Cukurova Medical Journal
ÇUKUROVA ÜNİVERSİTESİ TIP FAKÜLTESİ

Cukurova Med J 2020;45(4):1555-1561
DOI: 10.17826/cumj.740248

ARAŞTIRMA / RESEARCH

Relationship between blood lipids, inflammation parameters and body composition

Kan lipitleri, inflamasyon belirteçleri ve vücut kompozisyonu arasındaki ilişki

Burak Mete[1], Mehmet Sait Değer[2], Gülsüm Zoroğlu[2]

[1]Cukurova University Faculty of Medicine, Department of Public Health, Adana, Turkey
[2]Bingöl Provincial Health Directorate, Bingöl, Turkey

Cukurova Medical Journal 2020;45(4):1555-1561

Abstract

Purpose: The aim of this stuıdy was to determine the relation between inflammation markers, anthropometric measurements, and blood lipid values.
Materials and Methods: The present study was conducted with 274 adult healthy subjects in 2019. The relationship between anthropometric measurements and blood lipid values of individuals, full blood count inflammation markers, neutrophil lymphocyte ratio (NLR), platelet lymphocyte ratio (PLR) and lymphocyte monocyte ratio (LMR) were examined..
Results: The average age of the 274 subjects, who participated in the study, was 34 years. No significant differences were detected between the NLR, PLR and LMR ratios according to the BMI scores. A very weak and negative correlation was detected between PLR and skeletal muscle, basal metabolic rate, body fluid amount and lean mass; and a weak and negative correlation was detected between HDL and BMI, body fat amount, and internal fat amount. A weak and positive correlation was detected between NLR and LDL.
Conclusion: There was a very weak correlation between anthropometric values and inflammation markers, a weak-moderate correlation between blood lipid levels, and a weak correlation between inflammation markers and cholesterol levels.

Keywords: Inflammation mediators, body mass index, cholesterol, neutrophils

Öz

Amaç: Bu çalışma ile inflamasyon belirteçleri ile antropometrik ölçüm değerleri ve kan lipit değerleri arasındaki ilişkinin tespit edilmesi amaçlanmıştır.
Gereç ve Yöntem: Bu çalışma 2019 yılında 274 yetişkin sağlıklı kişi üstünde yapılmış bir çalışmadır. Kişilerin kan lipit değerleri, tam kan sayımı inflamasyon belirteçleri nötrofil lenfosit oranı (NLO), platelet lenfosit oranı (PLO) ve lenfosit monosit oranı (LMO) ile antropometrik ölçümleri arasındaki ilişki incelenmiştir.
Bulgular: Çalışmaya katılan 274 kişinin yaş ortalaması 34'dür. BKİ'ne göre NLO, PLO ve LMO oranları arasında anlamlı fark bulunamamıştır. PLO ile iskelet kası, bazal metabolik hız, vücut sıvı miktarı ve yağsız kütle arasında anlamlı çok zayıf negatif korelasyon, HDL ile BMİ, vücut yağ miktarı, iç yağlanma miktarı arasında zayıf negatif yönde korelasyon bulunmuştur. İskelet kası ve vücut yağ miktarındaki artış total kolesterol seviyesinde azalışa neden olurken, iç yağlanma miktarındaki artış total kolesterol seviyesinde artışa neden olmaktadır. NLO ile LDL arasında pozitif yönde zayıf, NLO ile total kolesterol arasında pozitif yönde çok zayıf, LMO ile LDL arasında pozitif yönde çok zayıf korelasyon bulunmuştur.
Sonuç: Antropometrik değerler ile inflamasyon belirteçleri arasında çok zayıf, kan lipit ile zayıf-orta düzey, inflamasyon belirteçleri ile kolesterol düzeyi arasında zayıf ilişki olduğu görülmüştür.

