ISSN 2458-8865 E-ISSN 2459-1505
www.fppc.com.tr
Family Practice & Palliative Care

Research Article

The comparison of inflammatory hematological parameters in obese and non-obese children

Obez ve obez olmayan çocuklarda inflamatuar hematolojik parametrelerin karşılaştırılması

Fatma Demir Yenigurbuz[a], Elif Sobu[b], Berkin Berk Akbeyaz[c]

[a] Department of Pediatric Hematology/Oncology & Bone Marrow Transplantation Unit, Faculty of Medicine, Acibadem University, Istanbul, Türkiye
[b] Department of Pediatric Endocrinology, Kartal Dr. Lutfi Kirdar City Hospital, Istanbul, Türkiye
[c] Department of Pediatric Hematology/Oncology, Kartal Dr. Lutfi Kirdar City Hospital, Istanbul, Türkiye

Abstract

Introduction: Obesity is an increasing health problem in the whole world, and it has an important inflammatory component related to the insulin resistance (IR), hypertension, atherosclerosis and some cancers. This study aims to evaluate the inflammatory hematological parameters in childhood obesity.

Methods: Sixty-four obese and 50 normal weight cases were included in the study. The physical examination features and laboratory data of the patients were evaluated retrospectively from the patient's files. Laboratory tests, hematological parameters, gender were compared between the groups. Correlations between Homeostasis model evaluation for insulin resistance (HOMA-IR) and other laboratory parameters in the obese group were examined.

Results: The leukocyte, neutrophile, monocyte, lymphocyte, thrombocyte and MPV values of the obese group were found to be statistically higher than the control group (p: 0.006, p:0.015, p:0.014, p:0.001, p<0.001). There was no statistically significant difference between the two groups for Neutrophile/Lymphocyte ratio (NLR), Monocyte/Lymphocyte ratio (MLR) and Platelet/Lymphocyte ratio (PLR) (p:0.642, p:0.989, 0.982). Also, there was no statistically significant correlation between Homa IR and age, BMI, Neutrophil, Lymphocyte, Monocyte, Thrombocyte, Neutrophil/Lymphocyte, Monocyte/Lymphocyte and Thrombocyte/Lymphocyte values.

Conclusion: The current study showed that there was no significant difference between obese and controls in terms of NLR, PLR, and MLR values. However, the leukocyte, neutrophile, monocyte, lymphocyte, thrombocyte and MPV values were statistically higher in obese group than controls. Nevertheless, these findings can point relation between obesity and inflammation.

Keywords: obesity, children, inflammation, hematological parameters

Öz

Giriş: Obezite, tüm dünyada giderek artan bir sağlık sorunudur ve insülin direnci (İD), hipertansiyon, ateroskleroz ve bazı kanserlerle ilgili önemli bir inflamatuar faktöre sahiptir. Bu çalışma, çocukluk çağı obezitesindeki inflamatuar hematolojik parametreleri değerlendirmeyi amaçlamaktadır.

Yöntem: Altmış dört obez ve 50 normal kilolu olgu çalışmaya dahil edildi. Hastaların fizik muayene özellikleri ve laboratuvar verileri dosyalarından geriye dönük olarak değerlendirildi. Gruplar arasında laboratuvar testleri, hematolojik parametreler, cinsiyet dağılımı karşılaştırıldı. Obez grupta insülin direnci (HOMA-IR) için Homeostasis modeli değerlendirmesi ile diğer laboratuvar parametreleri arasındaki korelasyonlar incelendi.

Bulgular: Obez grubun lökosit, nötrofil, monosit, lenfosit, trombosit ve MPV değerleri kontrol grubuna göre istatistiksel olarak yüksek bulundu (p: 0,006, p:0,015, p:0,014, p:0,001, p<0,001). Nötrofil/Lenfosit oranı (N/L), Monosit/Lenfosit oranı (M/L) ve Trombosit/Lenfosit oranı (T/L) açısından iki grup arasında istatistiksel olarak anlamlı fark yoktu (p: 0,642, p:0,989, 0,982). Ayrıca Homa IR ve yaş, VKİ, Nötrofil, Lenfosit, Monosit, Trombosit, Nötrofil/Lenfosit, Monosit/Lenfosit ve Trombosit/Lenfosit değerleri arasında istatistiksel olarak anlamlı bir ilişki bulunmamıştır.

