ÖZGÜN ARAŞTIRMA ORIGINAL RESEARCH

Med J SDU / SDÜ Tıp Fak Derg ▶ 2022:29(3):314-323 doi: 10.17343/sdutfd.1073876

THE RELATIONSHIP BETWEEN BLOOD GROUPS AND PLATELETCRIT IN HEALTHY TURKISH POPULATION

SAĞLIKLI TÜRK NÜFUSUNDA KAN GRUPLARI İLE PLATELETKRİTİN İLİŞKİSİ

Demircan ÖZBALCI[1], Emine Güçhan ALANOĞLU[1], Funda YILDIRIM BAŞ[2], Nurbanu TATAR[3], Yavuz ÖZKAN[2], Hasan YASAN[4], Erşan KAYA[5].

[1] Süleyman Demirel Üniversitesi, Tıp Fakültesi, İç Hastalıkları Ana Bilim Dalı, Hematoloji Bilim Dalı, Isparta, TÜRKİYE
[2] Süleyman Demirel Üniversitesi, Tıp Fakültesi, Aile Hekimliği Ana Bilim Dalı, Isparta, TÜRKİYE
[3] Süleyman Demirel Üniversitesi, Tıp Fakültesi, İç Hastalıkları Ana Bilim Dalı, Isparta, TÜRKİYE
[4] Süleyman Demirel Üniversitesi, Tıp Fakültesi, Kulak Burun Boğaz Ana Bilim Dalı, Isparta, TÜRKİYE
[5] Süleyman Demirel Üniversitesi, Tıp Fakültesi Hastanesi, Kan Bankası, Isparta, TÜRKİYE

Cite this article as: Özbalcı D, Alanoğlu EG, Yıldırım Baş F, Tatar N, Özkan Y, Yasan H, Kaya E. The Relationship between Blood Groups and Plateletcrit in Healthy Turkish Population. Med J SDU 2022; 29(3): 314-323.

Öz

Amaç
Plateletkrit (PCT) ve ortalama trombosit hacmi (MPV), çeşitli sistemik ve inflamatuar bozukluklarla ilişkili önemli trombosit göstergeleridir. Bu çalışmanın amacı, öncelikle sağlıklı popülasyonda normal PCT aralıklarının belirlenmesi ve ikincil olarak kan grupları ile PCT ve MPV arasındaki olası bağlantının değerlendirilmesidir.

Gereç ve Yöntem
Çalışma için, 2011'den 2021'e kadar, retrospektif olarak, bin beş yüz sağlıklı birey seçildi. Hemoglobin, hematokrit, ortalama alyuvar hacmi, lökosit sayısı, lökosit farklılıkları, MPV, PCT ve trombosit sayıları analiz edildi.

Bulgular
1082 denekte ortalama PCT 0,20±0,04 % (min 0,11-maks 0,46 %) ve ortalama MPV 8,41±0,92 fL (min 6,20-maks 11,90 fL) idi. Çalışma grubunun ortalama PCT, MPV ve trombosit düzeyleri kadınlarda erkeklere göre anlamlı derecede yüksek bulundu (p<0,001). PCT ve trombosit sayıları yaşla ters orantılıydı ve ortalama PCT 18-40 yaş grubunda, 41-60 yaş grubuna göre anlamlı derecede yüksekti (p=0,021). ABO grupları ile trombosit indeksleri arasında ilişki yoktu. Kan grupları Rh durumlarına göre ayrıldığında; Rh pozitif olan deneklerin ortalama PCT ve trombosit sayısının Rh negatif olanlara göre anlamlı derecede yüksek olduğu bulundu (p=0,003 ve p=0,006).

Sonuç
Ortalama PCT 0,20 % idi. Kadınlarda PCT ve trombosit sayıları erkeklere göre anlamlı derecede yüksekti ve bu değerler, ülkemizdeki diğer çalışmalara göre anlamlı derecede düşüktü. ABO grupları ile trombosit indeksleri arasında ilişki yoktu. PCT ve trombosit sayıları, Rh negatif olanlara kıyasla Rh pozitif çalışma deneklerinde önemli ölçüde daha yüksekti.

Anahtar Kelimeler: Kan Grupları, MPV, Plateletkrit, Rh faktörü

Abstract

Objective
Plateletcrit (PCT) and mean platelet volume (MPV) are important platelet indices that are associated

Sorumlu yazar ve iletişim adresi /Corresponding author and contact address: D.Ö. / demircanozbalci@sdu.edu.tr
Müracaat tarihi/Application Date: 15.02.2022 • Kabul tarihi/Accepted Date: 27.05.2022
ORCID IDs of the authors: D.Ö: 0000-0002-9635-3091; E.G.A: 0000-0002-8089-9401; F.Y.B: 0000-0001-6852-3180; N.T: 0000-0002-4119-5938; Y.Ö: 0000-0002-6608-4732; H.Y: 0000-0002-5470-6784; E.K: 0000-0002-7612-9367

with various systemic and inflammatory disorders. The aims of this study are, first to determine normal ranges of PCT in a healthy population and second, evaluation of the possible link between blood groups and two platelet indices, PCT and MPV.