Anahtar kelimeler: İnflamasyon mediyatörleri, vücut kitle indeksi, kolesterol, nötrofiller

Yazışma Adresi/Address for Correspondence: Dr. Burak Mete, Cukurova University Department of Public Health, Adana, Turkey Email: burakmete2008@gmail.com
Geliş tarihi/Received: 20.05.2020 Kabul tarihi/Accepted: 29.08.2020 Çevrimiçi yayın/Published online: 30.10.2020

INTRODUCTION

Obesity stimulates a low-degree inflammation in a constant way. In recent studies, it has been shown that adipose tissue is an important source of proinflammatory cytokines[1]. It was shown in many epidemiological studies that chronic low-level inflammation is associated with diabetes, hypertension, metabolic syndrome, obesity, smoking, and other lifestyle habits[2-8].

Low-grade inflammation can be measured from the white blood cell amount. In recent studies, it has been shown that the rates between white blood cell subtypes will become an important and reliable prognostic factor. Neutrophil Lymphocyte Ratio (NLR), Platelet Lymphocyte Ratio (PLR), and Lymphocyte Monocyte Ratio (LMR) are used as a factor in evaluating the prognosis in some diseases. It is known that increased neutrophil lymphocyte ratios shorten life expectancy in some diseases. Although there is evidence showing that systemic inflammation is associated with many diseases and comorbidities, the mechanism has not been clarified[9-12].

It is considered that some inflammatory biomarkers - CRP, white blood cells- may be used in predicting the prognosis of coronary heart disease and age-related degenerative diseases. These markers are also associated with the anthropometric measurements like BMI and waist circumference, which are the indicators of obesity[13]. Obesity is a chronic disease with multiple origins. It is a widespread global phenomenon carrying potentially serious complications which requires a multidisciplinary approach due to the significant clinical repercussions and elevated health costs associated with the disease.

The most recent evidence indicates that it shares a common characteristic with other prevalent, difficult-to-treat pathologies: chronic, low-grade inflammation which perpetuates the disease and is associated with multiple complications. The current interest in lipoinflammation or chronic inflammation associated with obesity derives from an understanding of the alterations and remodelling that occurs in the adipose tissue, with the participation of multiple factors and elements throughout the process[14]. With this study, the purpose was to determine the relations between inflammation markers (NLR, PLR, and LMR), anthropometric measurements and blood lipid values. The main research hypothesis of this study is to test whether there is a relationship between body composition and inflammation or not.

MATERIALS AND METHODS

This study was conducted with 274 adult healthy people who applied to Healthy Nutrition and Diet Clinic of Bingöl Community Health Center between January 1, 2018 and July 31, 2019. Consultancy services are provided to those who apply to the diet clinic. People give blood before the examination. Then the anthropometric measurements of the persons are made.

According to the results of the pilot study that was based on 80% power and 95% confidence interval, the minimum number of samples to be contacted was determined to be 197 (Reference values; R_0:0.163-R_1:0.350). This study is a retrospective research based on records. During the study period, 813 people applied for counseling. The systematic sampling method was used as the sampling method; and 274 people, who met the inclusion criteria, were included in the study. 539 people who applied to diet outpatient clinic were not included because they did not meet the inclusion and exclusion criteria. Official permission was received for the study from Bingöl Provincial Health Directorate, and approval was received from the Ethical Committee of Bingöl Provincial Health Directorate (Decision no: 81966737-929 Date:18/07/2019). Informed consent was obtained from the participants and the study was conducted in accordance with the Helsinki declaration.

Inclusion criteria of the study were being above 18 years of age, having no infectious disease at the time of measurements and having 3 measurements made at the same time (anthropometric measurements, fasting blood lipid level, complete blood count). Exclusion criteria of the study were presence of chronic disease and use lipid-lowering drugs

Measurements

The blood lipid parameters (HDL, LDL, Triglyceride (TG), and total cholesterol), and complete blood count laboratory tests are requested from the individuals who apply for healthy nutrition counseling (Mindray BS800M Biochemistry Device). With the results of the tests that are requested by family doctors, individuals apply to the Healthy Nutrition and Diet Clinic. Then, the measurements of these individuals are made with the Tanita BC418 Device. Tanita Body Composition Monitor uses the advanced Bioelectrical Impedance Analysis (BIA) technology. When you stand on a Tanita Monitor barefoot, the device sends a secure electrical signal from its electrodes. This electrical signal passes quickly through the water in the hydrated muscle tissue; however, when it reaches the adipose tissue, it faces resistance. This resistance, which is known as impedance, is measured and entered into the equations of the Tanita Device to calculate the body composition measurements. The body composition measurements are given based on the results on the monitor. The total body weights, muscle weights, fat weights, fluid weights, internal fat contents, Body Mass Indices, and basal metabolic rate measurements are made with the Tanita Device[15].

