Health Statistics Ethics Review Committee. All participants provided written informed consent before data collection[11]. Details of the data for this study are available from the NHANES (https://www.cdc.gov/nchs/nhanes/index.htm.) website. The research data are from seven consecutive NHANES cycles from 2005 to 2006 to 2017-2018. From 2005 to 2018, a total of 70 190 people participated in NHANES. After excluding individuals with missing data such as diabetes, hypertension, weight, and NLR, and those who did not meet the diagnosis of diabetes, the final study population was 6472. Figure 1 presents a flowchart that delineates the process of participant selection criteria.

2.2 Diabetes

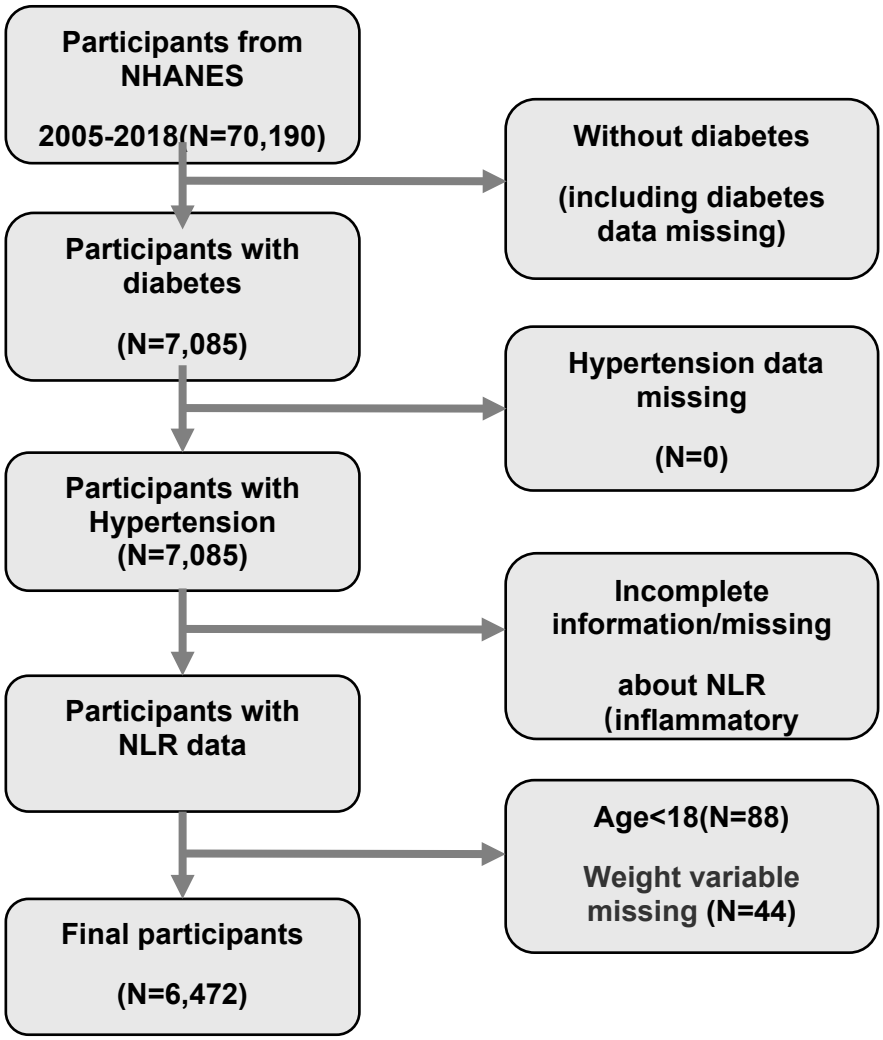

Figure 1: The flow chart of participants selection was derived from NHANES 2005-2018. Abbreviation: NHANES, National Health and Nutrition Examination Survey; NLR: Neutrophil-to-Lymphocyte Ratio.

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In this study, Individuals who meet one or more of the following criteria were considered to have diabetes : (1) Participants reported that they had been told by a doctor or health care professional that they had diabetes ; (2) Participants reported that they were currently using insulin;(3)Participants reported that they were currently taking hypoglycemic drugs ; (4) Individuals with glycated hemoglobin (HbA1c) levels reaching or exceeding 6.5 % ; (5) Individuals with fasting blood glucose (FBG) levels of 126 mg / dL or higher[12].

