Qiu *et al. BMC Endocrine Disorders* (2024) 24:155
https://doi.org/10.1186/s12902-024-01689-z

BMC Endocrine Disorders

RESEARCH Open Access

# Predictive role of neutrophil-to-lymphocyte ratio in metabolic syndrome: Meta-analysis of 70,937 individuals

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## Abstract

**Objective** Neutrophil-to-lymphocyte ratio (NLR) has been shown to be an independent predictor for cardiovascular diseases and metabolic diseases. The role of NLR in metabolic syndrome (MS) has also been explored albeit with conflicting results. The objective of this study was to assess the predictive role of NLR in MS.

**Methods** We conducted a meta-analysis of observational studies to evaluate the predictive role of NLR in MS. Cochrane library, PubMed, Medline, Embase, and Scopus were systematically searched from their inception to December 2023. The Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines was followed. The statistical analysis was performed using RevMan 5.3 software. A randomeffect model was used.

**Results** Twenty six studies enrolling 70,937 individuals were included in this meta-analysis. Compared with the individuals without MS, NLR value was significantly higher in the patients of MS (mean difference (MD) 0.40, 95% confidence intervals (CI): 0.27–0.52, $P<0.00001$, $I^2=97\%$). The derived NLR value also was significantly higher in participants with MS than those without MS (MD 0.48, 95%CI: 0.13–0.84, $P=0.007$, $I^2=96\%$). There was no statistically significant association for NLR between the patients with 4 metabolic risk factors (MRF) and those with 3 MRF, or between patients with 5 MRF and those with 4 MRF (MD 0.16, 95%CI: -0.02-0.35, $P=0.10$, $I^2=84\%$; MD 0.12, 95%CI: -0.06-0.29, $P=0.20$, $I^2=68\%$). However, MS patients with 5 MRF had a significantly higher mean NLR value than those with 3MRF (MD 0.37, 95%CI: 0.05–0.68, $P=0.02$, $I^2=92\%$). Compared with the individuals with low NLR, incidence of MS was significantly higher in those with high NLR (OR 2.23, 95%CI: 1.25–3.98, $P=0.006$, $I^2=97\%$).

**Conclusion** The findings of our meta-analysis suggested that the value of NLR and derived NLR were higher in MS patients. MS patients with 5 MRF had a significantly higher mean NLR value. High NLR also demonstrated a significantly increased the incidence of MS. NLR may be a good predictive biomarker in MS.

**Keywords** Neutrophil-to-lymphocyte ratio, Metabolic syndrome, Meta-analysis

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## Introduction

Metabolic syndrome (MS) is a cluster of disorders that together raise the risk of cardiovascular disease, diabetes, stroke, or all three. The main components of MS are obesity, hypertension, hypertriglyceridemia, low high-density lipoprotein cholesterol, and impaired fasting glucose or diabetes. The prevalence of MS ranges from 20 to 45% of the worldwide population, and the incidence of MS is expected to increase to approximately 53% by 2035 [1].

The levels of 3 systemic inflammatory markers, high-sensitivity C-reactive protein, tumor necrosis factor-a, and interleukin 6, have been found to be high in MS [2]. The causes of MS are complex and not well-understood. Many studies have shown that MS, like its downstream sequelae of atherosclerosis, cardiovascular disease, and diabetes, is an inflammatory disorder [3]. A variety of inflammatory markers and cell types have emerged as significant mediators of the development and progression of the MS [4]. Inflammation also appears to be an effective predictor of the prognosis of MS and its sequelae [5].

During inflammatory processes, leukocyte parameters in the circulation became activated and recruited. Recently, leukocyte parameters, including neutrophils, lymphocytes, the neutrophil-to-lymphocyte ratio (NLR), the platelet-to-lymphocyte ration (PLR), and the derived NLR, have been found to be closely related to the MS and cardiovascular diseases [6–9]. Buyukkaya E et al. first reported that NLR could contribute to identifying the presence and the severity of MS 9. The similar results were reached in many studies [10–20]. However, Several studies have shown that there was no significant difference for the comparison of NLR between the patients with MS and without MS [21–29]. Dervied NLR defined as absolute neutrophil count divided by the derived lymphocyte count (absolute leukocyte count–neutrophil count). Tang K et al. [15] found increased NLR, and dervied NLR positively correlated with MS comorbidities. Therefore, in this meta-analysis, we focus on NLR level and derived NLR level in patients of MS, the NLR level in varying degrees of severity of MS, and the incidence of MS in patients with low and high NLR. The current meta-analysis was performed to clarify the predictive role of NLR in MS.

## Methods

We systematically searched Cochrane library, PubMed, Medline, Embase, and Scopus databases for relevant literature from their inception to December 2023. For the search strategies we used a combination of medical subject heading descriptors and terms relating to the target condition of interest (metabolic syndrome, MetS, and MS) and the index tests (neutrophil-to-lymphocyte ratio, NLR, leukocyte parameters, lecocyte parameters, and complete blood parameters).

### Study selection

This meta-analysis is bases on studies from literature and does not include any studies involving human participants performed by the authors. We looked for the clinical studies that met all of the following criteria: (1) participants in the studies were diagnosed MS; (2) studies reported the NLR value by mean ± standard error (SD); (3) groups divided into MS group and control group, or high NLR group and low NLR group; (4) observational studies that examined the relationship between MS and NLR. The excluded criteria were: (1) studies which required data were not available; (2) letters, reviews, expert opinion, case reports, editorials or abstract; (3) non-human or nonclinical research; (4) duplicate publications; (5) non-English publications.

### Data extraction, quality assessment and publication bias

The relevant data were gathered independently by two investigators. Any disagreements in data extraction or quality assessment were resolved through discussion. The following information was extracted from included study: (1) publication details (first author name, publication year, country of study, and study design); (2) individual details (sample size, age, gender, and severity of MS); (3) diagnostic criteria of MS in included study; (4) NLR data (mean ± SD) or numbers of MS patients were compared between in the high NLR group and in the low NLR group.

The quality of case-control study and retrospective cohort study were evaluated by the Newcastle-Ottawa Quality Assessment Scale (NOS) [30]. The quality of cross-sectional study was evaluated by the Agency for Healthcare Research and Quality (AHRQ) [31]. The score of NOS > 6 and the stars of AHRQ > 8 were defined as high-quality studies.