Material and Method
One thousand five hundred healthy subjects were chosen for the study from 2011 to 2021 retrospectively. Hemoglobin, hematocrit, mean corpuscular volume, leukocyte count, leukocyte differentials, MPV, PCT and platelet counts were analysed.

Results
In 1082 subjects, the mean PCT count was 0.20±0.04 % (min 0.11-max 0.46 %) and mean MPV was 8.41±0.92 fL (min 6.20-max 11.90 fL). The mean PCT, MPV and platelet counts of the study group were found to be significantly higher in women than in men (p<0.001). PCT and platelet counts were inversely related to age and mean PCT was significantly higher in 18-40 than 41-60 age group (p=0.021). There was no association between ABO groups and platelet indices. When blood groups were separated according to their Rh status; it was found that subjects who were Rh positive had a significantly higher mean PCT and platelet count than Rh negatives (p=0.003 and p=0.006).

Conclusion
Mean PCT was 0.20 %. Women had significantly higher PCT, and platelet counts compared to men and these counts were significantly lower compared to other studies in our country. There was no association between ABO groups and platelet indices. PCT and platelet counts were significantly higher in Rh positive study subjects compared to Rh negatives.

Keywords: Blood Groups, MPV, Plateletcrit, Rh factor

Introduction

Complete blood cell count is an effective tool in screening for various hematologic disorders. Platelet count is a part of complete blood count and platelets which are originated from megakaryocytes delivered from bone marrow to circulation and have various roles on normal physiology including coagulation and inflammation. Mean platelet volume (MPV) which reflects the size of platelets, is a marker of platelet activation and has been used to discriminate bone marrow hyperproduction and/or peripheral destruction of platelets from primary production anomalies or insufficiencies such as aplastic anemia (1, 2). Plateletcrit (PCT) is a MPV plus platelet count bound platelet index, which is usually linked to inflammatory disorders and malignancies (3-5). Normal reference values of plateletcrit have been subject to change from country to country since racial as well as regional factors such as platelet disorders that are linked to a specific race or altitude changes (2, 6-8). So, it is important for every country to study and report normal ranges for PCT levels to reach better conclusions about studies about PCT.

ABO and Rh blood groups are the most widely used grouping system that discriminates blood groups from each other, and compatibility tests usually uses these two systems worldwide. ABO grouping system differs erythrocytes whether they contain A, B, both A and B or none of these proteins (O) whereas, Rh grouping system defines erythrocytes which express Rh factor on membrane as Rh positive and erythrocytes that do not express the protein as Rh negative. Rh factor is a protein which is found at first on membrane of Rhesus Maccacus monkey erythrocytes and it has been estimated that approximately 87.3% of humans are Rh positive in Türkiye (9). ABO and Rh groups have been linked to various inflammatory, infectious, and malignant disorders (10-12). PCT and MPV have also been linked to inflammatory state but there have been few studies evaluating the relationship between blood groups and platelet indices (13). The aims of this study are, first determining normal ranges of PCT in healthy population and second evaluation of possible link between blood groups and two platelet indices, PCT and MPV.

Material and Method

The complete blood count data, blood groups, age, and gender of one thousand five hundred healthy subjects were retrospectively recorded from data-processing unit of Hospital of Süleyman Demirel University. The healthy study group was collected from blood donors who were admitted to Blood Centre of Süleyman Demirel University Hospital from 2011 to 2021 and individuals who had no health problems and were admitted to Department of Family Medicine outpatient clinic for routine control from 2019 to 2021. The individuals who had no systemic disease and drug usage were included in this study. All the data of

study subjects were checked for any health problems and those who had systemic diseases, drug usage or had insufficient personal health data for evaluating his/her state of health were excluded from the study. Individuals who had nutritional (iron deficiency anemia, megaloblastic anemia), clonal anemia (hematological malignancy) or hemoglobinopathy (thalassemia minor) were also excluded from the study (Figure 1). Hemoglobin, hematocrit, mean corpuscular volume, leukocyte count, leukocyte differentials, platelet count and MPV count were recorded from complete blood count. PCT was calculated by using MPV x Platelet count/10000 formula. ABO and Rh blood groups of the study group were recorded. Our research is a cross-sectional analytical study and was completed in 6 months.