Sonuç: Çalışmamızda obez adolesan grubunun N/L, P/L, M/L değerleri kontrol grubu ile benzerdi. Bununla birlikte, obez grubundaki lökosit, nötrofil, monosit, lenfosit, trombosit ve MPV değerleri, istatistiksel olarak kontrol grubundan daha yüksekti. Ancak bu bulgular, HOMA-IR'den bağımsız olarak obezite ve inflamasyon arasında bir ilişkiye işaret etmektedir.

Anahtar kelimeler: obezite, çocuk, inflamasyon, hematolojik parametreler

Received	Accepted	Published Online	Corresponding Author	E-mail
November 1, 2022	January 6, 2023	February 7, 2023	Fatma Demir Yenigurbuz, M.D.	ftmdmr@yahoo.com
Correspondence	Dr. Fatma Demir Yenigürbüz, Yurtcan Street, Altunizade Acibadem Hospital, Pediatric bone marrow transplantation unit, Uskudar, 34662, Istanbul, Türkiye			
	https://doi.org/10.22391/fppc.1197997			

Key Points

1. Obese children without additional complications, it is thought that the increase of neutrophil, lymphocyte, monocyte, and platelet counts could be a possible outcome of insulin resistance.
2. In this study the leukocyte, neutrophile, monocyte, lymphocyte, platelet and MPV values of the obese group were found to be statistically higher than the control group.
3. Increased leukocyte, platelet and MPV values in childhood obesity probably trigger atherogenesis.

Introduction

Obesity is an increasing health problem in the whole world. According to World Health Organization (WHO) it is defined as "abnormal or excessive fat accumulation that presents a risk to health" [1]. It is an important public health problem that affects 25-30% of children worldwide. Only 1-2% of childhood obesity develops from underlying diseases and syndromes whereas the great majority has exogenous obesity [2,3]. Studies indicate that 50% of obese adolescents are also obese in adulthood, this situation is associated with increased morbidity and mortality [4].
Obesity has an important inflammatory component related to insulin resistance (IR), hypertension, atherosclerosis and some cancers. The release of large amounts of inflammatory cytokines such as tumor necrosis factor-alpha (TNF- α) and interleukin-6 (IL-6) from fatty tissue cause inflammation and trigger chronic inflammation [5,6]. It is shown in clinical studies that white blood cell (WBC) count, the number and ratio of lymphocytes, neutrophiles are elevated in obesity and metabolic syndrome. Also, increased platelet count and platelet activation may occur as part of the chronic inflammation process in obesity [7]. Platelet/lymphocyte ratio (PLR), neutrophil/lymphocyte ratio (NLR) and monocyte/lymphocyte ratio (MLR) are defined as affordable and easily accessible indicators of degree of inflammation [8,9]. Studies conducted in adults display that these parameters are associated with body mass index (BMI), however different results are reported regarding their use in childhood obesity. This study aims to evaluate the inflammatory hematological parameters in childhood obesity.

Methods

This retrospective study included 64 obese pediatric patients who presented to the pediatric endocrinology and pediatric hematology outpatient clinic of Kartal Dr. Lutfi Kirdar City Hospital and pediatric hematology outpatient clinic at Acibadem Mehmet Ali Aydinlar University Hospital between July 2021 and February 2022. The control group comprised who did not have any disorder and who underwent a complete blood test for routine purposes, were retrospectively examined. Patients with infections, insulin-dependent diabetes, congenital metabolic disease, and hormonal disorders were excluded from the study.

According to World Health Organization (WHO) Growth Reference median values; obesity is defined as body mass index (BMI) for age greater than above two standard deviations (10). The patients wore light clothing and they were without shoes for weight measurement. Height was measured with a millimeter sensitive stadiometer without shoes. Each patient's weight in kilograms was divided by the square of his or every height in the mistress (kg/m2) as for BMI defined. A single pediatric endocrinologist made all anthropometric measurements.