Egger test and Begg test were employed to evaluate the publication bias. When values of $P < 0.05$, the difference was considered statistically and there was publication bias. Leave-one-out sensitivity analysis was conducted to determine the relationship between NLR and MS.

### Statistical analysis

The statistical meta-analysis was performed by Review Manager software, version 5.3 (The Nordic Cochrane Centre, Rigshospitalet, Copenhagen, Denmark). The heterogeneity of the included studies was tested by Cochran's Q statistic and $I^2$ test. Higher $I^2$ was indicative of high heterogeneity, and then a random effects model was estimated the results ($P < 0.1$ and $I^2$ test value > 50%). Weighted mean differences (MD), 95% confidence intervals (CI), and odds ratio (OR) were used to investigate the relationship between NLR and MS. Leave-one-out sensitivity analysis was performed after each exclusion to assess the stability of the overall outcome. All statistical

tests were two-tailed and $P<0.05$ was considered statistically significant.

### Data synthesis and reporting

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to estimate the relationship between NLR and MS [32], and PRISMA checklist has been used. The weighted prevalence of NLR in patients with MS was presented using a forest plot.

## Results

### Characteristic of the studies

Figure 1 presents a flow chart showing our meta-analysis of individual articles. A total of 367 articles were identified, of which 45 adhered to the general inclusion criteria and were subjected to further screening. Out of these, 19 articles were excluded: 1 article was letter, 2 were abstract, 2 were review, 8 did not have SD, 6 data repeat or incomplete. The left 26 eligible observational studies, which were included in the final meta-analysis [9–29, 33–37].

These 26 studies covered a total of 70,937 individuals. The basic characteristics of the included studies are shown in Table 1. Overall, 21 studies evaluated the NLR value in patients with and without MS ($n=59,273$). Two studies investigated the derived NLR value in patients with and without MS ($n=763$). Four studies investigated the NLR value with respect to the severity of MS ($n=11,487$). Five studies estimated the relationship between high and low NLR and MS ($n=12,277$). The diagnostic criteria of MS in 14 studies were identified according to National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), the criteria of 7 were identified according to International Diabetes Federation (IDF), the criteria of 2 was identified according to the guidelines for Type 2 Diabetes in China by Diabetes Branch of the Chinese Medical Association, and the criteria of 3 was according to the guidelines issued by the American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI).

