INTRODUCTION

Obesity results in cardiovascular disease and an increase in the risk of type 2 diabetes. The global increase in obesity prevalence led to an increase in the frequency of metabolic syndrome, which resulted in the need to understand the underlying mechanisms.1

Many studies associated the complete blood count (CBC) and the resulting ratios with the neutrophil–
lymphocyte ratio (NLR), platelet–lymphocyte ratio (PLR), and some diseases and their clinical courses. A study determined the fasting blood glucose, body mass index (BMI), and effect on blood parameters of obese patients. The present study aimed to evaluate the potential impact of BMI and fasting blood glucose on the CBC parameters and derivatives.

**METHODS**

This was a prospective, observational clinical study. Hospitalized patients who participated in a physiotherapy program in the Physical Medicine and Rehabilitation Clinic between March and June 2016 were included in this study. The age, height, weight, BMI, fasting blood glucose, erythrocyte sedimentation (ESR) (0–20 mm/h), C-reactive protein (CRP) (0–0.8 mg/dl) and CBC parameters (leukocytes, platelets, neutrophil, lymphocytes, and monocytes), red cell distribution width (RDW), platelet distribution width (PDW), and derivates (NLR, PLR) of the patients were recorded. The relationship between the BMI, fasting glucose, and CBC parameters and derivates was investigated. Patients were divided into groups based on BMI: BMI ≤25 kg/m², normal; BMI=26–30 kg/m², overweight; and BMI >30 kg/m², obese. The patients were also divided into two groups based on BMI: normal and overweight/obese. The fasting blood glucose, BMI, and CBC parameters were compared.

The statistical analysis was performed using IBM SPSS for Windows, version 21.0 software (IBM Corporation, NY - USA). Descriptive data were presented as mean ± standard deviation and median scores. The Mann–Whitney U test and Kruskal–Wallis test were used to analyze abnormally distributed data. The Spearman’s correlation analysis was used to analyze the level of correlation between variables. The coherence of variables to normal distribution (normality) was analyzed using the Kolmogorov–Smirnov test. A p-value of <0.05 was considered statistically significant.

**RESULTS**

This study included 158 women (68.4%) and 73 men (31.6%) (Table-I). The mean age of the patients was 57.1±16.3 years; the mean value of BMI was 27.8±5.1 kg/m². The mean value of ESR of patients included in this study was 25.3±14.8 mm/h; the mean value of CRP was 1±8 g/dL, and the mean value of fasting glucose was 121.6±62.2 g/dL (Table-II). The distribution of these values according to groups is given in (Table-III).

**Table-I: Age, BMI, ESR, CRP, and FBG values.**

| Groups   | Age | BMI  | CRP  | FBG |
|----------|-----|------|------|-----|
| N        | 230 | 230  | 230  | 230 |
| Mean     | 57.32 | 25.3194 | 27.8171 | 1.0367 | 121.67 |
| Standard deviation | 16.248 | 14.8621 | 5.20387 | 8.04780 | 62.258 |

BMI: body mass index; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; FBG: fasting blood glucose.

**Table-II: ESR, fasting glucose, and CRP values of all groups.**

| Groups | ESR | Glucose | CRP |
|--------|-----|---------|-----|
| Normal | Mean | 20.7500 | 114.71 | 1.7666 |
| N      | 68   | 76      | 76   |
| Standard deviation | 13.26017 | 53.612 | 12.82142 |
| 25-30 overweight | Mean | 27.4857 | 133.08 | 0.6723 |
| N      | 70   | 65      | 65   |
| Standard deviation | 14.7704 | 79.493 | 1.52974 |
| >30 obese | Mean | 28.3208 | 117.60 | 0.4481 |
| N      | 53   | 48      | 54   |
| Standard deviation | 15.76239 | 45.996 | 0.58362 |
| Total  | Mean | 25.3194 | 121.76 | 1.0367 |
| N      | 191  | 189     | 195  |
| Standard deviation | 14.86421 | 62.410 | 8.04780 |

CRP: C-reactive protein; ESR: erythrocyte sedimentation rate.