2.3 Hypertension

In this study, we used questionnaires and blood pressure measurements to assess whether the subjects had hypertension. The specific methods were as follows : (1) Participants were asked through a questionnaire whether they had been informed by a doctor or health care professional that they had hypertension. Participants who answered ' yes ' were considered to be hypertensive patients ; (2) the blood pressure of each participant was measured for 3 to 4 consecutive times, and then the mean values of these measurements were calculated to assess their systolic blood pressure (SBP) and diastolic blood pressure (DBP) levels. Hypertension was defined as SBP ≥ 140 mmHg or DBP ≥ 90 mmHg[13].

2.4 NLR and covariates

NLR was used as a continuous independent variable in our study. The calculation formula of NLR is: NLR = neutrophil count / lymphocyte count[14]. In this study, we considered the following covariates : age, gender, race, marital status, education level, poverty income ratio(PIR), body mass index (BMI), drinking, smoking, physical activity, glycated hemoglobin A1c (HbA1c), fasting blood glucose, platelet count, triglyceride, total cholesterol, LDL and HDL. Participants were divided into three age groups : 18-39, 40-59 and ≥ 60 ; gender is divided into : male and female ; marital status was divided into : Married / Living with partner, Widowed / Divorced / Separated, Never married ; race : Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other Race ; the PIR is defined with the following criteria: individuals with a PIR of 1 or higher were classified as non-poor, whereas those with a PIR below 1 are considered poor; BMI was categorized into four ranges: less than 18.5, 18.5 to 24.9, 25 to 29.9, and greater than 30; drinking status was determined by alcohol consumption over the first two days, with categories for non-drinkers and drinkers; smoking status was classified into three groups: never smokers, former smokers, and current smokers; laboratory data directly provides values for HbA1c, fasting blood glucose, platelet count, triglycerides, total cholesterol, LDL, and HDL.

2.5 Statistical analysis

The continuous variables were expressed as mean ± standard error, and the categorical variables are expressed as values and percentages. Demographic characteristics were presented according to the hypertension group. Multivariate linear regression analysis was used to analyze the relationship between NLR and research variables, and to determine the potential factors affecting NLR. Logistic regression analysis was used to analyze the association between quartiles of NLR (Q1, Q2, Q3, Q4) and hypertension. Restricted cubic spline (RCS) regression analysis was used to confirm the nonlinearity of the association between NLR and hypertension. Accounting for the intricate survey design of NHANES, all statistical analyses have been adjusted with appropriate weights. All statistical analyses in this study were performed in R Studio software (version 4.4.1). A p-value < 0.05 was considered to indicate statistical significance.

3. Results

3.1 Baseline Characteristics of Participants

The baseline characteristics of the diabetes was presented in Table 1, categorized based on the hypertension or without hypertension. Age, gender, race, marital status, smoke, BMI, physical activity, NLR, HbA1c, fasting blood glucose, platelet count, total cholesterol and LDL were all found to be significantly associated with hypertension($p<0.05$). Specifically, compared with diabetes without hypertension, diabetes with hypertension tended to be age≥60, male, married/Living with partner, BMI ≥ 30kg/m^2, non-Hispanic White, no poor, Higher than high school, fomer smoker, inactive physical activity , lower platelet counts and higher NLR.

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Table 1: Baseline characteristics of study population according to Hypertension.