All blood samples were taken by venous punctures after night fasting. Complete blood count (CBC) data of all subjects (obese + control) and blood glucose and insulin levels of patients in the obese group after 8 hours of fasting were recorded. Complete blood count parameters were measured by Abbott CELL-DYN Ruby hemogram analyzer with the help of laser flow cytometry technique. N/L ratio was calculated by dividing the number of neutrophils by the number of lymphocytes, the P/L ratio was calculated by dividing the number of platelets by the number of lymphocytes, and the M/L ratio was calculated by dividing the number of monocytes by the number of lymphocytes. Homeostasis model evaluation for insulin resistance (HOMA-IR); fasting insulin (IU/L) x fasting glucose (mg/dl)/405 was calculated [11].

Ethical approval, informed consent, and permissions

The study has been reviewed by the Ethics Committee of Acibadem University, Faculty of Medicine and has therefore been performed in accordance with the ethical standards laid down in an appropriate version of the Declaration of Helsinki (ethics approval number: 2022-15/11).

Informed consent

The approval of the local institutional review board was obtained before the study was begun (2022-15/11). Written informed consent for scientific use of data was provided by all parents or legal guardians of patients.

Statistical analysis

The data was evaluated in IBM SPSS Statistics Standard Concurrent User V 26 (IBM Corp., Armonk, New York, USA) statistical package program. The descriptive statistics were denoted as number of units (n), percentage (%), mean ± standard deviation, median (M), minimum (min), maximum (max) and interquartile range (IQR). Normal distribution of the numeric variables was examined with Shapiro Wilk normality test. Comparisons between groups in independent cases were performed with t test if they were normally distributed, Mann-Whitney U test was used in situations that are not normally distributed. Spearman correlation analysis tests were used for correlation analysis. $p<0.05$ was considered statistically significant.

Results

Sixty-four obese and 50 normal weight cases were included in the study. Median age was 14 in the obese group, 13 in the control group. Boy to girl ratio was 0,56 in the obese group, 0,4 in the control group. There was no significant statistical difference between the age and gender of the groups.

The leukocyte, neutrophile, monocyte, lymphocyte, platelet and MPV values of the obese group were found to be statistically higher than the control group. There was no statistically significant difference between the two groups for Neutrophile/Lymphocyte ratio, Monocyte/Lymphocyte ratio and Platelet/Lymphocyte ratio (Table 1).

Table 1. The comparison of whole blood count parameters among study groups

	Study groups		Test statistics	
Median (min-max)	**Obese (n=64)**	**Controls (n=50)**	**Test value**	**p value**
Leukocyte	7815 (5150-16070)	7065 (4170-13340)	**-2.744** ϕ	**0.006**
Neutrophil	3860 (2100-8450)	3425 (1350-10840)	**-2.438** ϕ	**0.015**
Monocyte	855 (540-1590)	705 (440-2000)	**-2.448** ϕ	**0.014**
Lymphocyte	2720 (1600-6160)	2490 (970-5300)	**-2.033** ϕ	**0.042**
Platelet	324500 (192000-531000)	285000 (148000-403000)	**-3.602** ϕ	**0.001**
Neutrophil/Lymphocyte	1.46 (0.71-2.68)	1.38 (0.34-7.97)	-0.465 ϕ	0.642
Monocyte /Lymphocyte	0.3 (0.15-0.69)	0.29 (0.13-0.84)	-0.014 ϕ	0.989
Platelet /Lymphocyte	113.55 (55.24-206.88)	111.44 (37.37-366.36)	-0.023 ϕ	0.982
MPV	10.34 ± 0.97	9.33 ± 1.38	**4.388** ‡	**<0.001**

ϕ: Mann-Whitney U test (*z*), ‡: Independent sample *t* test (*t*), Summary statistics are denoted as *Median* (*min-max*). Bold printed parts are statistically significant (p<0.05).