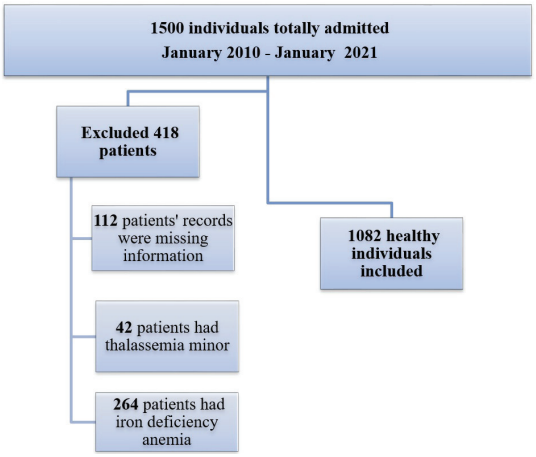

Figure 1
Number of individuals admitted

Conformity of continuous variables to normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Kolmogorov - Smirnov / Shapiro - Wilk tests). Descriptive statistics were given with number, percentage, mean, median, standard deviation and 95% confidence interval. ANOVA test was used to compare independent groups with more than two normal distributions. Student's t-Test was used for the comparison of normally distributed variables between two independent groups. Canonical Correlation Analysis was performed in order to determine the relationship between PCT, PLT and MPV values of the whole group and other hemogram parameters, to determine whether there is a correlation and to determine the variables that affect this correlation at the highest level. The first data set contains independent variables (WBC, RBC, MCV, RDW, RDW.SD, HCT and HGB), while the second data set includes dependent variables (PCT, PLT, MPV). The relationship between the variables was determined by Pearson correlation analysis. SPSS for Windows version 26.0 package program was used for statistical analysis and $p<0.05$ was considered statistically significant.

Informed consent was taken from all volunteers. The approval of the Ethics Committee of the Faculty of Medicine of Süleyman Demirel University dated 27.05.2021 and numbered 213 was obtained for the study.

Results

The data of 1500 subjects were analysed retrospectively and after evaluation and retraction of 418 patients due to insufficient data, iron deficiency anemia and thalassemia minor, 1082 patients were included in the study. The mean age of the study group was 35.9±10.1 (min 18-max 76) and 28.6% of the patients were female. The mean, median, standard deviation and expected values of the hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), leukocyte count (WBC), leukocyte distribution (neutrophil, lymphocyte, monocytes, eosinophil absolute values), mean platelet volume (MPV), red cell distribution width (RDW) values at the 95% confidence interval were presented in Table 1. The mean PCT count was 0.20±0.04% (min 0.11-max 0.46 %) and the mean MPV was 8.41±0.92 fL (min 6.20-max 11.90 fL).

In the second phase of the study, it was examined whether there were any variations of PCT, platelet counts and MPV related to blood group, age, and gender. The mean PCT, MPV and platelet counts were found to be significantly higher in women than in men ($p<0.001$). The patients were grouped according to age as 18-40 years old, 41-60 years old and 61-76 years old. When the PCT, MPV and platelet counts of the research group were examined according to age, it was observed that the PCT and platelet counts were inversely related to age. PCT averages were found to be significantly higher in the 18-40 age group than in the 41-60 age group ($p=0.021$; Table 2).

The blood group of 833 subjects were retrospectively collected and then changes in MPV and PCT count according to the blood groups of the study subjects were analysed. There was no difference of MPV and PCT according to blood groups. When blood groups were separated according to their Rh status it was found that subjects who were Rh positive had a significantly higher mean PCT and platelet count than Rh negatives ($p=0.003$ and $p=0.006$, Table 3).

Table 1 Descriptive Statistics of Hemogram Data

Parameters	Min	Max	Mean	Median	SD	95 % CI
Age (year)	18.0	76.0	35.9	36.0	10.1	35.27-36.47
PCT (%)	0.1139	0.4592	0.2029	0.1980	0.0370	0.2007-0.2051
PLT (%)	142.00	656.00	243.22	237.00	48.51	240.33-246.11
MPV (fL)	6.20	11.90	8.41	8.30	0.92	8.36-8.46
HCT (%)	34.30	54.10	44.60	44.30	3.50	44.39-44.81
HGB (g/dl)	12.00	18.40	15.27	15.20	1.33	15.20-15.35
MCV (fL)	62.10	98.50	86.09	85.80	4.43	85.83-86.35
MCH (pg)	19.30	36.70	29.49	29.50	1.83	29.38-29.60
MCHC(g/dl)	28.80	39.20	34.26	34.20	0.89	34.20-34.31
RDW (%)	11.80	21.10	13.54	13.50	0.83	13.49-13.59
RDW-SD (fL)	32.40	53.80	40.47	40.58	2.27	40.34-40.61
WBC (µ/mm³)	4.00	10.70	7.33	7.30	1.45	7.24-7.42
NE (10^3/mm³)	0.60	43.00	4.26	4.20	1.61	4.17-4.36
LY (10^3/mm³)	0.50	5.30	2.33	2.31	0.60	2.29-2.36
MO(10^3/mm³)	0.10	5.10	0.57	0.57	0.22	0.55-0.58
E0 (10^3/mm³)	0.00	1.40	0.17	0.17	0.12	0.17-0.18
NRBC (%)	0.00	0.25	0.008	0.010	0.015	0.007-0.009
RBC (µ/mm³)	0.00	6.71	1.72	0.10	2.21	1.59-1.85