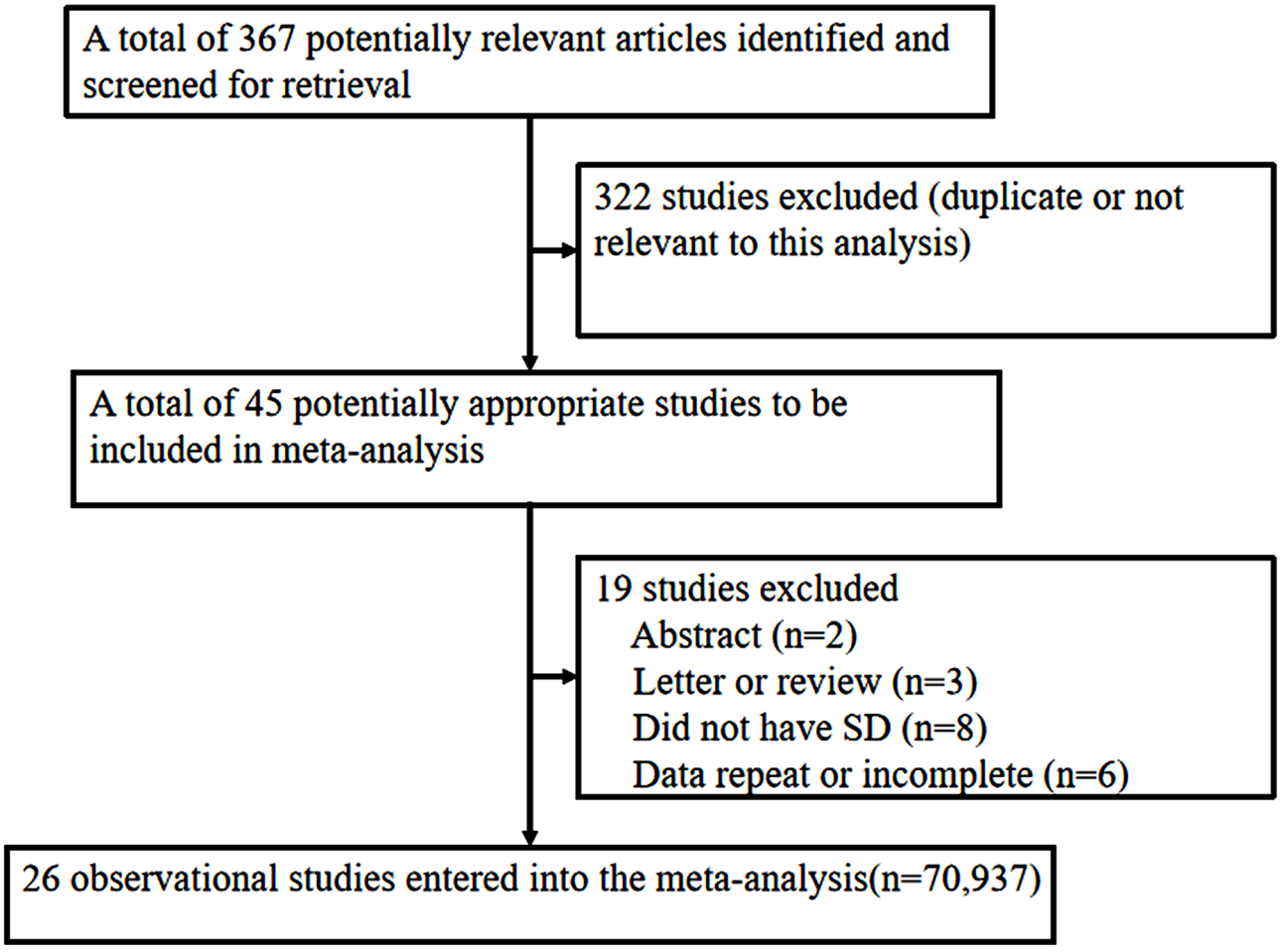


**Fig. 1** Flow diagram of study identification and selection

**Table 1** General characteristics of studies included in meta-analysis

| References | Time | Study design | Country | Sample size | Mean age (year) | Gender, M/F | Diagnostic criteria | Experiment group | Control group | AHQR/NOS (stars/scores) |
|---|---|---|---|---|---|---|---|---|---|---|
| Buyukkaya E [9] | 2014 | Case-control | Turkey | 141 | 47.5 ± 11.7 | 76/65 | NCEP-ATP3 | MS | Non-MS | 8/9 |
| Surendar J [10] | 2016 | Cross-sectional | India | 754 | 48.2 ± 12.2 | 420/334 | NCEP-ATP3 | MS | Non-MS | 10/11 |
| Battaglia S [11] | 2020 | Cross-sectional | Italy | 771 | 56.34 ± 13.63 | 391/380 | IDF | MS | Non-MS | 11/11 |
| Kaya T [12] | 2017 | Cross-sectional | Turkey | 261 | 56.7 ± 10.5 | 113/148 | NCEP-ATP3 | MS | Non-MS | 11/11 |
| Kim JH [13] | 2017 | Cross-sectional | Korea | 1,007 | 48.3 ± 9.7 | 659/348 | NCEP-ATP3 | MS | Non-MS | 10/11 |
| Liu CC [14] | 2019 | Retrospective cohort | Tai Wan | 34,013 | 50.46 ± 11.09 | 23,877/10,136 | NCEP-ATP3 | MS | Non-MS | 7/9 |
| Tang K [15] | 2017 | Retrospective cohort | China | 513 | 52.27 ± 10.95 | 294/219 | NCEP-ATP3 | MS | Non-MS | 7/9 |
| Wang PB [16] | 2022 | Cross-sectional | China | 7,420 | 53.71 ± 8.68 | 3,359/4,061 | IDF | MS | Non-MS | 10/11 |
| Yasar Z [17] | 2015 | Case-control | Turkey | 140 | 65.16 ± 10.3 | 103/37 | IDF | MS | Non-MS | 8/9 |
| Zubiaga L [18] | 2020 | Retrospective cohort | Spain | 200 | 43.9 ± 10.9 | 150/50 | NCEP-ATP3 | MS | Non-MS | 8/9 |
| Li N [19] | 2023 | Cross-sectional | China | 7,726 | 48.40 ± 10.73 | 4,397/3,329 | Chinese Diabetes Society criteria | MS | Non-MS | 10/11 |
| Mohan M [20] | 2021 | Cross-sectional | India | 210 | 57 ± 9.545 | 108/102 | NCEP-ATP3 | MS | Non-MS | 10/11 |
| Bahadir A [21] | 2015 | Cross-sectional | Turkey | 1,267 | 37.7 ± 10.8 | 109/1,068 | NCEP-ATP3 | MS | Non-MS | 11/11 |
| Najafzadeh MJ [22] | 2023 | Cross-sectional | Iran | 1,033 | 45.16 ± 13.88 | 373/660 | NCEP-ATP3 | MS | Non-MS | 10/11 |
| Omrani-Nava V [23] | 2023 | Retrospective cohort | Iran | 1,930 | 35–70 | 842/1,088 | NCEP-ATP3 | MS | Non-MS | 8/9 |
| Ustuntas G [24] | 2021 | Case-control | Turkey | 219 | 70.5 ± 5.4 | 155/64 | NCEP-ATP3 | MS | Non-MS | 8/9 |
| Al-Sarraf IAK [25] | 2018 | cross-sectional | Jordan | 87 | 42.7 ± 1.9 | 41/46 | IDF | MS | Non-MS | 10/11 |
| AbuZayed R [26] | 2019 | Cross-sectional | Jordan | 88 | 49.86 ± 11.34 | 24/64 | IDF | MS | Non-MS | 10/11 |
| Horan AA [27] | 2019 | Cross-sectional | Jordan | 88 | 49.78 ± 10.22 | 24/64 | IDF | MS | Non-MS | 10/11 |
| Mauss D [28] | 2021 | Retrospective cohort | Germany | 689 | 45.5 ± 9.8 | 620/69 | AHA/NHLBI 2009 | MS | Non-MS | 7/9 |
| Song PY [29] | 2022 | Cross-sectional | China | 860 | 61.45 ± 12.5 | 524/336 | IDF | MS | Non-MS | 10/11 |
| Abdel-Moneim A [33] | 2019 | Case-control | Egypt | 250 | 44.08 ± 8.41 | 125/125 | NCEP-ATP3 | MS | Non-MS | 8/9 |
| Lin HY [34] | 2021 | Retrospective cohort | China | 1,542 | 44.8 ± 12.6 | 1,056/486 | Chinese Diabetes Society criteria | High NLR | Low NLR | 9/9 |
| Fang Q [35] | 2018 | Case-control | China | 3,080 | 50.75 ± 10.36 | 0/3,080 | AHA/NHLBI 2005 | High NLR | Low NLR | 8/9 |
| Conteduca V [36] | 2018 | Retrospective cohort | Italy | 336 | 75 | 336/0 | NCEP-ATP3 | High NLR | Low NLR | 9/9 |
| Meng G [37] | 2017 | Cross-sectional | China | 6,312 | 60.28 | 3,821/2,491 | AHA/NHLBI 2009 | High NLR | Low NLR | 10/11 |

M male, F female, NOS Newcastle-Ottawa Scale, NLR neutrophil-to-lymphocyte ratio, MS metabolic syndrome, NCEP ATP III National Cholesterol Education Program Adult Treatment Panel III, AHRQ Agency for Healthcare Research and Quality, AHA/NHLBI American Heart Association/National Heart, Lung, and Blood Institute, IDF International Diabetes Federation

### Quality assessment

Among these 26 studies, 7 were retrospective cohort studies, 14 were cross-sectional studies, and 5 were case-control studies. The mean NOS score of studies in the meta-analysis was 7.9 score, and the mean AHQR star of studies in the meta-analysis was 10.2 stars. All of the included studies had high-quality.