Descriptive statistics are shown in Table 2. Since blood samples were not evaluated for insulin and glucose from healthy children in the control group, these parameters and Homa IR were obtained only from the medical records of obese group.

Table 2. Descriptive statistics of study groups

	Study groups	
	Obese (*n*=64)	**Controls (n=50)**
	Median (min-max)	**Median (min-max)**
Height (cm)	164.83 ± 9.95	147.21 ± 9.41
Height SDS	0.44 ± 1.09	-1.07 ± 0.65
Weight (kg)	92.92 ± 16.84	42.21 ± 8.13
Weight SDS	3.46 ± 1.03	-0.77 ± 0.61
BMI (kg/m2)	33.99 ± 4.35	17.44 ± 5.42
BMI SDS	2.99 ± 0.56	-0.23 ± 0.56
Insulin	29.1 (10.1-67.6)	-
Glucose	85.66 ± 7.01	-
Homa IR	5.63 (2.06-14.06)	-

ϕ: Summary statistics are *mean* ± *standard deviation*.

There is no statistically significant correlation found between Homa IR, Age, BMI, Neutrophil, Lymphocyte, Monocyte, Platelet, Neutrophil/Lymphocyte, Monocyte/Lymphocyte and Platelet/Lymphocyte values (Table 3).

Table 3. The correlation between HOMA-IR and other variables in obese group

	rho	**p**
Age	-0.136	0.284
BMI	0.225	0.073
Neutrophil	0.097	0.444
Lymphocyte	0.068	0.591
Monocyte	0.066	0.603
Platelet	0.187	0.138
Neutrophil/Lymphocyte	0.041	0.746
Monocyte / Lymphocyte	-0.007	0.954
Platelet/Lymphocyte	0.104	0.416

ϕ: *rho:* Spearman Correlation Coefficient.

Discussion

In recent years, the prevalence of obesity has been increasing rapidly because of high fat diets and a sedentary lifestyle. Obesity plays a leading role in insulin resistance consisting of hyperinsulinemia, hypertension, hyperlipidemia, and type 2 diabetes and causes an increase in the risk of cardiovascular disease [12]. It is shown in studies that pathogenesis and associated risk factors of atherosclerotic cardiovascular disease extends to pediatric period [13].

The presence of chronic inflammation is defined in obesity. For the indication of chronic inflammation, various parameters and their ratios in blood counts are used [14,15]. Leukocytes which are partly responsible for the relationship between obesity and inflammation, infiltrate fatty tissue can cause the release of inflammatory cytokines [16,17]. Previously meta-analyses indicated that obese patients have an increased number of leukocytes in circulation and are at elevated risk for type 2 diabetes [18]. Also, in diabetic individuals there is a relationship between leukocyte subgroups and insulin resistance [19]. It is thought that one of the major determinants of the significant relationship between high leukocyte number and obesity is the presence of insulin resistance [20]. However, in this study, even in the absence of insulin resistance, obese individuals have higher leukocyte numbers compared to the control group. Nevertheless, the absolute leukocyte count of obese individuals is in the normal range. These findings support the findings of previous studies that indicate a positive relationship between leukocyte count and BMI. Besides, the high number of neutrophils can be attributed to the chemokines produced by adipose tissue which plays a role in bone marrow hematopoiesis and limitation of intravascular neutrophils [21].

The role of platelets in systemic inflammation has been reported in numerous studies. The value of MPV has been found associated with low grade inflammation. Mean platelet volume also increases in some risk situations such as hypercholesterolemia, diabetes mellitus and hypertension. Even though the underlying mechanism for the increase seen in obese individuals is unknown, it is thought to be induced by adipocytokines such as leptin, adiponectin, resistin and PAI [22]. Despite positive correlations reported between platelet and leukocyte counts and the development of cardiovascular disease, studies about the relationship between these measurements and obesity as a risk factor for cardiovascular disease are deficient. In this study, platelet count and MPV value is statistically significantly higher in obese patient group compared to the control group.