Characteristics	**Overall** ***N=6472***	**Hypertension** ***N=4642***	**Without hypertension** ***N=1830***	***P-value***
Age, years(%):	60.9 ±13.8	63.4 ±12.2	54.6 ±15.4	<0.001
18-39	517 (11.0%)	198 (4.27%)	319 (17.4%)	
40-59	2051 (36.3%)	1289 (27.8%)	762 (41.6%)	
>=60	3904 (53.7%)	3155 (68.0%)	749 (40.9%)	
Gender(%):				0.004
Male	3349 (51.7%)	2349 (50.6%)	1000 (54.6%)	
Female	3123 (48.3%)	2293 (49.4%)	830 (45.4%)	
Race (%):				<0.001
Mexican American	1192 (9.3%)	748 (16.1%)	444 (24.3%)	
Other Hispanic	673 (5.7%)	478 (10.3%)	195 (10.7%)	
Non-Hispanic White	2242 (63.4%)	1628 (35.1%)	614 (33.6%)	
Non-Hispanic Black	1660 (13.1%)	1346 (29.0%)	314 (17.2%)	
Other Race	705 (8.5%)	442 (9.52%)	263 (14.4%)	
Marital status (%):				<0.001
Married/Living with partner	3825 (64.1%)	2681 (57.8%)	1144 (62.5%)	
Widowed/Divorced/Separated	2618 (35.6%)	1950 (42.0%)	668 (36.5%)	
Never married	29 (0.33%)	11 (0.24%)	18 (0.98%)	
PIR(%):				0.638
No poor	5091 (85.7%)	3644 (78.5%)	1447 (79.1%)	
Poor	1381 (14.3%)	998 (21.5%)	383 (20.9%)	
Education level%:				0.859
Lower than high school	1158 (10.0%)	825 (17.8%)	333 (18.2%)	
Completed high school	1061 (12.3%)	767 (16.6%)	294 (16.1%)	
Higher than high school	4241 (77.7%)	3039 (65.6%)	1202 (65.7%)	
BMI, kg/cm^2(%):				<0.001
<18.5	24 (0.38%)	13 (0.29%)	11 (0.62%)	
18.5-24.9	824 (13.1%)	501 (11.1%)	323 (18.1%)	
25-29.9	1792 (28.5%)	1246 (27.6%)	546 (30.6%)	
>30	3655 (58.1%)	2748 (61.0%)	907 (50.8%)	
Smoke(%):				<0.001
Former smoker	3259 (49.7%)	2318 (50.0%)	941 (51.8%)	
Current smoker	2155 (35.0%)	1633 (35.3%)	522 (28.7%)	
Never smoker	1035 (15.3%)	681 (14.7%)	354 (19.5%)	
Drinking(%):				0.874
No drinking	5538 (93.0%)	3990 (94.4%)	1548 (94.6%)	
Drinking	325 (7.0%)	236 (5.58%)	89 (5.44%)	
Physical activity level(%):				0.002
Inactive	3976 (58.1%)	2909 (65.9%)	1067 (61.4%)	
Moderate	1269 (24.9%)	891 (20.2%)	378 (21.8%)	
Vigorous	905 (17.0%)	613 (13.9%)	292 (16.8%)	
NLR	2.48 ± 0.03	2.40 ± 1.47	2.28 ± 1.27	0.001
HbA1c(%)	7.14 ± 0.03	7.22 ± 1.68	7.44 ± 2.00	<0.001
Fasting blood glucose(mg/dL)	93.90 ± 1.60	80.6 ± 88.5	85.9 ± 94.3	0.039
Platelet count(/μl)	243.14 ± 1.55	240 ± 72.2	247 ± 73.0	0.002
Triglyceride(mmol/L)	2.13 ± 0.04	2.07 ± 1.63	2.13 ± 2.06	0.202
Total cholesterol(mmol/L)	4.69 ± 0.02	4.64 ± 1.37	4.86 ± 1.35	<0.001
LDL(mmol/L)	1.53 ± 0.03	1.29 ± 1.49	1.45 ± 1.60	<0.001
HDL(mmol/L)	3.01 ± 0.20	3.43 ± 14.5	2.74 ± 12.1	0.054

The continuous variables are expressed by mean ± standard error (Se). Categorical variables are expressed by counting (weighted percentage) ; Abbreviation : NLR : immune inflammation index, calculated by the ratio of neutrophil count / lymphocyte count ; pIR : poverty income ratio, non-poverty income ratio ≥ 1, poverty income ratio < 1 ; BMI : Body mass index; HbA1c :glycated hemoglobin a1c.

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3.2 The association between NLR quartiles and research variables.

Table 2: Baseline characteristics of study population according to NLR quartiles.