### Level of NLR in MS

The relationship between the NLR value and MS was reported in 21 studies that covered a total of 19,084 MS patients and 40,189 controls [9–29]. Analysis of the overall effect of NLR revealed a significant difference in NLR between individuals in MS and control groups, with evidence of inter-study heterogeneity (MD 0.40, 95%CI: 0.27–0.52, $P<0.00001$, $I^2=97\%$)(Fig. 2). Overall, the NLR value in the patients with MS was higher than those without MS.

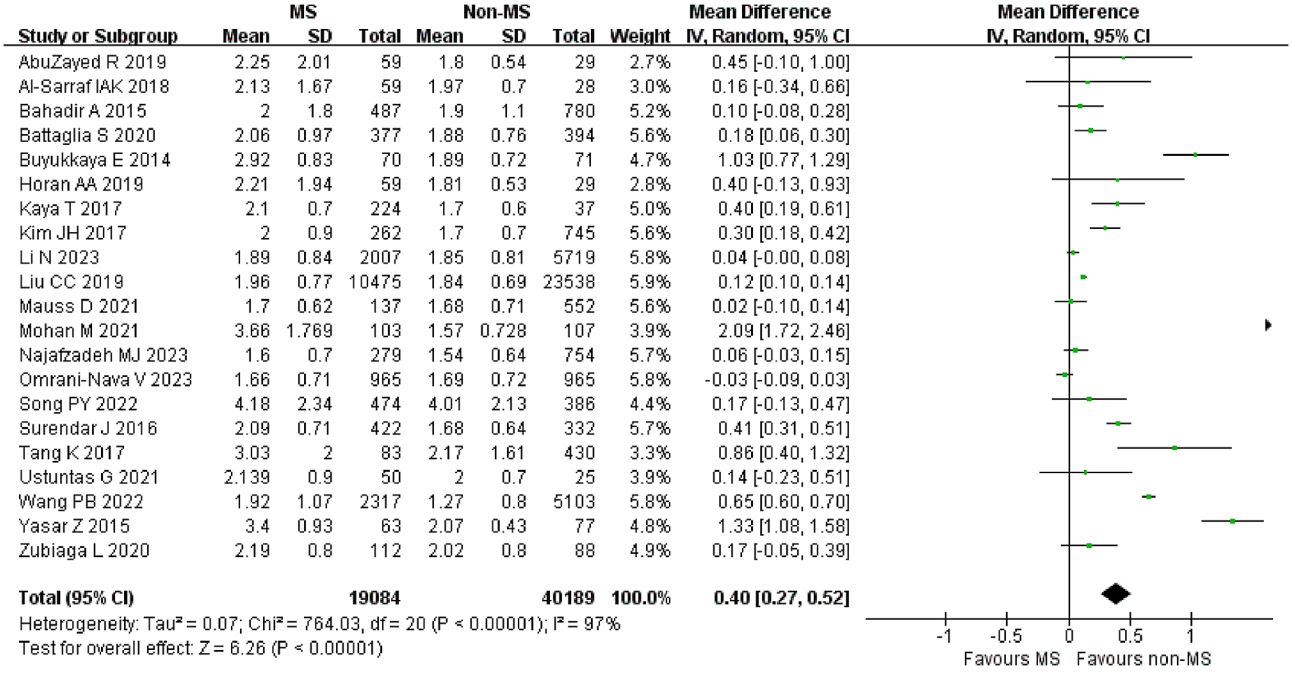


**Fig. 2** The level of NLR in metabolic syndrome

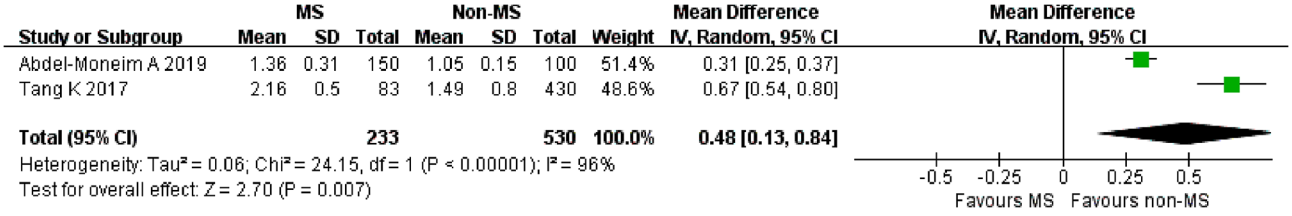


**Fig. 3** The level of derived NLR in metabolic syndrome

### Level of derived NLR in MS

Derived NLR has recently been reported to be a novel potential biomarker associated with MS [15, 33]. Two studies investigated the derived NLR level in patients with and without MS. The meta-analysis covered 233 MS patients and 530 controls. Significant heterogeneity was observed between these 2 groups ($I^2$=96%). Analysis of the overall effect showed the derived NLR value to be significantly higher in MS patients than in controls (MD 0.48, 95%CI: 0.13–0.84, *P*=0.007)(Fig. 3).

### Level of NLR in the severity of MS

Four studies also investigated the association of NLR with the severity of MS [10, 14, 19, 20]. MS patients were classified into 3 groups based on the number of metabolic risk factors (MRF): group 1 (6,884 patients with 3 MRF), group 2 (3,520 patients with 4 MRF), and group 3 (1,083 patients with 5 MRF). There was no significant difference in the overall NLR value between the MS patients with 4 MRF and those with 3 MRF with highly heterogeneous results (MD 0.16, 95%CI: -0.02-0.35, *P*=0.10, $I^2$=84%) (Fig. 4a). Analysis of the overall NLR value between the 5 MRF patients and 4 MRF patients also got the negative result (MD 0.12, 95%CI: -0.06-0.29, *P*=0.20, $I^2$=68%) (Fig. 4c). However, MS patients with 5 MRF had a significantly higher mean NLR value than those with 3MRF (MD 0.37, 95%CI: 0.05–0.68, *P*=0.02, $I^2$=92%)(Fig. 4b).