**Table-III: CBC parameter and derivative values.**

| Minimum | Maximum | Mean | Standard Deviation |
|---------|---------|------|--------------------|
| Leukocyte | 3.920 | 17.450 | 7.54662 | 2.190777 |
| Platelet | 142.000 | 591.000 | 288.37719 | 75.977204 |
| Neutrophil | 1.400 | 82.100 | 5.27508 | 6.367838 |
| Lymphocyte | 0.150 | 11.400 | 2.12497 | 0.935861 |
| Monocyte | 0.060 | 4.000 | 0.52342 | 0.673543 |
| RDW | 10.700 | 48.000 | 14.44348 | 4.267602 |
| PDW | 7.800 | 48.000 | 15.85618 | 9.080572 |
| NLR | 0.57 | 17.40 | 2.7396 | 2.16918 |
| PLR | 0.26 | 17.40 | 1.5844 | 1.23967 |

NLR: Neutrophil–lymphocyte ratio; PDW: Platelet distribution width; PLR: Platelet–lymphocyte ratio; RDW: Red cell distribution width.
The CBC parameter and derivative values of the patients are given in (Table-IV). The distributions of CBC parameters and derivatives according to groups are given in (Tables-V). A significant difference in the lymphocyte count, ESR, and NLR values was found among the three groups (P=0.011; P=0.021; P=0.04). The average lymphocyte count and ESR values were higher in the obese and overweight groups, and the NLR value was lower in the obese group.

A significant difference in the NLR value was found between groups 1 and 3 (P=0.04). Between groups 1 and 3, a significant difference in platelet count was noted (P=0.013). The platelet count was found to be higher and the NLR lower in the obese group. No statistically significant difference was found in the other blood parameters.

On dividing the patients into two groups: normal and overweight/obese, a significant difference in lymphocyte count, glucose, and ESR values was observed (P=0.038; P=0.05; P=0.013). The lymphocyte count, ESR, and glucose values were found to be higher in the overweight group. No statistically significant difference was found in the other blood parameters.

According to Spearman’s correlation analysis, the BMI and NLR values were negatively correlated (P=0.029; r=0.145); however, the lymphocyte count and ESR values were positively correlated (P=0.009; r=0.173; P=0.013; r=0.182). The BMI and platelet count were not correlated.

**DISCUSSION**

The incidence of overweight and obesity is gradually increasing in developed and developing countries around the world. Obesity is an important cause of cardiovascular (CVS) diseases, musculoskeletal system diseases, and malignancies. Also, it is one of the preventable causes of death. Metabolic syndrome is a common and complex disorder often seen together with dyslipidemia, hypertension, and insulin resistance.

| Table-IV: Distribution of CBC parameters. |
|------------------------------------------|
| **Group** | **Leukocyte** | **Platelet** | **Neutrophil** | **Lymphocyte** | **Monocyte** |
|-----------|---------------|--------------|---------------|---------------|-------------|
| Normal    | Mean          | 7.54602      | 273.78409     | 5.61942       | 2.05822     | .53434     |
|           | N             | 88           | 88            | 89            | 89          | 89         |
|           | Standard deviation | 2.415059 | 63.062357     | 8.479803      | 1.229092    | .652518    |
| 25–30 overweight | Mean | 7.59410      | 293.87179     | 5.50139       | 2.05316     | .58861     |
|           | N             | 78           | 78            | 79            | 79          | 79         |
|           | Standard deviation | 2.073063 | 88.134543     | 5.939608      | .692881     | .907481    |
| >30 obese | Mean          | 7.48774      | 302.17742     | 4.49242       | 2.31226     | .42468     |
|           | N             | 62           | 62            | 62            | 62          | 62         |
|           | Standard deviation | 2.027491 | 73.925422     | 1.587071      | .667792     | .142239    |
| Total     | Mean          | 7.54662      | 288.37719     | 5.27508       | 2.12497     | .52342     |
|           | N             | 228          | 228           | 230           | 230         | 230        |
|           | Standard deviation | 2.190777 | 75.977204     | 6.367838      | .935861     | .673543    |

| NLR: Neutrophil–lymphocyte ratio; PDW: platelet distribution width; PLR: Platelet–lymphocyte ratio; RDW: red cell distribution width. |