Statistical analysis

The correlations between anthropometric measurements and blood lipid values, total blood count inflammation markers according to Neutrophil Lymphocyte Ratio (NLR), Platelet Lymphocyte Ratio (PLR), and Monocyte Lymphocyte Ratio (MLR) of the participants were evaluated. The SPSS 22 Program was used in data analyses. The Kolmogorov Smirnov Test was used as the normal distribution test. Non-parametric tests were used in the analyses of the data that did not show normal distribution. The Spearman Correlation Test, Kruskal Wallis Test, and Multiple Linear Regression Test were used for data analyses. In the Multiple Linear Regression Model, the dependent variable of the model is the total cholesterol amount; and the independent variables are the BMI, skeletal muscle amounts, internal fat amounts, and body total fat amounts. The total cholesterol variable provides the normal distribution assumption (p=0.200). The significance value was taken as p<0.05.

RESULTS

The mean age of the 274 people who participated in the study was 34.0±9.9 years. The majority of the participants were women (n: 234, 85.4%), and n: 111 (40.5%) were overweight, n: 106 (38.7%) were obese, and the rest of them were at normal weight. The NLR, PLR and LMR results are given according to Body Mass Index (BMI) groups in Table 1.

Table 1. Comparison of NLR, PLR, LMR according to BMI

	BMI Median (min-max)			
Inflammation markers	24.99 and below (n=57)	25-29.99 (n=111)	30 and over (n=106)	p
NLR	1.5 (0.4-5.3)	1.49 (0.2-5.2)	1.65(0.3-5.2)	0.567
PLR	116 (60-296)	110(34-238)	112 (55-244)	0.707
LMR	8.83 (1.9-20.7)	8.3(2.2-60.8)	8.1 (0.9-60.2)	0.707

Kruskal Wallis test, BMI: Body Mass İndex, NLR: neutrophil lymphocyte ratio, PLR: platelet lymphocyte ratio, LMR: lymphocyte monocyte ratio

Table 2. The correlation between body composition and inflammation markers

Body composition	NLR	PLR	LMR
BMI (kg/m²)	r: 0.013 p:0.828	r: -0.045 p:0.455	r: -0.034 p:0.578
Fat (kg)	r: 0.066 p:0.276	r: 0.007 p:0.905	r: -0.068 p:0.261
Lean mass (kg)	r: -0.067 p:0.267	r: -0.149 p:0.014	r: -0.013 p:0.219
Internal fat (kg)	r: -0.109 p:0.072	r: -0.119 p:0.050	r: 0.014 p:0.812
Basal metabolic ratio	r: -0.042 p:0.485	r: -0.152 p:0.012	r: -0.075 p:0.215
Fluid (kg)	r: -0.066 p:0.276	r: -0.158 p:0.009	r: -0.073 p:0.227
Fat free mass (kg)	r: -0.066 p:0.273	r: -0.159 p:0.009	r: -0.073 p:0.228

Spearman Correlation Test, BMI: Body Mass İndex

No significant differences were detected between the NLR, PLR and LMR rates according to the BMI scores in terms of being normal weight, overweight and obese (Table 1). The results of the correlation between the anthropometric measurements of the bioimpedance analysis and the inflammation markers are given in Table 2.

A significant, negative and very weak correlation was detected between inflammation markers PLR, lean mass, basal metabolic rate, body fluid amount and fat free mass. The results of the correlation between anthropometric measurements and blood lipid levels are given in Table 3.