Characteristics	Q1	Q2	Q3	Q4	p-value
	N=1971	*N=1580*	*N=1532*	*N=1389*	
Age,years(%):					<0.001
18-39	173 (8.8%)	138 (8.7%)	127 (8.3%)	79 (5.7%)	
40-59	698 (35.4%)	541 (34.2%)	469 (30.6%)	343 (24.7%)	
>=60	1100 (55.8%)	901 (57.0%)	936 (61.1%)	967 (69.6%)	
Gender(%):					<0.001
Female	1064 (54.0%)	808 (51.1%)	701 (45.8%)	550 (39.6%)	
Male	907 (46.0%)	772 (48.9%)	831 (54.2%)	839 (60.4%)	
Race(%):					<0.001
Mexican American	330 (16.7%)	353 (22.3%)	303 (19.8%)	206 (14.8%)	
Non-Hispanic Black	766 (38.9%)	357 (22.6%)	308 (20.1%)	229 (16.5%)	
Non-Hispanic White	429 (21.8%)	501 (31.7%)	608 (39.7%)	704 (50.7%)	
Other Hispanic	205 (10.4%)	183 (11.6%)	157 (10.2%)	128 (9.2%)	
Other Race	241 (12.2%)	186 (11.8%)	156 (10.2%)	122 (8.78%)	
Marital status (%):					0.433
Married/Living with partner	1151 (58.4%)	955 (60.4%)	892 (58.2%)	827 (59.5%)	
Widowed/Divorced/Separated	810 (41.1%)	616 (39.0%)	632 (41.3%)	560 (40.3%)	
Never married	10 (0.5%)	9 (0.6%)	8 (0.5%)	2 (0.1%)	
PIR(%):					0.170
No poor	1546 (78.4%)	1241 (78.5%)	1184 (77.3%)	1120 (80.6%)	
poor	425 (21.6%)	339 (21.5%)	348 (22.7%)	269 (19.4%)	
Education level%:					0.014
Lower than high school	376 (19.1%)	313 (19.8%)	264 (17.3%)	205 (14.8%)	
Completed high school	324 (16.5%)	243 (15.4%)	256 (16.7%)	238 (17.2%)	
higher than high school	1267 (64.4%)	1023 (64.8%)	1010 (66.0%)	941 (68.0%)	
BMI, kg/cm^2(%):					0.012
<18.5	7 (0.36%)	1 (0.06%)	7 (0.47%)	9 (0.7%)	
18.5-24.9	244 (12.6%)	193 (12.5%)	183 (12.3%)	204 (15.3%)	
25-29.9	586 (30.3%)	419 (27.1%)	414 (27.8%)	373 (28.0%)	
>30	1096 (56.7%)	931 (60.3%)	884 (59.4%)	744 (55.9%)	
Smoke(%):					<0.001
Never smoker	300 (15.3%)	247 (15.7%)	265 (17.4%)	223 (16.1%)	
Current smoker	582 (29.6%)	493 (31.3%)	506 (33.2%)	574 (41.4%)	
Former smoker	1082 (55.1%)	834 (53.0%)	754 (49.4%)	589 (42.5%)	
Drinking(%):					0.642
No drinking	1687 (94.6%)	1375 (95.0%)	1294 (94.1%)	1182 (94.0%)	
Drinking	97 (5.4%)	72 (5.0%)	81 (5.9%)	75 (5.97%)	
Physical activity level(%):					0.089
Inactive	1204 (64.4%)	954 (63.3%)	933 (64.0%)	885 (67.3%)	
Moderate	393 (21.0%)	303 (20.1%)	307 (21.1%)	266 (20.2%)	
Vigorous	272 (14.6%)	251 (16.6%)	218 (15.0%)	164 (12.5%)	
Hypertension:					0.001
Yes	1393 (70.7%)	1087 (68.8%)	1130 (73.8%)	1032 (74.3%)	
No	578 (29.3%)	493 (31.2%)	402 (26.2%)	357 (25.7%)	
HbA1c (%)	7.30 ± 1.81	7.37 ± 1.82	7.32 ± 1.81	7.13 ± 1.65	0.002
Fasting blood glucose(mg/dL)	79.7 ± 89.3	82.9 ± 91.0	84.3 ± 93.7	82.4 ± 86.7	0.491
Platelet count(/μl)	244 ±68.4	243 ± 71.0	242 ± 73.6	239 ± 78.0	0.250
Triglyceride(mmol/L)	2.13 ± 1.87	2.14 ± 1.73	2.14 ± 1.97	1.89 ± 1.34	<0.001
Total cholesterol(mmol/L)	4.91 ± 1.36	4.76 ± 1.36	4.60 ± 1.43	4.46 ± 1.26	<0.001
LDL(mmol/L)	1.39 ± 1.59	1.35 ± 1.54	1.29 ± 1.50	1.29 ± 1.44	0.173
HDL(mmol/L)	2.62 ± 11.5	3.24 ± 13.9	4.39 ± 17.4	2.81 ± 12.3	0.001

Mean ± SD for continuous variables: the p-value was calculated by a weighted linear regression model. % for categorical variables: the p-value was calculated by chi-square test. Q,quartile; BMI, body mass index; NLR, The neutrophil-lymphocyte ratio; HbA1c :glycated hemoglobin A1c.