PCT: Plateletcrit, PLT: Platelet, MPV: Mean Platelet Volume, HCT: Hematocrit, HGB: Hemoglobin, MCV: Mean Corpuscular Volume, MCH: Mean Corpuscular Hemoglobin, MCHC: Mean Corpuscular Hemoglobin Concentration, RDW: Red Cell Distribution Width, RDW-SD: Red Cell Distribution Width-Standard Derivation, WBC: White Blood Cell, Ne: Neutrophil, LY: Lymphocyte, Mo: Monocyte, Eo: Eosinophil, RBC: Red Blood Cell, NRBC: Nucleated Red Blood Cell

Table 2 Distribution of PCT, PLT and MPV by Age and Gender

			PCT		PLT		MPV	
		N (%)	Mean	SD	Mean	SD	Mean	SD
Gender*	**F**	310 (%28.6)	0.2224	0.0410	259.27	58.93	8.69	0.98
	M	772 (%71.4)	0.1951	0.0321	236.78	41.98	8.30	0.80
p			**<0.001**		**<0.001**		**<0.001**	
Age **	**18-40**	743(%68.6)	0.2045	0.0375	245.88	49.69	8.39	0.87
	41-60	324 (%29.9)	0.1999	0.0357	237.80	45.60	8.47	0.88
	61-76	15 (%1.5)	0.1889	0.0309	228.40	39.55	8.34	1.03
p			0.061		**0.021*** **		0.302	
TOTAL		1082 (%100)						

In the analysis of variables; *independent groups T-test; ** Anova test performed.
***The difference in post-hoc tests is between 18-49 and 41-60 groups. F:female ; M:Male; PCT: Plateletcrit ; PLT: Platelet; MPV: Mean Platelet Volume

Table 3 Distribution of PCT, PLT and MPV by Blood Type

			PCT		PLT		MPV	
		N (%)	Mean	SD	Mean	SD	Mean	SD
Blood group**	0	256 (%30.7)	0.2018	0.0381	242.75	51.74	8.38	0.83
	A	392 (%47.1)	0.2025	0.0347	245.63	45.11	8.30	0.78
	AB	75 (%9.0)	0.2076	0.0339	251.21	45.76	8.34	0.93
	B	110 (%13.2)	0.1951	0.0359	235.63	43.20	8.33	0.89
	p		0.113		0.118		0.692	
Rh group*	RH-	128 (%15.4)	0.1931	0.0327	233.38	45.53	8.34	0.78
	RH+	705 (%84.6)	0.2034	0.0363	245.84	47.22	8.33	0.84
p			0.003		0.006		0.866	
TOTAL		833 (%100)						

In the analysis of variables; *independent groups T-test; ** Anova test performed. PCT: Plateletcrit, PLT: Platelet, MPV: Mean Platelet Volume

Table 4 Canonical Correlation Coefficients and Significance Tests

Root No	Correlation	Eigenvalue	Wilks L.	F	p
1	0.416	0.209	0.781	13.199	**<0.001**
2	0.223	0.052	0.944	5.254	**<0.001**
3	0.083	0.007	0.993	1.480	0.194

Table 5 Correlations Between Dependent Independent Variables

	PCT(r)	PLT(r)	MPV(r)
WBC	0.20***	0.19***	-0.03
RBC	0.07*	-0.02	0.18***
MCV	-0.07*	-0.05	-0.02
RDW	0.15***	0.10**	0.07**
RDW.SD	0.11**	0.06*	0.09***
HCT	-0.28***	-0.19***	-0.14***
HGB	-0.29***	-0.19***	-0.16***

*p<0.05; **p<0.01; ***p<0.001. r:Pearson correlation coefficient.

As a result of Canonical Correlation and Wilk's Lambda analysis, three canonical function correlations were obtained, model one and two were found to be statistically significant. Wilk's Lambda (λ) value indicates the variance that the model does not explain, while 1-λ value indicates the degree of influence of the model (14). It was found that the first model proposed in this study explained 22% of the relationships between the two sets (Table 4).

When the correlation values and significance between the dependent and independent variables are

examined; were observed to have weak correlation values, the results are shown in Table 5.

Standardized Canonical coefficients showing the contribution of the original variables in the related variable set in the formation of canonical variables are shown in Table 6. The variables that contributed the most to the first canonical variable were MPV and HGB. The variables that contributed the most to the second canonical variable were PCT and RDW.SD.