### Incidence of MS in high and low NLR

Five studies also investigated the incidence of MS in high and low NLR [13, 34–37]. In the meta-analysis, there were 5,242 patients in high NLR group, and 7,035 patients in the low NLR group. The incidence of MS in the high NLR group was 31.21% (*n*=1,636/5,242). In the low NLR group, it was 28.82%(*n*=2,028/7,035). Analysis of the overall effect showed the incidence of MS in the high NLR group to be 2.23 times higher than in the low NLR group (OR 2.23, 95%CI: 1.25–3.98, *P*=0.006, $I^2$=97%)(Fig. 5). Overall, the incidence of MS was significantly higher in the high NLR group than those in the low NLR group.

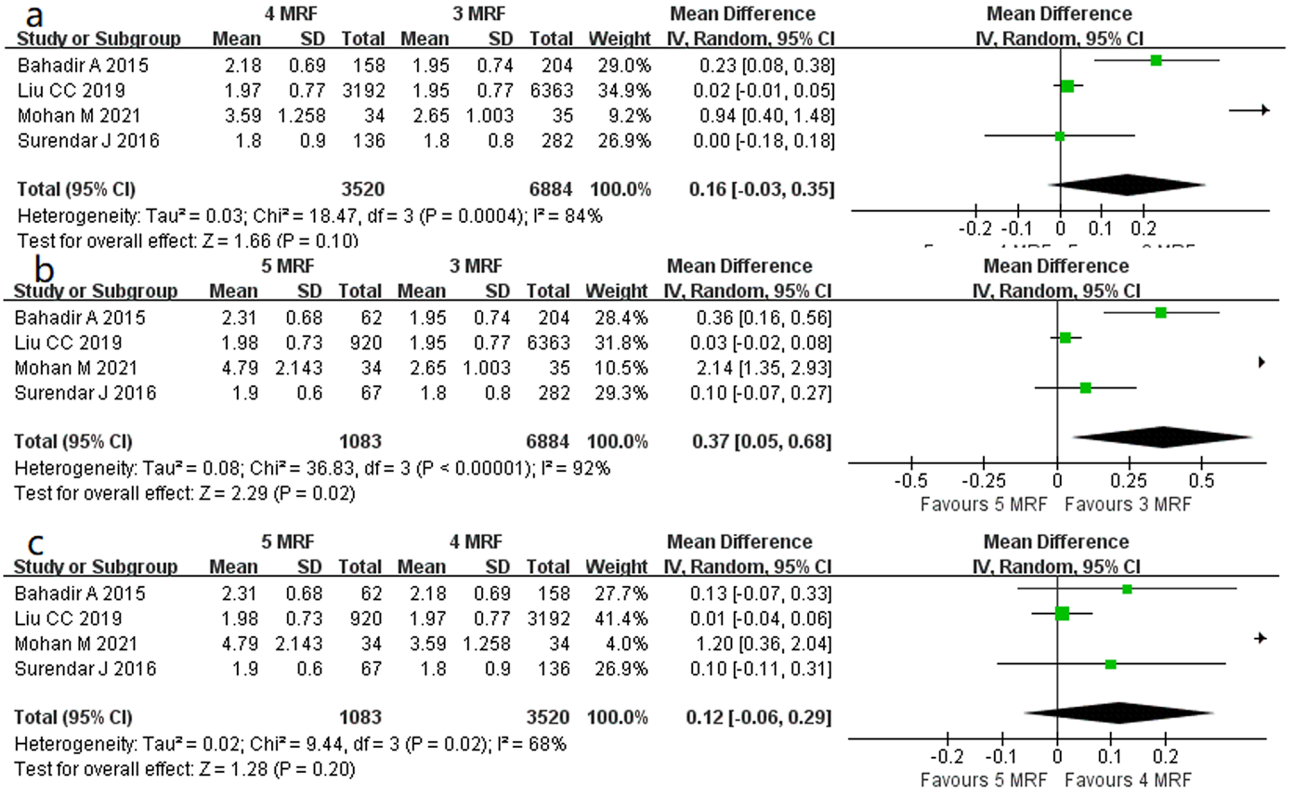


**Fig. 4** The level of NLR in the severity of metabolic syndrome

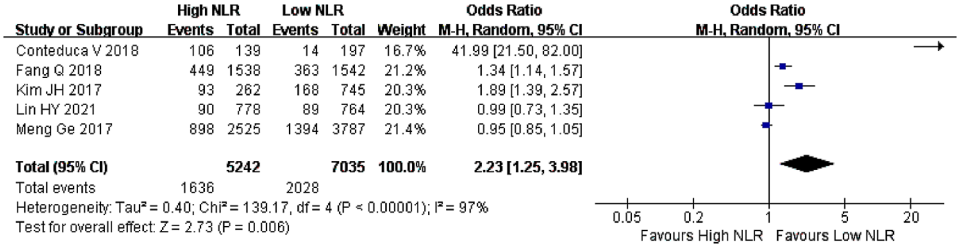


**Fig. 5** Incidence of metabolic syndrome in high and low NLR

### Sensitivity analysis and publication bias

We performed leave-one-out sensitivity analysis to determine the overall effect of NLR level in MS. Leave-one-out results indicated whether an association was or was not disproportionately affected by a specific instrumental variable. The sensitivity analysis confirmed the prognostic role of NLR in MS (Table 2).

No significant publication bias was revealed in our meta-analysis (Begg's test: z = 1.60, *P* = 0.1095 (Figure S1a) and Egger's test: t = 1.77, *P* = 0.0935 (Figure S1b)).

## Discussion

The present meta-analysis summarize the current literature on NLR role in MS. It was based on a large number of studies with a total sample of 70,937 patients. Our findings suggested that both NLR and derived NLR are higher in MS patients. MS patients with 5 MRF had a significantly higher mean NLR value than those with 3MRF. However, when comparing the NLR value between patients with 4 MRF and those with 3 MRF, or between patients with 5 MRF and those with 4 MRF, the results were negative. Higher NLR was associated with an increased risk of MS.