Table2 was a weighted demographic feature analysis based on the NLR quartile level. There were

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significant differences in age, gender, race, education level, BMI, smoking and hypertension among NLR quartile participants ($P < 0.05$). Participants in the fourth quartile (Q4) of the NLR quartile tended to be older (69.6 % over 60 years), male (60.4 %), Non-Hispanic White (50.7 %), Married / Living with partner (59.5 %), higher than high school (68.0 %), BMI ≥ 30 kg / cm2 (55.9 %), Former smoker (42.5 %). Inactive physical activity (67.3 %), hypertension (74.3 %). There were also significant differences between NLR and HbA1c, Triglyceride, Total cholesterol and HDL in the quartile, with the highest in the third quartile (Q3).

3.3 Relationship between NLR and hypertension

Table3 analyzed the correlation between NLR quartiles and hypertension by weighted logistic regression model. In the unadjusted model, compared to the first percentile, the fourth percentile increased by 44% (Model 1, OR=1.44, 95% CI [1.16, 1.79], p=0.001); in the partially adjusted model, compared to the first percentile, the fourth percentile increased by 27% (Model 2, OR=1.27, 95% CI [1.02, 1.59], p=0.032); in the fully adjusted model, compared to the first percentile, the fourth percentile increased by 35% (Model 3, OR=1.35, 95% CI [1.06, 1.71], p=0.017). All three models demonstrate that the risk of hypertension significantly increases with the rise in NLR quartiles, particularly in the upper quartiles (Q3 and Q4). The trend tests all have P<0.05, which was statistically significant.

Table 3: Logistic regression analysis between NLR quartiles and hypertension.

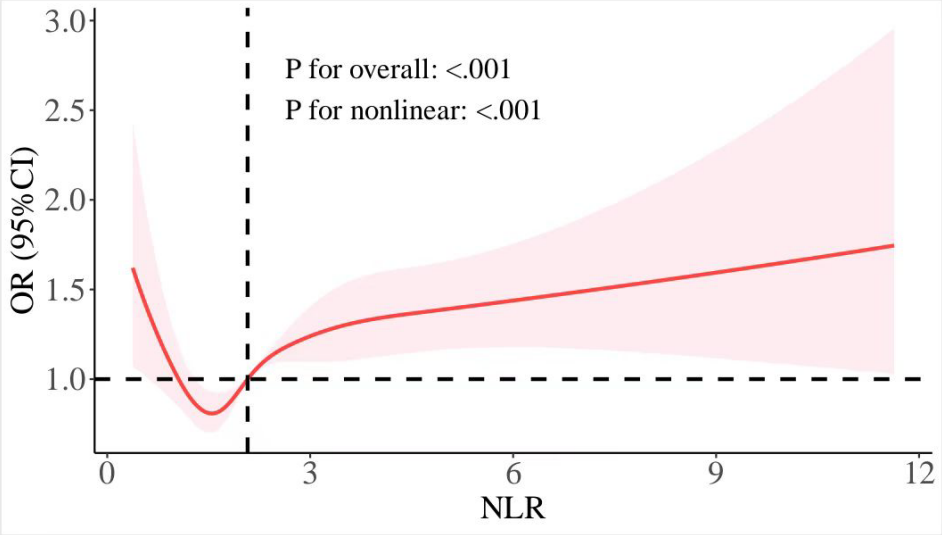
	Model 1 OR (95%CI) P value	Model2 OR (95%CI) P value	Model3 OR (95%CI) P value
NLR quartiles			
Q1	Reference	Reference	Reference
Q2	1.04 [0.84, 1.28] 0.731	1.04 [0.84, 1.30] 0.710	1.12 [0.89, 1.41] 0.324
Q3	1.37 [1.08, 1.73] 0.009	1.33 [1.04, 1.69] 0.022	1.39 [1.08, 1.80] 0.011
Q4	1.44 [1.16, 1.79] 0.001	1.27 [1.02, 1.59] 0.032	1.35 [1.06, 1.71] 0.017
P for trend	<0.001	0.016	0.015

Model 1:Unadjusted; Model 2:Adjusted for age (18-39, 40–59 and ≥60 years), gender; Model 3:Adjusted for age, gender, race, marital status, education level, poverty income ratios, smoke, HbA1c , Physical activity level, triglyceride, total cholesterol, HDL.