When the relation between anthropometric measurements and blood lipid levels was evaluated, it was determined that there was a weak and negative correlation between HDL and BMI, body fat amount, internal fat amount; there was a negative correlation at a moderate level between HDL and basal metabolic rate, and there was a positive correlation at a moderate level between skeletal muscle amount and HDL. There was a weak and positive correlation between triglyceride, BMI, body fat, internal fat amount and basal metabolic rate; and there was a negative and weak correlation between skeletal muscle and TG. There was a weak and positive correlation between LDL and BMI, internal fat amount and basal metabolic rate; and there was a weak and negative correlation between LDL and skeletal muscle amount. There was a very weak and positive correlation between total cholesterol and only internal fat amount. The results of the correlation between inflammation markers and blood lipid levels are given in Table 4.

Table 3. The correlation between anthropometric measurements and blood lipid levels

Anthropometric Measurements	HDL	Triglyceride	LDL	T. Cholesterol
BMI	r:-0.265 p<0.001	r: 0.380 p<0.001	r:0154 p:0.011	r: 0.077 p:0.209
Fat (kg)	r:-0.222 p<0.001	r:0.342 p<0.001	r: 0.079 p:0.195	r: 0.037 p:0.547
Lean mass (kg)	r:0.403 p<0.001	r:-0.222 p<0.001	r:-0.145 p<0.018	r: 0.002 p:0.972
Internal fat (kg)	r:-0.287 p<0.001	r:0.399 p<0.001	r:0.254 p<0.001	r:0.172 p:0.005
Basal metabolic ratio	r:-0.406 p<0.001	r:0.337 p<0.001	r:0.112 p<0.045	r:-0.014 p:0.825

Spearman Correlation Test, BMI: Body Mass İndex, HDL: high density lipoprotein, LDL: low density lipoprotein

Table 4. The correlation between inflammation markers and blood lipid levels

	HDL	Triglyceride	LDL	T. Cholesterol
NLR	r:-0.061 p:0.322	r: 0.047 p:0.439	r: 0.260 p<0.001	r:0.182 p:0.003
PLR	r:-0.223 p:0.075	r: -0.061 p:0.316	r:0.118 p:0.054	r:0.052 p:0.395
LMR	r:-0.050 p:0.419	r:-0.055 p:0.370	r: 0.135 p:0.027	r: 0.095 p:0.120

Spearman Correlation Test, BMI: Body Mass İndex, NLR: neutrophil lymphocyte ratio, PLR: platelet lymphocyte ratio, LMR: lymphocyte monocyte ratio, HDL: high density lipoprotein, LDL: low density lipoprotein

A weak and positive correlation was detected between NLR and LDL; a very weak and positive correlation was detected between NLR and total cholesterol, and a very weak and positive correlation between LMR and LDL. The results of the Multiple Linear Regression Model that was formed to estimate the total cholesterol amount are given in Table 5. The model was found to be significant (ANOVA p=0.003). The independent variables explained 6% of the change in the dependent variables. It was seen that skeletal muscle, internal fat amount and body fat mass contributed to the model at a significant level. One unit increase in the skeletal muscle and fat amounts lead to a decrease of 1.2 units and 1.9 units in the total cholesterol levels, respectively; and one unit increase in the internal fat amount lead to an increase of 4.1 units of total cholesterol levels. It was determined that BMI did not make a significant contribution to the model.

Table 5. Total cholesterol multiple regression results

	B	p	CI %95 Lower/Upper limit	Tolerance	VIF
Lean mass	-1.218	0.020	-2.224/-0.191	0.582	1.719
Internal fat	4.107	0.001	1.619/6.596	0.219	4.559
Fat	-1.927	0.004	-3.230/-0.625	0.122	8.177
BMI	1.517	0.222	-0.961/4.115	0.103	9.747
Constant	194.039	<0.001	148.693/239.385		

Multiple Linear Regression Test (Regression Equation= 194.03+4.1x Internal fat amount -1.2x Skeletal muscle -1.9x Fat amount) VIF: varyans inflation factor