When the canonical loads in the independent set (Set 1) were examined, HGB made the greatest contribution to the first independent canonical variable, followed by HCT. RBC made the largest contribution to the second independent canonical variant. When the canonical loads in the dependent set (Set 2) were examined, PCT made the greatest contribution to the

Table 6 Standardized Canonical Coefficients for Variables

	Variable	1	2	3
Set 1	WBC	-0.566	-0.542	-0.027
	RBC	-0.212	0.653	0.172
	MCV	0.533	-0.922	2.519
	RDW	0.527	-1.239	2.773
	RDW.SD	-0.707	1.281	-2.120
	HGB	0.805	-1.265	0.312
	HCT	-0.025	1.426	-0.353
Set 2	PCT	-0.406	-2.924	-7.777
	PLT	-0.527	2.662	8.504
	MPV	-0.608	2.274	4.078

PCT: Plateletcrit, PLT: Platelet, MPV: Mean Platelet Volume, HCT: Hematocrit, HGB: Hemoglobin, MCV: Mean Corpuscular Volume, RDW: Red Cell Distribution Width, RDW-SD: Red Cell Distribution Width-Standard Derivation, WBC: White Blood Cell, RBC: Red Blood Cell

Table 7 Canonical Loadings for Variables

	Variable	1	2	3
Set 1	WBC	0.403	0.556	0.080
	RBC	0.305	-0.672	-0.172
	MCV	-0.163	-0.127	-0.379
	RDW	0.373	-0.016	-0.314
	RDW.SD	0.321	-0.220	-0.395
	HGB	-0.756	0.116	0.122
	HCT	-0.727	0.022	0.055
Set 2	PCT	0.941	0.335	-0.046
	PLT	0.639	0.708	-0.300
	MPV	0.461	-0.838	0.291

PCT: Plateletcrit, PLT: Platelet, MPV: Mean Platelet Volume, HCT: Hematocrit, HGB: Hemoglobin, MCV: Mean Corpuscular Volume, RDW: Red Cell Distribution Width, RDW-SD: Red Cell Distribution Width-Standard Derivation, WBC: White Blood Cell, RBC: Red Blood Cell

Table 8 Proportion of Variance Explained

	Set 1 by self	Set 1 by set 2	Set 2 by self	Set 2 by set 1
1	0.232	0.040	0.503	0.087
2	0.120	0.006	0.439	0.022
3	0.065	0.000	0.059	0.000

first independent canonical variable, while MPV made the greatest contribution to the second independent canonical variable (Table 7)

The lastly examined redundancy index is presented in Table 8. The portion explained by the first independent canonical variables in the dependent set was found to be 8.7%.

Discussion

Reference levels for hematologic indices were usually referred from western countries, but it is important for every nation to evaluate the normal ranges for whole blood count indices as genetic, biologic, and environmental differences were observed in many studies. For example, it was found that platelet counts of African populations were significantly lower than western values and an Iranian study showed that platelet counts of subjects were slightly higher than Africans but also; slightly lower than Europeans (8, 15). Environmental factors directly affect blood indices; low platelet count was thought to be related to chronic malaria parasitemia which was a common infestation in Africa. PCT, a platelet bound index, could also be affected by platelet count changes. Age and gender also affected PCT counts. Giovanetti et al had found that PCT counts were elevated in women and PCT was significantly affected by age (6). This was explained by high platelet counts in women compared to men. Also, a slightly positive correlation was also found between age and PCT. PCT has been slightly increased till age 50 in women (6).

Based on these variations, studies focused on reference ranges for PCT in many countries. Mean PCT was found as 0.24% in Thailand, 0.23% in India 0.22% in Iran and 0.27% in Egypt (2, 7, 8, 16). Also, in some studies, significant differences were found for PCT which was calculated for men and women separately. Boshnak NH, Ali et al and Adibi et al had found PCT as 0.26%, 0.21%, 0.26% and 0.28%, 0.23%, 0.28% for men and women respectively (8, 16, 17). Giovanetti et al had showed more remarkable results; PCT was 0.24% and 0.28% for men and women respectively (6). A Korean study also showed significant differences in PCT of all genders (18). Mean PCT in our study was 0.20% and we also found significant differences between genders; mean PCT was 0.19% for men; whereas PCT count for women was 0.22%. These counts were much lower compared to literature and it also showed the need for data from every country. Only PCT data we could reach so far in our country showed that mean PCT was 0.24% for mean and 0.22% for women (19). These counts were also higher than our results.

In our study we also found that, besides from PCT; MPV and platelet counts of women were significantly higher than males. Also, PCT levels fell as age increased in women, albeit insignificantly. Boshnak et al showed significantly lower PCT over age 52 (16). Ali et al, did not find significant MPV changes between gender (17). In contrast, Boshnak et al and Kim et al found a significant increase in platelet counts, MPV and PCT in women (16, 18). Our findings were compatible with literature; minor differences might be due to racial or environmental changes.