3.4 Non-linear relationship between NLR and hypertension

RCS analyzed the nonlinear relationship between NLR and hypertension. As shown in Fig 2A, it was proved that there is a significant nonlinear positive correlation between NLR and hypertension ($p < 0.001$, nonlinear $p < 0.001$) ; after adjusting the covariates(see Fig 2B), the non-linear positive correlation between NLR and hypertension was still significant ($p < 0.001$, non-linear $p < 0.001$).

A.



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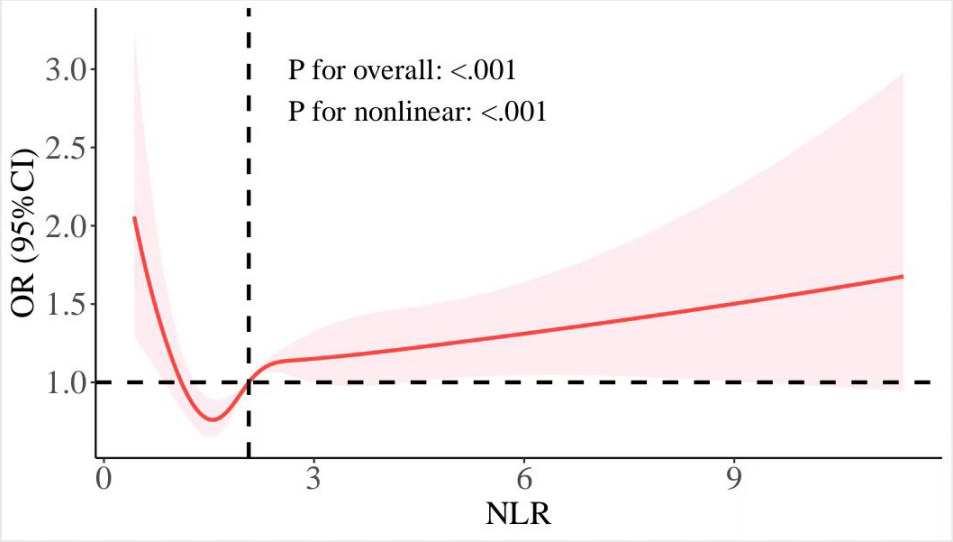
B



A : Not adjusted . B:Variables of age (18–39, 40–59 and ≥60years), race, education level, and poverty income ratios, marital, BMI, smoke, physical activity level, HbA1c, triglyceride, total cholesterol, LDL were adjusted. Abbreviations: RCS, restricted cubic spline. P nonlinear > 0.05 implies a significant linear relationship.

Figure 2: The association between NLR levels and hypertension was determined by weighted RCS analysis.

4. Discussion

In this cross-sectional study, we mainly focused on exploring the association between neutrophil / lymphocyte ratio (NLR) and hypertension in diabetic patients. Because the level of inflammation has an important impact on the occurrence of hypertension. Our data were extracted from the diabetic population over 18 years of age enrolled in the NHANES from 2005 to 2018. After adjusting for other covariates, we found that compared with diabetic patients with low NLR quartiles, diabetes with high NLR quartiles had a higher incidence of hypertension. In order to test whether this relationship is non-linear, we found a non-linear positive correlation between NLR levels and the prevalence of hypertension after using multivariate adjustment of unrestricted cubic splines. In short, this can indicate that the inflammatory marker NLR is closely related to hypertension events. A large-scale cohort study also proved the same results, consistent with our study[6].

The pathogenesis of hypertension is multifactorial and complex.Numerous studies have shown that inflammation plays an important role in the pathogenesis of hypertension[15, 16]. The immune system plays a central role in the development of hypertension[16-18]. Some harmful factors, including viral infection, autoimmune diseases and lifestyle factors, can trigger immune responses. Activated immune cells release inflammatory factors, causing chronic inflammation, leading to kidney and endothelial cell dysfunction and organ damage, and ultimately contributing to the formation of hypertension[17]. In addition, oxidative stress is also closely related to the formation of hypertension[19, 20]. Inflammation and oxidative stress are interrelated in the pathogenesis of hypertension, which significantly leads to hypertension-related vascular dysfunction and renal injury[20]. Under pathological conditions, increased release of reactive oxygen species (ROS) and decreased nitric oxide (NO) can lead to renal function damage, vascular damage, chronic inflammation and hypertension[21].