Platelet activation is also a critical component of thrombogenesis, and platelet hyperactivity is recorded in obese individuals. Moreover, platelets isolated from obese individuals after aspirin treatment, are found to preserve reactivity more compared to non-obese individuals [23].
Aydin et al. reports higher NLR in obese adolescents compared to the control group [24]. Santoz et al. reports a positive relationship between NLR and BMI in a study with obese children [25]. Dilek et al. reported no difference between NLR values in obese adolescents when compared to the control group [26]. Another research done on obese patients obtained comparable results and emphasized that NLR is not a good indicator of inflammation [27].

Monocyte lymphocyte ratio is accepted as a new indicator appropriate for routine use to determine systemic inflammatory response. In a study, it is found that MLR is an independent risk factor for cardiovascular disease (CVD) presence and in patients with previous coronary artery disease and it is associated with the severity of lesion [28]. In another study, MLR is reported to be a strong and independent predictor of cardiovascular disease mortality [29].

Increasing PLR values are related with cardiovascular diseases and situations that increase cardiovascular diseases. When we examine studies conducted on obese children, Anik et al. reported that PLR is not different in obese adolescents compared to healthy controls [30]. Likewise, no difference was found in the study conducted by Yazaki et al. [31].

In this study high NLR, MLR, PLR values were not detected in the obese patient group, moreover no significant relationship was found with BMI. The reason for this is thought to be the increase of lymphocyte count among with the increase in neutrophil, monocyte and platelet count.

Obesity is an independent risk factor in children to have higher cell counts, especially leukocytes, neutrophils and platelets. In the current study it is detected that obese adolescents have higher leukocyte counts and subgroups, platelet counts and MPV compared to their healthy peers however no difference was detected in N/L, P/L and M/L among the two groups. Correlation was not found between HOMA-IR and these parameters. However, the increase of leukocyte parameters indicates a relationship between obesity and inflammation independent of HOMA-IR.

Limitations

The limitations of current study such as the cross-sectional design of current work, that only, complete blood count parameters and ratios were used to assess chronic inflammation and that a wider spectrum of inflammatory biomarkers, such as C-reactive protein, erythrocyte sedimentation rate, fibrinogen and IL-6 would have been desirable.

Conclusion

In this study of obese children without additional complications, it is thought that the increase of neutrophil, lymphocyte, monocyte and platelet counts could be a possible outcome of IR. Moreover, increased leukocyte, platelet and MPV values in childhood obesity probably trigger atherogenesis. For this reason, keeping obesity under control with diet changes and other treatment methods is important to decrease mortality and morbidity rates in adulthood. More comprehensive studies on this subject are needed.

Conflict of interest: There are no conflicts of interest.

Author Contributions		**Author Initials**
SCD	Study Conception and Design	FDY, ES, BBA
AD	Acquisition of Data	ES, BBA
AID	Analysis and Interpretation of Data	FDY, ES
DM	Drafting of Manuscript	FDY, ES
CR	Critical Revision	FDY, ES, BBA

Financial support: None.
Acknowledgments: None.
Prior publication: This study was presented as an oral presentation at the Cerrahpasa Pediatri Gunleri on 22-24 September 2022, Istanbul/Türkiye.