| Table-V: CBC parameter and derivative distribution. |
|------------------------------------------|
| **Group** | **PDW** | **RDW** | **NLR** | **PLR** |
|-----------|---------|---------|---------|---------|
| Normal    | Mean    | 15.71011| 14.36180| 2.9980  | 1.5926  |
|           | N       | 89      | 89      | 89      | 88      |
|           | Standard deviation | 1.468073| 4.333682| 2.30528 | .82140  |
| 25–30 overweight | Mean | 15.93824| 14.14937| 2.9672  | 1.7298  |
|           | N       | 79      | 79      | 79      | 78      |
|           | Standard deviation | 0.479646| 2.189654| 2.55807 | 1.88659 |
| >30 obese | Mean    | 15.96129| 14.93548| 2.0788  | 1.3897  |
|           | N       | 62      | 62      | 62      | 62      |
|           | Standard deviation | 0.393952| 5.897376| 1.01105 | .44512  |
| Total     | Mean    | 15.85618| 14.44348| 2.7396  | 1.5844  |
|           | N       | 230     | 230     | 230     | 228     |
|           | Standard deviation | 0.980572| 4.267602| 2.16918 | 1.23967 |
Obesity is related to many diseases including different types of cancers and is a major public health concern. Obesity has a negative effect on the development and prognosis of breast cancer. The pathophysiological mechanisms underlying the relationship between obesity and cancer are still subject to research.3 See comment in PubMed Commons below

Evidence shows that obesity is related to insulin resistance and low-grade chronic inflammation. It has also been proven that obesity is part of many complications. Macrophages accumulated in the fat tissue of obese individual’s have significance in the development of obesity-related inflammation. The number of macrophages in the fat tissue is strongly related to the person’s weight, BMI, and total body fat. Measures to reduce the number of macrophages or inflammatory properties reduce systemic inflammation and increase insulin sensitivity.4

The underlying mechanisms are important for gerontology, since obesity, insulin resistance, and inflammation are also related to aging. Although the reduction in insulin sensitivity in obese people is related to various molecular and cellular mechanisms, the pathogenesis of obesity-related insulin resistance is still unclear. Recent studies focus on the fact that inflammation is induced by macrophages in the adipose tissue; however, the involvement of other organs (liver, muscles, and pancreas) also needs to be considered.5

Pre-diabetes contributes to the development of cardiovascular disease and is associated with central obesity, inflammation, oxidative stress, and endothelial dysfunction. A study by Holvoet P et al.6 found that the metabolic syndrome was related to a high fraction of oxidized low-density lipoprotein. It is known that metabolic syndrome is closely related to insulin signaling, oxidative stress, inflammation, and atherosclerosis.7

Abdominal obesity is due to an increased oxidative stress and decreased nitric oxide associated with endothelial dysfunction. Perivascular adipose tissue–induced proinflammatory cytokines in obese individuals target the vasculature, which is a source of low-grade inflammation and oxidative stress. This contributes to endothelial dysfunction.8

Zhao et al.9 assessed the risk of diabetes with anthropometric measurements and found that women with diabetes and pre-diabetes have increased BMI, waist-hip ratio, and waist-height ratio.

Acute-phase protein markers (CRP and ESR) are insufficient to show disease activity, and only few specific biomarkers help in controlling the disease. Since acute-phase proteins increase only as an indirect result of the local inflammatory process, they are insufficient to show a systemic inflammatory response. Also, the ESR and CRP values can be affected by new infections and are nonspecific in estimating inflammation.10-12

Research on neutrophil and subgroups and their relationship with inflammation has increased in recent years. Many studies have found a positive correlation between RDW, CRP, and ESR.13,14 High RDW has been associated with undesirable consequences in various clinical situations. The mechanism behind it is not known. Metabolic syndrome increases the chances of CVS disease and causes death. The extensive cohort study by Laufer et al.15 found that an RDW value of > 14% was independently associated with metabolic syndrome and long-term mortality. A study of Rodriguez-Carrio J et al.16 found that RDW was associated with a reduction in endothelial progenitor cells and vascular repair insufficiency and related to increased levels of various mediators. It was concluded that RDW was an important indicator of CVS diseases.

The present study compared CBC parameters and derivatives with the BMI and fasting glucose levels. When divided the patients into normal and overweight/obese, it was found that only the NLR, lymphocyte count, ESR, and glucose values were of statistical significance and correlated with BMI. However, the platelet count was found to be statistically significantly different between groups one and three. In other words, the more a person gains weight, the more the increase in lymphocyte count, platelet count, and ESR values. The NLR value, however, decreases. No significant difference was found in the other parameters.

**CONCLUSION**

The present study found a negative correlation between the NLR and BMI values and a lower NLR value in the obese group compared with the normal group. The obese group showed a higher lymphocyte count, thereby confirming the positive correlation of lymphocyte count with BMI. A comprehensive understanding of the mechanisms underlying the relationship between obesity and inflammation may allow developing treatment strategies to reduce the negative effects of obesity.
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