In recent years, a large number of studies have emphasized that systemic inflammatory markers are closely related to cardiovascular disease[22]. For example, a cross-sectional study found a positive correlation between systemic inflammatory markers SII and NLR and the prevalence of hypertension[23]. Similarly, a study based on NHANES data found that elevated NLR was positively correlated with the risk of all-cause and cardiovascular death in hypertensive patients[24]. In addition, a study has shown that indirect inflammatory markers such as high-sensitivity C-reactive protein (hsCRP), systemic inflammatory response index (SIRI) and neutrophil-to-monocyte ratio (NMR) are positively correlated with the risk of hypertension in HIV-infected patients[25]. However, there are

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also a large number of studies have reported that increased levels of inflammatory markers in diabetic patients are closely related to the occurrence of CVD events[26-28]. To our knowledge, few studies have individually assessed the association between NLR and the risk of hypertension in diabetic patients. Our study will not only enrich the research literature on the role of NLR in cardiovascular health, but also provide valuable insights for clinical practice.

Our research has limitations in some aspects. First, although we try to identify and incorporate possible confounding factors, there may still be some variables that we cannot quantify. Secondly, due to the incompleteness or lack of data, some participants were not included in the analysis. In spite of this, our study still provides new insights into the role of NLR in hypertension and its potential mechanism.

In conclusion, higher NLR levels are closely related to hypertension in the American diabetic population. The current research results need to be verified by more research in the future and explore the underlying mechanism behind it.

Ethics Statement

The ethical review committee of the National Center for Health Statistics has approved the NHANES project, and all participants have submitted written informed consent.

Data availability statement

The original data of this study can be downloaded directly from the public database, it can be obtained by visiting the following links: https://www.cdc.gov/nchs/nhanes/index.htm. For further consultation, please contact the author.

References

[1] RICHARDSON L C, VAUGHAN A S, WRIGHT J S, et al. Examining the Hypertension Control Cascade in Adults With Uncontrolled Hypertension in the US [J]. JAMA Netw Open, 2024, 7(9): e2431997.

[2] ROTH G A, MENSAH G A, JOHNSON C O, et al. Global Burden of Cardiovascular Diseases and Risk Factors, 1990-2019: Update From the GBD 2019 Study [J]. J Am Coll Cardiol, 2020, 76(25): 2982-3021.

[3] HENGEL F E, BENITAH J P, WENZEL U O. Mosaic theory revised: inflammation and salt play central roles in arterial hypertension [J]. Cell Mol Immunol, 2022, 19(5): 561-76.

[4] BUFORD T W. Hypertension and aging [J]. Ageing Res Rev, 2016, 26: 96-111.

[5] GARCíA-ESCOBAR A, VERA-VERA S, TéBAR-MáRQUEZ D, et al. Neutrophil-to-lymphocyte ratio an inflammatory biomarker, and prognostic marker in heart failure, cardiovascular disease and chronic inflammatory diseases: New insights for a potential predictor of anti-cytokine therapy responsiveness [J]. Microvasc Res, 2023, 150: 104598.

[6] JHUANG Y H, KAO T W, PENG T C, et al. Neutrophil to lymphocyte ratio as predictor for incident hypertension: a 9-year cohort study in Taiwan [J]. Hypertens Res, 2019, 42(8): 1209-14.

[7] CHEN X, LI A, MA Q. Neutrophil-lymphocyte ratio and systemic immune-inflammation index as predictors of cardiovascular risk and mortality in prediabetes and diabetes: a population-based study [J]. Inflammopharmacology, 2024, 32(5): 3213-27.

[8] CHEN G, CHE L, LAI M, et al. Association of neutrophil-lymphocyte ratio with all-cause and cardiovascular mortality in US adults with diabetes and prediabetes: a prospective cohort study [J]. BMC Endocr Disord, 2024, 24(1): 64.

[9] CHEN H L, WU C, CAO L, et al. The association between the neutrophil-to-lymphocyte ratio and type 2 diabetes mellitus: a cross-sectional study [J]. BMC Endocr Disord, 2024, 24(1): 107.

[10] Lloyd-Jones D M, Ning H, Labarthe D, et al. Status of cardiovascular health in US adults and children using the American Heart Association's new "Life's Essential 8" metrics: prevalence estimates from the National Health and Nutrition Examination Survey (NHANES), 2013 through 2018[J]. Circulation, 2022, 146(11): 822-835.