DISCUSSION

Studies that are conducted on the relations between neutrophil and other subgroups and inflammation are increasing. In many studies, it was found that there is a positive correlation between CRP, ESR and Red Cell Distribution Width[16]. Obesity is a condition that stimulates reactive leukocytosis. Accumulation of macrophage occurs in obese individuals in the adipose tissue, and increase leukocytosis because of the leptin secretion in adipocytes[17]. In our study, no significant differences were detected between the new inflammation markers according to BMI. A weak correlation was detected between lean mass, skeletal muscle and PLR. When the relations between anthropometric measurements and blood lipid levels was evaluated, it was determined that there was a weak and negative correlation between HDL, BMI, body fat amount, and internal fat; however, there was a positive and weak correlation between NLR and LDL; a very weak and positive correlation between NLR and total cholesterol; and a very weak correlation between LMR and LDL. In a study conducted by Atmaca et al., no differences were detected between NLR according to BMI; however, a weak correlation was detected between waist and hip circumference and NLR[18]. In a study conducted by Koca, it was found that NLR was lower in obese people, and showed a negative correlation with BMI[19]. In a study conducted by Karakaya et al., it was reported that NLR was higher at a significant level in obese people who had insulin resistance when compared to people who did not have obesity[20].

In a study conducted with patients who had PCOS, a negative correlation was detected between BMI, NLR and PLR[21]. In a study that was conducted by Yılmaz et al. with obese patients who had PCOS, a positive correlation was detected between NLR and BMI[22]. In another study conducted by Aydın et al. it was determined that NLR was higher and PLR was insignificant[23]. Furuncuoğlu et al. conducted another study and determined that there were no significant differences between NLR and PLR compared with BMI[24].In a study that was conducted by Nalbant et al., no significant relations were detected between obesity, NLR and PLR[25].In another study that investigated the relations between inflammation markers and blood lipids in obese patients, a strong relation was detected between BMI, HDL, HDL percentages, and triglyceride levels. However, no correlations were detected with the new inflammation markers (NLR and PLR)[26]. In a study conducted in Tehran investigating the relations between obesity and inflammatory markers, a positive correlation was determined between CRP, IL-6, and abdominal obesity; and a negative correlation with HDL[27]. In a study that was conducted in overweight and obese people in Korea, no relations were detected between visceral adipose tissues, NLR and PLR. In the same study, a positive correlation was detected between visceral adipose tissue and TG, Total cholesterol and LDL; and a negative correlation was detected with HDL[28]. In a study that was conducted in Taiwan with people who had metabolic syndrome, it was determined that BMI, waist circumference, hip circumference and waist/hip ratios were higher in people who had NLR above 3; HDL levels were lower; LDL, TG and total cholesterol levels were lower[29]. In a study examining the relations between obesity and immune cells in Saudi women, a positive correlation was detected between BMI, waist-hip ratio, and white blood cells[30]. In the study conducted by Bahadır et al., in was determined that there were no significant differences between NLR and BML according to BMI; however, it was also determined that there was a negative trend between NLR and HDL, and a positive trend between TG, but not at statistically significant levels[31]. The results of the studies in the literature show parallelism with our study. It is seen that there are no strong correlations between anthropometric measurements and new inflammation markers.

That the study having a single-center fashion, use of bio-impedance method for measuring muscle mass and the majority of the sample is female and not community based are the limitations of it.

In this study, weak-to-medium relationships were found between anthropometric measurements, blood lipids and inflammation parameters. There was a weak correlation between inflammation marker PLR and lean mass, basal metabolic rate, body fluid amount and fat free mass. There was a weak and positive correlation between triglyceride, BMI, body fat, internal fat amount and basal metabolic rate; and there was a negative and weak correlation between skeletal muscle and TG. There was a weak and positive correlation between LDL and BMI, internal fat amount and basal metabolic rate; and there was a weak and negative correlation between LDL and skeletal muscle amount. There was a very weak and positive correlation between total cholesterol and only internal fat amount. Body composition appears to be associated with inflammation and blood lipids.

Body analysis may be recommended before starting sports or dieting. Body analysis may be recommended for patients with lipid disorders.