There are few studies evaluating the normal range of complete blood count intervals in Turkey. Kabasakal et al had found that PCT and platelet counts were significantly higher in women compared to men, MPV was also found to be significantly higher in women in our study (19). Alper et al evaluated whether there was any difference in MPV, and platelet counts of patients with previous acute coronary syndrome and found that MPV counts of patients who lived in Erzurum (altitude 1890 meters) were higher than patients living in Istanbul (altitude 40 meters) (8, 9, 20). Therefore, MPV (and PCT) counts could also be affected in Isparta, a city at 1080 meters above sea level. Tekkesin et al found significant differences most notably in platelets and leukocyte counts in city of Istanbul which was 40 meters above sea level compared to other studies in Turkey (21). In contrast, Kaya et al, evaluated the normal hematologic

reference intervals in city of Erzurum with an altitude of 1890 meters and they did not find significant difference related to high altitude compared to studies based on sea level findings (22). Of note, none of these two studies had evaluated MPV counts. The only multi-centre study to the reference intervals of hemogram values in Turkey found no altitude related significant changes in platelet count and MPV (23). In our study, MPV count was found to be 8.44 fL, similar to levels in Istanbul. Based on these studies, it can be concluded that, the altitude in Isparta might have no effect on MPV and PCT. In any way, our study may add valuable information about reference intervals for MPV and PCT in Turkey.

We evaluated and found that although there was no association between ABO groups and PCT, a definite and significant high PCT was shown in Rh positive study subjects. This could be attributable to many reasons. We showed that, Rh positive subjects had also significantly higher platelet counts compared to Rh negatives. PCT is a platelet bound index; changes in platelet counts should directly affect PCT. Second, the major difference between the Rh positive and negative subjects was the expression of D antigen on erythrocyte surface of positive ones (24). Only 4-7% of human platelets express ABO group antigens and normally, platelets do not express RhD antigen but, it was shown that platelets could carry small fragments of red blood cells (24, 25). Thiabault et al, have shown that platelet concentrates had carried significant amount of red blood cells and their particles (26). ABO groups were found to be significantly related to platelet function; O group were found to have significant fewer thrombotic attacks and lower expression of von Willebrand Factor antigen compared to other blood groups (27). Although we did not find any relationship between MPV-PCT and ABO groups in this study, we could speculate that, RhD antigen expression could somehow be related to increased platelet reactivity and/or count in association with ABO blood group as PCT was associated with platelet reactivity (28). A third possibility was that the naturally low number of Rh-negative study groups affected the results; in fact, at about 0.5-15% of humans do not express RhD antigen on red blood cells (29, 30). Salduz et al found that 85.8% of blood donors were Rh positive and 14.2% were Rh negative in Istanbul, Turkey (31). We found that 15.3% of our study group were Rh negative and this finding was compatible with literature.

We could only reach one study evaluating the association of ABO groups and MPV. Celik et al found that study subjects with blood group O and A had significantly low MPV and platelet distribution width counts compared to group B and AB (13). With a much larger study group (833 versus 301 healthy subjects) we did not reach the same conclusion in our study.

Our study group was small compared to some larger ones in literature and also retrospective design of the study was another limitation of the study. The advantages of this study were the evaluation of the blood groups and PCT for the first time in literature and the significant relationship between PCT and Rh blood group was also shown for the first time so, the study should add valuable information to literature.

In conclusion, we found that mean PCT was 0.20% and women had significantly high PCT, and platelet counts compared to men and these counts were significantly lower compared to other studies in our country. PCT and platelet counts were significantly higher in Rh positive study subjects compared to Rh negatives. There was no association between ABO groups and platelet indices. More studies are needed to evaluate the possible association of Rh blood group and platelet indices.

Conflict of Interest Statement
The authors have no conflicts of interest to declare.

Ethical Approval
The study was conducted in line with the principles of the Helsinki Declaration. The approval of the Ethics Committee of the Faculty of Medicine of Süleyman Demirel University dated 27.05.2021 and numbered 213 was obtained for the study.

Consent to Participate and Publish
Written informed consent to participate and publish was obtained from all individual participants included in the study.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgments
The authors appreciate the efforts of Dr. Hande Nur Eroglu for the article.

Availability of Data and Materials
Veriler üçüncü parti kısıtlamalar sebebi ile paylaşılamamaktadır.