[11] JOHNSON C L, DOHRMANN S M, BURT V L, et al. National health and nutrition examination survey: sample design, 2011-2014 [J]. Vital Health Stat 2, 2014, (162): 1-33.

[12] LOPRINZI P D, RAMULU P Y. Objectively measured physical activity and inflammatory markers

ISSN 2618-1584 Vol. 6, Issue 12: 28-36, DOI: 10.25236/FMSR.2024.061205

among US adults with diabetes: implications for attenuating disease progression [J]. Mayo Clin Proc, 2013, 88(9): 942-51.
[13] MUNTNER P, HARDY S T, FINE L J, et al. Trends in Blood Pressure Control Among US Adults With Hypertension, 1999-2000 to 2017-2018 [J]. Jama, 2020, 324(12): 1190-200.
[14] DONG G, GAN M, XU S, et al. The neutrophil-lymphocyte ratio as a risk factor for all-cause and cardiovascular mortality among individuals with diabetes: evidence from the NHANES 2003-2016 [J]. Cardiovasc Diabetol, 2023, 22(1): 267.
[15] DE MIGUEL C, PELEGRíN P, BAROJA-MAZO A, et al. Emerging Role of the Inflammasome and Pyroptosis in Hypertension [J]. Int J Mol Sci, 2021, 22(3).
[16] MOUTON A J, LI X, HALL M E, et al. Obesity, Hypertension, and Cardiac Dysfunction: Novel Roles of Immunometabolism in Macrophage Activation and Inflammation [J]. Circ Res, 2020, 126(6): 789-806.
[17] MADHUR M S, ELIJOVICH F, ALEXANDER M R, et al. Hypertension: Do Inflammation and Immunity Hold the Key to Solving this Epidemic? [J]. Circ Res, 2021, 128(7): 908-33.
[18] WENZEL U, TURNER J E, KREBS C, et al. Immune Mechanisms in Arterial Hypertension [J]. J Am Soc Nephrol, 2016, 27(3): 677-86.
[19] DIKALOVA A E, PANDEY A, XIAO L, et al. Mitochondrial Deacetylase Sirt3 Reduces Vascular Dysfunction and Hypertension While Sirt3 Depletion in Essential Hypertension Is Linked to Vascular Inflammation and Oxidative Stress [J]. Circ Res, 2020, 126(4): 439-52.
[20] SMALL H Y, MIGLIARINO S, CZESNIKIEWICZ-GUZIK M, et al. Hypertension: Focus on autoimmunity and oxidative stress [J]. Free Radic Biol Med, 2018, 125: 104-15.
[21] TOUYZ R M. Reactive oxygen species, vascular oxidative stress, and redox signaling in hypertension: what is the clinical significance? [J]. Hypertension, 2004, 44(3): 248-52.
[22] LAWLER P R, BHATT D L, GODOY L C, et al. Targeting cardiovascular inflammation: next steps in clinical translation [J]. Eur Heart J, 2021, 42(1): 113-31.
[23] XU J P, ZENG R X, ZHANG Y Z, et al. Systemic inflammation markers and the prevalence of hypertension: A NHANES cross-sectional study [J]. Hypertens Res, 2023, 46(4): 1009-19.
[24] ZHANG X, WEI R, WANG X, et al. The neutrophil-to-lymphocyte ratio is associated with all-cause and cardiovascular mortality among individuals with hypertension [J]. Cardiovasc Diabetol, 2024, 23(1): 117.
[25] OU-YANG H, FU H Y, LUO Y, et al. Inflammation markers and the risk of hypertension in people living with HIV [J]. Front Immunol, 2023, 14: 1133640.
[26] HOES L L F, RIKSEN N P, GELEIJNSE J M, et al. Relationship of neutrophil-to-lymphocyte ratio, in addition to C-reactive protein, with cardiovascular events in patients with type 2 diabetes [J]. Diabetes Res Clin Pract, 2024, 213: 111727.
[27] VERDOIA M, SCHAFFER A, BARBIERI L, et al. Impact of diabetes on neutrophil-to-lymphocyte ratio and its relationship to coronary artery disease [J]. Diabetes Metab, 2015, 41(4): 304-11.
[28] HE J, BIAN X, SONG C, et al. High neutrophil to lymphocyte ratio with type 2 diabetes mellitus predicts poor prognosis in patients undergoing percutaneous coronary intervention: a large-scale cohort study [J]. Cardiovasc Diabetol, 2022, 21(1): 156.