References

1. Finucane MM, Stevens GA, Cowan MJ, et al. Global Burden of Metabolic Risk Factors of Chronic Diseases Collaborating Group (Body Mass Index). National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants. Lancet. 2011;377(9765):557-67. https://doi.org/10.1016/s0140-6736(10)62037-5
2. Kumar S, Kelly AS. Review of childhood obesity: From epidemiology, etiology, and comorbidities to clinical assessment and treatment. Mayo Clin Proc. 2017;92(2):251-65. https://doi.org/10.1016/j.mayocp.2016.09.017
3. Thomas-Eapen N. Childhood obesity. Prim Care. 2021;48(3):505-15. https://doi.org/10.1016/j.pop.2021.04.002
4. Cunningham SA, Kramer MR, Narayan KM. Incidence of childhood obesity in the United States. N Engl J Med. 2014;370(5):403-11. https://doi.org/10.1056/nejmoa1309753
5. Ellulu MS, Patimah I, Khaza'ai H, Rahmat A, Abed Y. Obesity and inflammation: the linking mechanism and the complications. Arch Med Sci. 2017;13(4): 851–3. https://doi.org/10.5114%2Faoms.2016.58928
6. Khanna D, Khanna S, Khanna P, Kahar P, Patel BM. Obesity: A chronic low-grade inflammation and its markers. Cureus. 2022;14(2): e22711. https://doi.org/10.7759%2Fcureus.22711
7. de Heredia FP, Gómez-Martínez S, Marcos A: Obesity, inflammation and the immune system. Proc Nutr Soc 2012;71(2):332-8. https://doi.org/10.1017/s0029665112000092
8. Gijsberts CM, Ellenbroek GHJM, Ten Berg MJ, Pasterkamp G, Hoefer IE, de Klejin DP, et al. Effect of monocyte-to-lymphocyte ratio on heart failure characteristics and hospitalizations in a coronary angiography cohort. Am J Cardiol. 2017;120(6):911-6.https://doi.org/10.1016/j.amjcard.2017.06.020
9. Hyun S, Kwon S, Cho S, Park S, Jung W, Moon S, et al. Can the Neutrophil-to-Lymphocyte Ratio Appropriately Predict Carotid Artery Stenosis in Patients with Ischemic Stroke?-A Retrospective Study. J Stroke Cerebrovasc Dis. 2015;24(11):2646-51. https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.07.024
10. Obesity and overweight. World Health Organisation. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (Access Date: January 25, 2023)
11. Kurtogu S, Hatipoglu N, Mazicioglu M, Kendirici M, Keskin M, Kondolot M. Insulin resistance in obese children and adolescents: HOMA-IR cut-off levels in the prepubertal and pubertal periods. J Clin Res Pediatr Endocrinol. 2010;2(3):100-6. https://doi.org/10.4274/jcrpe.v2i3.100
12. Apperley LJ, Blackburn J, Erlandson-Parry K, Gait L, Laing P, Senniappan S. Childhood obesity: A review of current and future management options. Clin Endocrinol (Oxf). 2022;96(3):288-301. https://doi.org/10.1111/cen.14625
13. Musaad S, Haynes EN. Biomarkers of obesity and subsequent cardiovascular events. Epidemiol Rev 2007:98–4. https://doi.org/10.1093/epirev/mxm005
14. Fest J, Ruiter R, Ikram MA, Voortman T, van Eijck CHJ, Stricker BH. Reference values for white blood-cell-based inflammatory markers in the Rotterdam Study: a population-based prospective cohort study. Sci Rep. 2018;8(1):10566. https://doi.org/10.1038/s41598-018-28646-w
15. Zatterale F, Longo M, Naderi J, Raciti GA, Desiderio A, Miele C, et al. Chronic Adipose Tissue Inflammation Linking Obesity to Insulin Resistance and Type 2 Diabetes. Front Physiol. 2020;10:1607. https://doi.org/10.3389/fphys.2019.01607
16. Pecht T, Gutman-Tirosh A, Bashan N, Rudich A. Peripheral blood leucocyte subclasses as potential biomarkers of adipose tissue inflammation and obesity subphenotypes in humans. Obes Rev. 2014;15(4):322-37. https://doi.org/10.1111/obr.12133
17. Carvalheira JB, Qiu Y, Chawla A. Blood spotlight on leukocytes and obesity. Blood. 2013;122(19):3263-7. https://doi.org/10.1182/blood-2013-04-459446
18. Gkrania-Klotsas E, Ye Z, Cooper AJ, Sharp SJ, Luben R, Biggs MLet al. Differential white blood cell count and type 2 diabetes: systematic review and meta-analysis of cross-sectional and prospective studies. PLoS One. 2010;5(10):e13405. https://doi.org/10.1371/journal.pone.0013405
19. Lee CT, Harris SB, Retnakaran R, Gerstein HC, Perkins BA, Zinman B, et al. White blood cell subtypes, insulin resistance and β-cell dysfunction in high-risk individuals--the PROMISE cohort. Clin Endocrinol (Oxf). 2014;81(4):536-41. https://doi.org/10.1111/cen.12390
20. Yoshimura A, Ohnishi S, Orito C, Kawahara Y, Takasaki H, Takeda H, et al. Association of peripheral total and differential leukocyte counts with obesity-related complications in young adults. Obes Facts. 2015;8(1):1-16. https://doi.org/10.1159/000373881
21. Suwa T, Hogg JC, English D, Van Eeden SF. Interleukin-6 induces demargination of intravascular neutrophils and shortens their transit in marrow. Am J Physiol Heart Circ Physiol. 2000;279(6):H2954-60. https://doi.org/10.1152/ajpheart.2000.279.6.h2954
22. Aydin M, Nalbantoglu B, Donma MM, Feti T, Volkan K, Erkut K, et al. The effect of obesity and dietary habits on mean platelet volume and other platelet indices. J Pediatr Biochem. 2014;4(3)167-70. https://doi.org/10.3233/JPB-140122
23. Bordeaux BC, Qayyum R, Yanek LR, Vaidya D, Becker LC, Faraday N, Becker DM. Effect of obesity on platelet reactivity and response to low-dose aspirin. Prev Cardiol. 2010;13(2):56-62. https://doi.org/10.1111/j.1751-7141.2009.00058.x
24. Aydin M, Yilmaz A, Donma MM, Tulubas F, Demirkol M, Erdogan M, Gurel A. Neutrophil/lymphocyte ratio in obese adolescents. North Clin Istanb. 2015;2(2):87-91. https://doi.org/10.14744/nci.2015.25238
25. Santos C, Picoito J, Teixeira AL, Rodrigues C, Ferreira S. Platelet to lymphocyte ratio and homeostasis model assessment of insulin resistance in pediatric obesity and overweight. Rev Port Endocrinol Diabetes Metab. 2017;12(2):177-182. http://dx.doi.org/10.1016/j.rpedm.2016.10.041
26. Dilek TD, Gayret OB, Kilinc S, Erol M, Yigit O, Mete F. The assessment of the neutrophil-lymphocyte ratio and platelet-lymphocyte ratio in dyslipidemic obese children. Bagcilar Med Bull 2019;4(3):56-60. https://doi.org/10.4274/BMB.galenos.2019.06.010