Authors Contributions
DO: Conceptualization; Data curation; Formal

analysis; Investigation; Methodology; Validation; Visualization; Writing-original draft
EGA: Conceptualization; Supervision; Writing-review & editing
FYB: Supervision; Writing-review & editing
NT: Investigation; Data Curation
YO: Investigation; Data Curation
HY: Supervision; Writing-review & editing
EK: Investigation; Data Curation

References

1. Gasparyan AY, Ayvazyan L, Mikhailidis DP, Kitas GD. Mean platelet volume: a link between thrombosis and inflammation? Curr Pharm Des. 2011;17(1):47-58. doi: 10.2174/138161211795049804. PMID: 21247392.
2. Wiwanitkit V. Plateletcrit, mean platelet volume, platelet distribution width: its expected values and correlation with parallel red blood cell parameters. Clin Appl Thromb Hemost. 2004 Apr;10(2):175-8. doi: 10.1177/107602960401000208. PMID: 15094938.
3. Hur JY, Lee HY, Chang HJ, Choi CW, Kim DH, Eo WK. Preoperative plateletcrit is a Prognostic Biomarker for Survival in Patients with Non-Small Cell Lung Cancer. J Cancer. 2020 Feb 25;11(10):2800-2807. doi: 10.7150/jca.41122. PMID: 32226498; PMCID: PMC7086273.
4. Ustaoglu G, Erdal E, Inanır M. Does periodontitis affect mean platelet volume (MPV) and plateletcrit (PCT) levels in healthy adults? Rev Assoc Med Bras (1992). 2020 May 15;66(2):133-138. doi: 10.1590/1806-9282.66.2.133. PMID: 32428146.
5. Cetin MS, Ozcan Cetin EH, Akdi A, Aras D, Topaloglu S, Temizhan A, et al. Platelet distribution width and plateletcrit: novel biomarkers of ST elevation myocardial infarction in young patients. Kardiol Pol. 2017;75(10):1005-1012. doi: 10.5603/KP.a2017.0135. Epub 2017 Jul 17. PMID: 28715073.
6. Giovanetti TV, do Nascimento AJ, de Paula JP. Platelet indices: laboratory and clinical applications. Rev Bras Hematol Hemoter. 2011;33(2):164-5. doi: 10.5581/1516-8484.20110040. PMID: 23284267; PMCID: PMC3520644.
7. Chandrashekar V. Plateletcrit as a Screening Tool for Detection of Platelet Quantitative Disorders. J Hematol • 2013;2(1):22-26. doi: http://dx.doi.org/10.4021/jh70w
8. Adibi P, Faghih Imani E, Talaei M, Ghanei M. Population-based platelet reference values for an Iranian population. Int J Lab Hematol. 2007 Jun;29(3):195-9. doi: 10.1111/j.1751-553X.2006.00843. x. PMID: 17474897.
9. Kumas LT. [Kan grup antijenleri ve antikorları]. In: [HematoLog. Kan Bankacılığı, Transfüzyon Tıbbı ve Aferez]. Soysal T, Bayık B, Demir AM, Tiftik EC, (eds). Türk Hematoloji Derneği Ankara, Mart 2015 Cilt 5, Sayı 1. (In Turkish)
10. Oral A, Sahin T. Prognostic role of ABO blood group and Rhesus factor in cirrhotic patients with hepatocellular carcinoma. Sci Rep. 2019 Dec 13;9(1):19087. doi: 10.1038/s41598-019-55685-8. PMID: 31836844; PMCID: PMC6910915.
11. Solmaz I, Araç S. ABO blood groups in COVID-19 patients; Cross-sectional study. Int J Clin Pract. 2021 Apr;75(4): e13927. doi: 10.1111/ijcp.13927. Epub 2020 Dec 19. PMID: 33296536; PMCID: PMC7883261.
12. Cildag S, Kara Y, Senturk T. ABO blood groups and rheumatic diseases. Eur J Rheumatol. 2017 Dec;4(4):250-253. doi: 10.5152/eurjrheum.2017.17044. Epub 2017 Nov 2. PMID: 29308278; PMCID: PMC5741336.
13. Celik H, Duzenli U, Aslan M, Altiparmak IH, Kirmit A, Kara E, et al. The relationship between platelet indices and ABO blood groups in healthy adults. J Clin Lab Anal. 2019 Mar;33(3): e22720. doi: 10.1002/jcla.22720. Epub 2018 Nov 21. PMID: 30461052; PMCID: PMC6818600.
14. Sherry A, Henson RK. Conducting and interpreting canonical correlation analysis in personality research: a user-friendly primer. J Pers Assess. 2005 Feb;84(1):37-48. doi: 10.1207/s15327752jpa8401_09. PMID: 15639766.
15. Gill GV, England A, Marshal C. Low platelet counts in Zambians. Trans R Soc Trop Med Hyg. 1979;73(1):111-2. doi: 10.1016/0035-9203(79)90142-1. PMID: 442169.
16. Boshnak NH. Reference intervals for platelet indices using Sysmex XT-1800i in Egyptian population. Hematol., Transfus. Cell Ther. 41 (2) • Apr-Jun 2019https://doi.org/10.1016/j.htct.2018.09.005