MS is a chronic non-infective disease clinically characterized by a set of vascular risk factors that include arterial hypertension, abdominal obesity, impaired glucose metabolism, and dyslipidemia. Chronic low-grade inflammation was here considered a molecular basis of MS. The evaluated inflammatory markers were found to be related to the different stages of MS. Recently, the ratio of absolute neutrophil count to absolute lymphocyte count was found to have a role as a novel inflammatory biomarker that can dispose individuals to MS, coronary artery disease, diabetes [38]. Studies have indicated that

**Table 2** Sensitivity analysis for the level of NLR in MS

| Omitting study | MD | 95%CI | *P* value | Tau2 | I2 |
|---|---|---|---|---|---|
| / | 0.40 | 0.27–0.52 | < 0.00001 | 0.07 | 97% |
| Buyukkaya E [9] | 0.36 | 0.24–0.49 | < 0.00001 | 0.06 | 97% |
| Surendar J [10] | 0.40 | 0.27–0.52 | < 0.00001 | 0.07 | 97% |
| Battaglia S [11] | 0.41 | 0.28–0.54 | < 0.00001 | 0.07 | 98% |
| Kaya T [12] | 0.40 | 0.27–0.52 | < 0.00001 | 0.07 | 97% |
| Kim JH [13] | 0.40 | 0.27–0.53 | < 0.00001 | 0.07 | 97% |
| Liu CC [14] | 0.43 | 0.26–0.59 | < 0.00001 | 0.12 | 97% |
| Tang K [15] | 0.38 | 0.25–0.51 | < 0.00001 | 0.07 | 97% |
| Wang PB [16] | 0.36 | 0.26–0.46 | < 0.00001 | 0.04 | 95% |
| Yasar Z [17] | 0.35 | 0.22–0.47 | < 0.00001 | 0.06 | 97% |
| Zubiaga L [18] | 0.41 | 0.28–0.54 | < 0.00001 | 0.07 | 98% |
| Li N [19] | 0.42 | 0.28–0.57 | < 0.00001 | 0.09 | 97% |
| Mohan M [20] | 0.32 | 0.21–0.44 | < 0.00001 | 0.06 | 97% |
| Bahadir A [21] | 0.41 | 0.28–0.54 | < 0.00001 | 0.07 | 98% |
| Najafzadeh MJ [22] | 0.42 | 0.29–0.55 | < 0.00001 | 0.07 | 97% |
| Omrani-Nava V [23] | 0.42 | 0.29–0.56 | < 0.00001 | 0.07 | 97% |
| Ustuntas G [24] | 0.41 | 0.28–0.53 | < 0.00001 | 0.07 | 98% |
| Al-Sarraf IAK [25] | 0.40 | 0.28–0.53 | < 0.00001 | 0.07 | 98% |
| AbuZayed R [25] | 0.39 | 0.27–0.52 | < 0.00001 | 0.07 | 98% |
| Horan AA [27] | 0.40 | 0.27–0.52 | < 0.00001 | 0.07 | 98% |
| Mauss D [28] | 0.42 | 0.29–0.55 | < 0.00001 | 0.07 | 97% |
| Song PY [29] | 0.41 | 0.28–0.53 | < 0.00001 | 0.07 | 98% |

MD mean difference, CI confidence intervals;

obesity, hypertension, dyslipidemia, and the incidence of type 2 diabetes, diabetes severity are related to the NLR. In our meta-analysis, we also found the value of NLR to be higher in MS patients, and high NLR could produce an increased risk of MS. Mahmood A et al. [39] conducted a meta-analysis about the association of white blood cell parameters with MS, they also found NLR was higher in MS patients. However, the subjects and studies were much more in our meta-analysis, and we also concerned derived NLR, the severity of MS, and the incidence of MS in high NLR group and in low NLR group in our meta-analysis.

Derived NLR was also used as an inflammatory marker in cardiovascular disease, metabolic syndrome, and cancer [8, 40, 41]. Derived NLR was found to be a suitable laboratory marker capable of predicting major adverse cardiovascular events in coronary heart disease after percutaneous intervention, and its value was higher in MS, prediabetes, and type 2 diabetes mellitus than in healthy controls. We collected the similar results showing derived NLR level to be higher in MS patients.

Surendar J et al. [10] and Liu CC et al. [14] showed subjects with 5 MRF to have the highest NLR. They also showed that, with a decreasing number of MRF, the NLR decreasedin a linear fashion. They found NLR value to be associated with MS severity. However, in Bahadir A's study [20], NLR value in MS subjects with MRF of 3–5 increased gradually, and these increases were not significant. In our meta-analysis, we found MS patients with 5 MRF had a significantly higher mean NLR value than those with 3MRF. The relationship between NLR and the severity of MS warrants further investigation.

NLR is an inflammatory marker affected by lifestyle and health status [42]. It is not clear whether lifestyle interventions meant to lower NLR have any ability to reduce anti-systemic inflammation. Tani S et al. [43] found that NLR value decreased significantly as the weekly frequency of fish intake increased, and the presence of MS was a significant positive determinant of NLR. Sharifan P et al. [44] found vitamin D3 in the form of nanoencapsulated in low-fat dairy products could signifcantly decrease NLR and could also decrease infammation in individuals with abdominal obesity. Future studies should try to identify the effect of lower NLR in MS and cardiovascular diseases.

The limitations of the current meta-analysis were as follows: (1) only studies published in Englishlanguage publications were included; (2) all included studies were observational studies, and high heterogeneity was observed among them; (3) the diagnostic criteria of MS in the included studies were non-uniform. This meta-analysis also had some strengths: (1) all included studies were of high-quality; (2) the number of included studies was large, and it covered diverse baseline population with different ethnicities were included in our meta-analysis.

## Conclusion

NLR and derived NLR have been shown to be higher in MS patients. There was no significant association between NLR and the severity of MS. High NLR was also found to significantly increase the incidence of MS. NLR may be a good predictive biomarker of MS. However, large-scale randomized controlled trials are needed to establish causality.

### Abbreviations

| | |
|---|---|
| MS | Metabolic syndrome |
| NLR | Neutrophil-to-lymphocyte ratio |
| PLR | Platelet-to-lymphocyte ration |
| SD | Standard error |
| NOS | Newcastle-Ottawa Quality Assessment Scale |
| AHRQ | Agency for Healthcare Research and Quality |
| MD | Mean differences |
| CI | Confidence interval |
| OR | odds ratio |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12902-024-01689-z.

Supplementary Material 1: Begg's test and Egger's test for NLR in metabolic syndrome.

### Acknowledgements

Not applicable.