Yazar Katkıları: Çalışma konsepti/Tasarımı: BM, MSD, GZ; Veri toplama: BM, MSD, GZ; Veri analizi ve yorumlama: BM, MSD, GZ; Yazı taslağı: BM, MSD, GZ; İçeriğin eleştirel incelenmesi: BM, MSD, GZ; Son onay ve sorumluluk: BM, MSD, GZ; Teknik ve malzeme desteği: -; Süpervizyon: BM, MSD, GZ; Fon sağlama (mevcut ise): yok.
Etik Onay: Bu çalışma için Bingöl İl Sağlık Müdürlüğü Etik Kurulundan 03.07.2019 tarih ve 4405 sayılı dilekçesine istinaden etik onay alınmıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Çıkar Çatışması: Yazarlar çıkar çatışması beyan etmemişlerdir.
Finansal Destek: Yazarlar finansal destek beyan etmemişlerdir.
Author Contributions: Concept/Design : BM, MSD, GZ; Data acquisition: BM, MSD, GZ; Data analysis and interpretation: BM, MSD, GZ; Drafting manuscript: BM, MSD, GZ; Critical revision of manuscript: BM, MSD, GZ; Final approval and accountability: BM, MSD, GZ; Technical or material support: -; Supervision: BM, MSD, GZ; Securing funding (if available): n/a.
Ethical Approval: Ethical approval was obtained for this study from the Bingöl Provincial Health Directorate Ethics Committee, based on the petition dated 03.07.2019 and numbered 4405.
Peer-review: Externally peer-reviewed.
Conflict of Interest: Authors declared no conflict of interest.
Financial Disclosure: Authors declared no financial support

REFERENCES

1. Bastard JP, Maachi M, Van Nhieu JT, Jardel C, Bruckert E, Grimaldi A et al. Adipose tissue IL-6 content correlates with resistance to insulin activation of glucose uptake both in vivo and in vitro. J Clin Endocrinol Metab. 2002;87:2084-89.
2. Pitsavos C, Tampourlou M, Panagiotakos DB, Skoumas Y, Chrysohoou C, Nomikos T et al. Association between low-grade systemic inflammation and type 2 diabetes mellitus among men and women from the ATTICA study. RDS. 2007;4:98.
3. Nakanishi N, Sato M, Shirai K, Suzuki K, Tatara K. White blood cell count as a risk factor for hypertension; a study of Japanese male office workers. J Hypertens. 2002;20:851-57.
4. Bell DS, O'Keefe JH, White cell count, mortality, and metabolic syndrome in the Baltimore longitudinal study of aging. J Am Coll Cardiol. 2007;50:1810-11.
5. Marsland AL, McCaffery JM, Muldoon MF, Manuck SB. Systemic inflammation and the metabolic syndrome among middle-aged community volunteers. Metabolism. 2010;59:1801–08.
6. Brooks GC, Blaha MJ, Blumenthal RS. Relation of C-reactive protein to abdominal adiposity. Am J Cardiol. 2010;106:56–61.
7. Yasue H, Hirai N, Mizuno Y, Harada E, Itoh T, Yoshimura M et al. Low-grade ınflammation, thrombogenicity, and atherogenic lipid profile in cigarette smokers. Circ. J. 2006;70:8–13.
8. Pirkola J, Vääräsmäki M, Ala-Korpela M, Bloigu A, Canoy D, Hartikainen AL et al. Low-grade, systemic ınflammation in adolescents: association with early-life factors, gender, and lifestyle. Am J Epidemiol. 2009;171:72–82.
9. Bovill EG, Bild DE, Heiss G, Kuller LH, Lee MH, Rock R et al. White blood cell counts in persons aged 65 years or more from the cardiovascular health study: correlations with baseline clinical and demographic characteristics. Am J Epidemiol. 1996;143:1107-15.
10. Freedman DS, Joesoef MR, Barboriak JJ, Stallone DD, Byers T. Correlates of leukocyte counts in men. Ann Epidemiol.1996;6:74–82.
11. Facchını F, Hollenbeck Cb, Chen Yn, Chen Y-Dı, Reaven Gm. Demonstration of a relationship between white blood cell count, insulin resistance, and several risk factors for coronary heart disease in women. J Intern Med. 1992;232:267–72.
12. Gibson PH, Croal BL, Cuthbertson BH, Small GR, Ifezulike AI, Gibson G et al. Preoperative neutrophil-lymphocyte ratio and outcome from coronary artery bypass grafting. Am Heart J. 2007;154:995–02.
13. Faam B, Zarkesh M, Daneshpour MS, Azizi F, Hedayati M. The association between inflammatory markers and obesity-related factors in Tehranian adults: Tehran lipid and glucose study. Iran J Basic Med Sci. 2014;17:577.
14. Izaola O, de Luis D, Sajoux I, Domingo JC, Vidal M. Inflammation and obesity Nutr Hosp. 2015;31:2352-58.
15. TANITA BC 418 https://asmmed.com/urunlerimiz/vucut-analiz-cihazlari/tanita-bc-418/ (accessed Aug 2020)
16. Guthrie GJ, Charles KA, Roxburgh CS, Horgan PG, McMillan DC, Clarke SJ. The systemic inflammation-based neutrophil–lymphocyte ratio: experience in patients with cancer. Crit Rev Oncol Hematol. 2013;88:218-30.
17. Hirosumi J, Tuncman G, Chang L, Görgün CZ, Uysal KT, Maeda K et al. A central role for JNK in obesity and insulin resistance. Nature. 2002;420:333.
18. Atmaca HU, Akbaş F, Ökten İN, Nuhoğlu E, İnal BB. Can neutrophil-to-lymphocyte ratio Serve as an inflammatory marker in obesity? İstanbul Med J. 2014;15:216-20
19. Koca TT. Does obesity cause chronic inflammation? The association between complete blood parameters with body mass index and fasting glucose. Pak J Med Sci. 2017;33:65-9
20. Karakaya S, Altay M, Kaplan Efe F, Karadağ İ, Ünsal O, Bulur O et al. The neutrophil-lymphocyte ratio and its relationship with insulin resistance in obesity. Turk J Med Sci. 2019;49:245-48.
21. Çakıroğlu Y, Vural F, Vural B. The inflammatory markers in polycystic ovary syndrome: association with obesity and IVF outcomes. J Endocrinol Invest. 2016;39:899-07.
22. Yılmaz MA, Duran C, Başaran M. The mean platelet volume and neutrophil to lymphocyte ratio in obese and lean patients with polycystic ovary syndrome. J Endocrinol Invest. 2016;39:45-53.
23. Aydın M, Yılmaz A, Donma MM, Tulubas F, Demirkol M, Erdogan M et al.