17. Ali U, Gibbs R, Knight G, Tsitsikas D. Sex-divided reference intervals for mean platelet volume, platelet large cell ratio and plateletcrit using the Sysmex XN-10 automated haematology analyzer in a UK population. Hematol Transfus Cell Ther. 2019 Apr-Jun;41(2):153-157. doi: 10.1016/j.htct.2018.09.005. Epub 2018 Dec 31. PMID: 31079661; PMCID: PMC6517618.
18. Kim MJ, Park PW, Seo YH, Kim KH, Seo JY, Jeong JH, et al. Reference intervals for platelet parameters in Korean adults using ADVIA 2120. Ann Lab Med. 2013 Sep;33(5):364-6. doi: 10.3343/alm.2013.33.5.364. Epub 2013 Aug 8. PMID: 24003429; PMCID: PMC3756243.
19. Kabasakal EA, Ergene U, Ozlu C. Normal complete blood count reference intervals in the Turkish population: a prospective study. Hematol Transfus Int J. 2018;6(4):135-139. DOI: 10.15406/htij.2018.06.00169
20. Alper AT, Sevimli S, Hasdemir H, Nurkalem Z, Guvenc TS, Akyol A, et al. Effects of high altitude and sea level on mean platelet volume and platelet count in patients with acute coronary syndrome. J Thromb Thrombolysis. 2009 Feb;27(2):130-4. doi: 10.1007/s11239-007-0159-9. Epub 2007 Nov 4. PMID: 17978877.
21. Tekkesin, N, Bekoz, H. and Tukenmez, F. The largest reference range study for hematological parameters from Turkey: A case control study. Journal of Clinical and Experimental Investigations, 5(4), 548-552. https:// dx.doi.org/ 10.5799/ahinjs.01.2014.04.0455
22. Kaya H, Kiki I, Akarsu E, Gundogdu M, Basol Tekin S, Inandı T. Hematological Values of Healthy Adult Population Living at Moderate Altitude (1869 m, Erzurum, Turkey). Turk J Haematol. 2000 Sep 5;17(3):123-8. PMID: 27263502.
23. Ozarda Y, Ichihara K, Bakan E, Polat H, Ozturk N, Baygutalp NK, et al. A nationwide multicentre study in Turkey for establishing reference intervals of haematological parameters with novel use of a panel of whole blood. Biochem Med (Zagreb). 2017 Jun 15;27(2):350-377. doi: 10.11613/BM.2017.038. PMID: 28694726; PMCID: PMC5493180.
24. Dunbar NM. Does ABO and RhD matching matter for platelet transfusion? Hematology Am Soc Hematol Educ Program. 2020 Dec 4;2020(1):512-517. doi: 10.1182/hematology.2020000135. PMID: 33275681; PMCID: PMC7727583.
25. Curtis BR, Edwards JT, Hessner MJ, Klein JP, Aster RH. Blood group A and B antigens are strongly expressed on platelets of some individuals. Blood. 2000 Aug 15;96(4):1574-81. PMID: 10942408.
26. Thibault L, de Grandmont MJ, Cayer MP, Dussault N, Jacques A, Ducas E, et al. Rhesus D Antigenic Determinants on Residual Red Blood Cells in Apheresis and Buffy Coat Platelet Concentrates. Transfus Med Hemother. 2020 Apr;47(2):129-134. doi: 10.1159/000501106. Epub 2019 Jun 27. PMID: 32355472; PMCID: PMC7184823.
27. Ward SE, O'Sullivan JM, O'Donnell JS. The relationship between ABO blood group, von Willebrand factor, and primary hemostasis. Blood. 2020 Dec 17;136(25):2864-2874. doi: 10.1182/blood.2020005843. PMID: 32785650; PMCID: PMC7751360.
28. Karolczak K, Soltysik B, Kostka T, Witas PJ, Watala C. Platelet and Red Blood Cell Counts, as well as the Concentrations of Uric Acid, but Not Homocysteinaemia or Oxidative Stress, Contribute Mostly to Platelet Reactivity in Older

Adults. Oxid Med Cell Longev. 2019 Jan 16; 2019:9467562. doi: 10.1155/2019/9467562. PMID: 30800213; PMCID: PMC6360040.
29. Yanasik M, Oguz FS, Besisik SK, Huslu M, Ozturk G, Temurhan S, et al. Frequency of RHD variants in serologically weak D Turkish blood donors. Transfus Apher Sci. 2021 Apr;60(2):103024. doi: 10.1016/j.transci.2020.103024. Epub 2020 Nov 27. PMID: 33308979.
30. Daniels G. Variants of RhD--current testing and clinical consequences. Br J Haematol. 2013 May;161(4):461-70. doi: 10.1111/bjh.12275. Epub 2013 Feb 25. PMID: 23432139.
31. Salduz ZIY, Cetin G, Karatoprak C, Ozder A, Bilginc M, Gultepe I, et al. ABO and Rh Blood Group Distribution in Istanbul Province (Turkey). İstanbul Med J 2015; 16: 98-100. DOI: 10.5152/imj.2015.14890