**Author contributions**
Xu Y. Acquisition, analysis, or interpretation of data: Qiu ZQ, Xu CC, Xu Y. Drafting the work or revising: Qiu ZQ, Huang CH. Final approval of the manuscript: Qiu ZQ, Xu Y, Huang CH, Xu CC.

**Funding**
This study was supported by grants from the National Nature Science Foundation of Jiangxi Province (No. 20181BBG78056) and Jiangxi Provincial Health Commission Science and Technology Project (20185212).

**Data availability**
The datasets analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethics approval and consent to participate**
No needed for this meta-analysis of already published data.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

Received: 24 April 2023 / Accepted: 13 August 2024
Published online: 20 August 2024

**References**

1. Engin A. The definition and prevalence of obesity and metabolic syndrome. Adv Exp Med Biol. 2017;960:1–17.
2. Malik MS, Malik M, Sukhera AB, Khalid MA, Waqas A, Qayyum W, et al. Metabolic syndrome and related inflammation, prevalence, and predictive value of C-Reactive protein in south Asian youths. Metab Syndr Relat Disord. 2021;19(9):483–90.
3. Reddy P, Lent-Schochet D, Ramakrishnan N, McLaughlin M, Jialal I. Metabolic syndrome is an inflammatory disorder: a conspiracy between adipose tissue and phagocytes. Clin Chim Acta. 2019;496:35–44.
4. Rodríguez-Vera D, Vergara-Castañeda A, Lazcano-Orozco DK, Ramírez-Vélez G, Vivar-Sierra A, Araiza-Macías MJ, et al. Inflammation Parameters Associated with metabolic disorders: Relationship between Diet and Microbiota. Metab Syndr Relat Disord. 2021;19(9):469–82.
5. Maiorino MI, Bellastella G, Giugliano D, Esposito K. From inflammation to sexual dysfunctions: a journey through diabetes, obesity, and metabolic syndrome. J Endocrinol Invest. 2018;41(11):1249–58.
6. Yang XJ, Tian S, Ma QH, Sun HP, Xu Y, Pan CW. Leukocyte-related parameters in older adults with metabolic syndrome. Endocrine. 2020;68(2):312–19.
7. Qiu Z, Jiang Y, Jiang X, Yang RQ, Wu YQ, Xu Y, et al. Relationship between platelet to lymphocyte ratio and stable coronary artery disease: Meta-Analysis of Observational studies. Angiology. 2020;71(10):909–15.
8. Liu GQ, Zhang WJ, Shangguan JH, Zhu XD, Wang W, Guo QQ, et al. Association of Derived Neutrophil-To-Lymphocyte ratio with prognosis of Coronary Heart Disease after PCI. Front Cardiovasc Med. 2021;8:705862.
9. Buyukkaya E, Karakas MF, Karakas E, Akcay AB, Tanboga IH, Kurt M, et al. Correlation of neutrophil to lymphocyte ratio with the presence and severity of metabolic syndrome. Clin Appl Thromb Hemost. 2014;20(2):159–63.
10. Surendar J, Indulekha K, Mohan V, Pradeepa R. Association of neutrophil-lymphocyte ratio with metabolic syndrome and its components in Asian indians (CURES-143). J Diabetes Complications. 2016 Nov-Dec;30(8):1525–29.
11. Battaglia S, Scialpi N, Berardi E, et al. Gender, BMI and fasting hyperglycaemia influence monocyte to-HDL ratio (MHR) index in metabolic subjects. PLoS ONE. 2020;15(4):e0231927.
12. Kaya T, Solak Y, Akcay EU, Erturk Z, Ergenc H, Tamer A. The relationship between neutrophil to lymphocyte ratio and metabolic syndrome in patients with type 2 diabetes. Int J Diabetes Dev Ctries. 2017;37(2):215–20.
13. Kim JH, Cho KI, Kim YA, Park SJ. Elevated neutrophil-to-lymphocyte ratio in metabolic syndrome is Associated with increased risk of colorectal adenoma. Metab Syndr Relat Disord. 2017;15(8):393–9.
14. Liu CC, Ko HJ, Liu WS, Hung CL, Hu KC, Yu LY, et al. Neutrophil-to-lymphocyte ratio as a predictive marker of metabolic syndrome. Med (Baltim). 2019;98(43):e17537.
15. Tang K, Liu H, Jiang K, Ye T, Yan LB, Liu PJ, et al. Predictive value of preoperative inflammatory response biomarkers for metabolic syndrome and post-PCNL systemic inflammatory response syndrome in patients with nephrolithiasis. Oncotarget. 2017;8(49):85612–27.
16. Wang P, Guo X, Zhou Y, Li Z, Yu SS, Sun YX, et al. Monocyte to-high-density lipoprotein ratio and systemic inflflammation response index are associated with the risk of metabolic disorders and cardiovascular diseases in general rural population. Front Endocrinol. 2022;13:944991.
17. Yasar Z, Buyuksirin M, Ucsular FD, KARGI A, ERDEM F, TALAY F, et al. Is an elevated neutrophil-to-lymphocyte ratio a predictor of metabolic syndrome in patients with chronic obstructive pulmonary disease? Eur Rev Med Pharmacol Sci. 2015;19(6):956–62.
18. Zubiaga L, Ruiz-Tovar J. Correlation of preoperative neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio with metabolic parameters in patients undergoing sleeve gastrectomy. Surg Obes Relat Dis. 2020;16(8):999–1004.
19. Li N, Liu C, Luo Q, Zhang F, Sheng D, Liu Z. Correlation of White Blood Cell, neutrophils, and hemoglobin with metabolic syndrome and its components. Diabetes Metab Syndr Obes. 2023;01–01:161347–1355.
20. Mohan M, Kavya ST, Sanjay Kumar HR. A study of neutrophil-to-lymphocyte ratio in patients with metabolic syndrome. APIK J Int Med. 2021;9:167–70.
21. Bahadır A, Baltacı D, Türker Y, Türker Y, Iliev D, Öztürk S, et al. Is the neutrophil-to-lymphocyte ratio indicative of inflammatory state in patients with obesity and metabolic syndrome? Anatol J Cardiol. 2015Oct;15(10):816–22.
22. Najafzadeh MJ, Baniasad A, Shahabinejad R, Mashrooteh M, Najafipour H, Gozashti MH. Investigating the relationship between haematological parameters and metabolic syndrome: a population-based study. Endocrinol Diabetes Metab. 2023;6(2):e407.
23. Omrani-Nava V, Moosazadeh M, Bahar A, Hedayatizadeh-Omran A, Ahmadi A, Alizadeh-Navaei R. Neutrophil-to-lymphocyte, platelet-to-lymphocyte and lymphocyte-to-monocyte ratios, any association with metabolic syndrome? CASP J INTERN MED. 2023-01-01;14(3):567–71.
24. Ustuntas G, Basat SU, Calik AN, Sivritepe R, Basat O. Relationship between Epicardial Fat Tissue Thickness and CRP and Neutrophil-Lymphocyte Ratio in Metabolic Syndrome Patients Over 65 Years. Sisli Etfal Hastan Tip Bul. 2021 Sep 24;55(3):405 – 11.
25. Al-Sarraf IAK, Kasabri V, Akour A, Naffa R. Melatonin and cryptochrome 2 in metabolic syndrome patients with or without diabetes: a cross-sectional study. Horm Mol Biol Clin Investig. 2018;35(2).
26. AbuZayed R, Bulatova N, Kasabri V, Suyagh M, Halaseh L, AlAlawi S. Correlates of zinc finger BED domain-containing protein 3 and ghrelin in metabolic syndrome patients with and without prediabetes. Horm Mol Biol Clin Investig. 2019 Jan 22;37(3).
27. Horan AA, Albsoul-Younes A, Kasabri V, Suyagh M, Halaseh L, AlAlawi S. Correlates of resistin and retinol-binding protein 4 in metabolic syndrome patients with and without prediabetes. Horm Mol Biol Clin Investig. 2019 Jan 23;37(3).
28. Mauss D, Herr RM, Jarczok MN, Motoc I, Fischer JE, Bosch JA. The association of cortisol levels with leukocyte distribution is disrupted in the metabolic syndrome. Obes Res Clin Pract. 2021 Jan-Feb;15(1):78–84.
29. Song P, Zhao Y, Zhang H, Chen X, Han P, Fang C, Yu C, Guo Q. Comparison of inflammatory markers in the diagnosis of metabolic syndrome in Hemodialysis patients: a Multicenter Observational Study. Diabetes Metab Syndr Obes. 2022-01-01;15:1995–2002.
30. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M et al. The Newcastle Ottawa Scale(NOS)for assessing the quality of nonrandomized studies in meta-analyses. Symposium on Systematic Reviews: Beyond the Basics. 2000.
31. Rostom A, Dubé C, Cranney A, et al. Celiac Disease. Rockville (MD): Agency for Healthcare Research and Quality (US).Appendix D. Quality Assessment forms. Evid Rep Technol Assess (Summ). 2004;104:1–6.
32. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med. 2009;6(7):e100010.
33. Abdel-Moneim A, Mahmoud B, Sultan EA, Mahmoud R. Relationship of leukocytes, platelet indices and adipocytokines in metabolic syndrome patients. Diabetes Metab Syndr. 2019 Jan-Feb;13(1):874–80.
34. Lin HY, Zhang XJ, Liu YM, Geng LY, Guan LY, Li XH. Comparison of the triglyceride glucose index and blood leukocyte indices as predictors of metabolic syndrome in healthy Chinese population. Sci Rep. 2021 May;11(1):10036.