27. Bahadir A, Baltaci D, Turker Y, Sariguzel YC, Turker Y, Lliev D, et al. Is the neutrophil-to-lymphocyte ratio indicative of inflammatory state in patients with obesity and metabolic syndrome? Anatol J Cardiol. 2015;15(10):816-22. https://doi.org/10.5152/akd.2014.5787
28. Ji H, Li Y, Fan Z, Zuo B, Jian X, Li L, Liu T. Monocyte/lymphocyte ratio predicts the severity of coronary artery disease: a syntax score assessment. BMC Cardiovasc Disord. 2017;17(1):90. https://doi.org/10.1186/s12872-017-0507-4
29. Xiang F, Chen R, Cao X, Shen B, Liu Z, Tan X, et al. Monocyte/lymphocyte ratio as a better predictor of cardiovascular and all-cause mortality in hemodialysis patients: A prospective cohort study. Hemodial Int. 2018;22(1):82-92. https://doi.org/10.1111/hdi.12549
30. Anik A, Celik E, Anik A. The relation of complete blood count parameters with metabolic and clinical parameters in overweight and obese children. J Pediatr Res 2021;8(2):161-70. http://doi.org/10.4274/jpr.galenos.2020.74824
31. Yazaki LG, Faria JCP, Souza FIS, Sarni ROS. Neutrophil-to-lymphocyte and platelet-to-lymphocyte ratios of overweight children and adolescents. Rev Assoc Med Bras 2022;68(8):1006-1010. https://doi.org/10.1590/1806-9282.20211253