Neutrophil/lymphocyte ratio in obese adolescents. North Clin Istanb. 2015;2:87–91

24. Furuncuoğlu Y, Tulgar S, Doğan AN, Çakar S, Tulgar YK, Cakiroglu B. How obesity affects the neutrophil/lymphocyte and platelet/lymphocyte ratio, systemic immune-inflammatory index and platelet indices: a retrospective study. Eur Rev Med Pharmacol Sci. 2016;20:1300-06.
25. Nalbant A, Konuk S. Association of obesity with vitamin D, C-reactive protein, blood group and hemogram parameters. Ortadoğu Tıp Dergisi. 2018;10:20-25.
26. Suárez-Cuenca JA, Ruíz-Hernández AS, Mendoza-Castañeda AA, Domínguez-Pérez GA, Hernández-Patricio A, Vera-Gómez E,et al. Neutrophil-to-lymphocyte ratio and its relation with pro-inflammatory mediators, visceral adiposity and carotid intima-media thickness in population with obesity. Eur J Clin Invest. 2019;49:5.
27. Faam B, Zarkesh M, Daneshpour MS, Azizi F, Hedayati M. The association between inflammatory markers and obesity-related factors in Tehranian adults: Tehran lipid and glucose study. Iran J Basic Med Sci. 2014;17:577.
28. Yu JY, Choi WJ, Lee HS, Lee JW. Relationship between inflammatory markers and visceral obesity in obese and overweight Korean adults: An observational study. Medicine. 2019;98:147
29. Syauqy A, Hsu CY, Rau HH, Chao JC. Association of dietary patterns, anthropometric measurements, and metabolic parameters with C-reactive protein and neutrophil-to-lymphocyte ratio in middle-aged and older adults with metabolic syndrome in Taiwan: a cross-sectional study. Nutr J. 2018;17:106.
30. Al-Sufyani AA, Mahassni SH. Obesity and immune cells in Saudi females. Innate Immun. 2011;17:439-50.
31. 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. 2015;15:816.