35. Fang Q, Tong YW, Wang G, Zhang N, Chen WG, Li YF, et al. Neutrophil-to-lymphocyte ratio, obesity, and breast cancer risk in Chinese population. Med (Baltim). 2018;97(30):e11692.
36. Conteduca V, Caffo O, Galli L, Maugeri A, Scarpi E, MainesF et al. Association among metabolic syndrome, inflammation, and survival in prostate cancer. Urol Oncol. 2018 May;36(5):240.e1-240.e11.
37. Meng G, Zhu Q, Shao J, Zhang Q, Liu L, Wu H. Comparing the diagnostic ability of inflammatory markers in metabolic syndrome. CLIN CHIM ACTA. 2017;12–01:475 1–6.
38. Hashemi Moghanjoughi P, Neshat S, Rezaei A, Heshmat-Ghahdarijani K. Is the neutrophil-to-lymphocyte ratio an exceptional Indicator for Metabolic Syndrome Disease and outcomes? Endocr Pract. 2022;28(3):342–8.
39. Mahmood A, Haider H, Samad S, Kumar D, Perwaiz A, Mushtaq R, et al. Association of white blood cell parameters with metabolic syndrome: a systematic review and meta-analysis of 168,000 patients. Medicine. 2024;103:10e37331.
40. Fan W, Zhang Y, Gao X, Liu Y, Shi F, Liu J, et al. The Prognostic Value of a derived neutrophil-lymphocyte ratio in patients with Acute Coronary Syndrome undergoing percutaneous coronary intervention. Clin Appl Thromb Hemost. 2021 Jan-Dec;27:10760296211034579.
41. Klisic A, Scepanovic A, Kotur-Stevuljevic J, Ninic A. Novel leukocyte and thrombocyte indexes in patients with prediabetes and type 2 diabetes mellitus. Eur Rev Med Pharmacol Sci. 2022;26(8):2775–81.
42. Adachi K, Nishijo K, Abo T. Those with the habit of going to sleep early show a higher ratio of lymphocytes while those with the habit of staying up late show a higher ratio of granulocytes. Biomed Res. 2010;31(2):143–9.
43. Tani S, Matsuo R, Atsumi W, Kawauchi K, Ashida T, Yagi T, et al. Higher frequency of Fish Intake May be Associated with a lower Neutrophil/Lymphocyte Ratio: Anti-atherosclerotic effects of Fish Consumption. Ann Nutr Metab. 2021;77(3):146–53.
44. Sharifan P, Rashidmayvan M, Khorasanchi Z, Darroudi S, Heidari A, Hoseinpoor F, et al. Efficacy of low-fat milk and yogurt fortified with vitamin D(3) on systemic inflammation in adults with abdominal obesity. J Health Popul Nutr. 2022;41(1):8.

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