Clinical Research

Evaluation of Hematological Indices in Newborn Infants According to Gestational Age

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ABSTRACT

Objective: Complete blood count (CBC) results should be interpreted by comparing them with reference ranges that vary according to gestational and postnatal age. This study aimed to establish normal reference values of CBC parameters for different gestational ages and birth-weights in the neonatal population.

Material and Method: Complete blood count parameters obtained on the first day of life of neonates born between January 2015 and December 2019 were analyzed retrospectively. The distribution and correlation of hematological indices according to gestational age and birth-weight were examined.

Results: The mean gestational age of 340 newborns was 32.0±4.9 weeks and birth-weight was 1821.68±923.97 g. There was no difference between the two genders in terms of hematological indices, except that RDW value was higher in girls than in boys. There was a weak positive correlation between gestational age and leukocyte, platelet and erythrocyte counts (r =0.245, r =0.347 and r =0.310, respectively; p <0.05 in all comparisons). A moderate negative correlation was found between gestational age and MCV and MCH (r =-0.611, r =-0.564, respectively; p <0.05 in all comparisons). When hematological indices were compared according to gestational weeks, leukocyte and platelet counts were also different, similar to erythrocyte indices (p <0.05). When these hematological indices were analyzed according to birth-weight, similar results were obtained to those obtained according to gestational age.

Conclusion: The reference ranges for various hematologic indices in the neonatal period are not constant and change significantly with advancing gestational age. To identify abnormal results, normal reference values for CBC parameters must be determined for each neonatal population.

Keywords: *Neonate, Hematology, Complete Blood Count, Gestational Age, Birth-Weight.*

ÖZ

Yenidoğan Bebeklerde Hematolojik İndekslerin Gebelik Yaşına Göre Değerlendirilmesi

Amaç: Tam kan sayımı (CBC) sonuçları, gebelik yaşı ve postnatal yaşa göre değişen referans aralıklarıyla karşılaştırılarak yorumlanmalıdır. Bu çalışma yenidoğan popülasyonunda farklı gebelik yaşları ve doğum ağırlıkları için CBC parametrelerinin normal referans değerlerini ortaya koymayı amaçlamıştır.

Gereç ve Yöntem: Ocak 2015 ile Aralık 2019 tarihleri arasında dünyaya gelen yenidoğanların yaşamlarının ilk gününde alınan CBC parametreleri retrospektif olarak analiz edildi. Hematolojik indekslerin gebelik yaşına ve doğum ağırlığına göre dağılımı ve korelasyonu incelendi.

Bulgular: Üçyüzkırk yenidoğan bebeğin ortalama gebelik yaşı 32.0±4.9 hafta ve doğum ağırlığı 1821.68±923.97 gr idi. Hematolojik indeksler açısından iki cinsiyet arasında fark yoktu, sadece RDW değeri kızlarda erkeklerden daha yüksekti. Gebelik yaşı ile lökosit, trombosit ve eritrosit sayıları arasında zayıf bir pozitif korelasyon vardı (sırasıyla r =0.245, r =0.347 ve r =0.310; tüm karşılaştırmalarda p <0.05). Gebelik yaşı ile MCV ve MCH arasında orta düzeyde bir negatif korelasyon bulundu (sırasıyla r =-0.611, r =-0.564; tüm karşılaştırmalarda p <0.05). Hematolojik indeksler gebelik haftalarına göre karşılaştırıldığında lökosit ve trombosit sayıları da eritrosit indekslerine benzer şekilde farklıydı (p <0.05). Bu hematolojik indeksler doğum ağırlığına göre incelendiğinde gebelik yaşına göre elde edilen sonuçlara benzer sonuçlar elde edildi.

Sonuç: Yenidoğan döneminde çeşitli hematolojik indeksler için referans aralıkları sabit değildir ve ilerleyen gebelik yaşıyla önemli ölçüde değişir. Anormal sonuçları belirlemek için, her yenidoğan popülasyonu için CBC parametrelerinin normal referans değerleri belirlenmelidir.

Anahtar Sözcükler: *Yenidoğan, Hematoloji, Tam Kan Sayımı, Gebelik Yaşı, Doğum Ağırlığı.*

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Circulating blood cells, including red blood cells (RBCs), white blood cells (WBCs), and platelets (PLTs), are electronically counted and sized with modern devices. The complete blood count (CBC) is one of the most frequently used laboratory tests in medicine.

The various parameters of CBC analyzed in this way include erythrocyte indices such as RBC count, hematocrit (HCT), hemoglobin (HGB) concentration, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concen-

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tration (MCHC), and PLT count, mean platelet volume (MPV), and WBC count (1).

Recognizing low or high blood concentrations of erythrocytes, platelets, or leukocytes, or abnormally small or large erythrocytes or platelets, may affect clinical decisions. These cannot be interpreted with normal reference ranges established in healthy children, but rather with reference ranges derived from neonatal datasets. Unfortunately, reference ranges for various CBC parameters in the neonatal period are not fixed and change significantly with advancing gestation or birthweight. Therefore, results are interpreted according to high-quality reference ranges based on gestational - and postnatal age (2, 3).

Accepting that a laboratory test result is abnormal is an integral part of medical practice. Hematologic reference ranges are used as medical decision tools to interpret numerical test results in newborn patients. Establishing reference ranges for various CBC parameters in newborn infants is of great importance to neonatologists or provides much information regarding the diagnosis and treatment of many diseases (4, 5). It is widely known that neonatal hematologic parameters differ from those in infants and adults. Therefore, hematologic reference ranges established for neonates are of great importance (6). However, reference ranges for various parameters in the CBC are often based on small studies and are obtained with laboratory equipment that is now considered obsolete. Recent studies at Intermountain Healthcare have established new reference ranges for neonatal hematologic parameters based on very large sample sizes obtained with modern hematologic analyzers (7-10).

Therefore, this study aimed to determine the normal reference ranges of CBC parameters according to different gestational ages and birth-weights in the Turkish newborn population.

MATERIAL AND METHOD

Newborn infants of different gestational ages born in our hospital between January 2015 and December 2019, were evaluated retrospectively. The study was approved by the Ethics Committee of xxx University (decision no. 10/01 dated January 01, 2019). Since it was a retrospective study, it was not deemed necessary to obtain informed consent from the parents. Hematological indices (erythrocyte elements (RBC, HGB, HCT, MCV, MCH, MCHC), WBC and PLT9 counts in umbilical cord blood or in blood taken within the first 24 hours after birth were recorded on the study forms and then evaluated. Complete blood count analysis was performed with ADVIA 2120i analyzer (Siemens AG, Erlangen, Germany). The cases were divided into different groups for comparison according to their gestational age and birth-weight. Nomograms of these hematological parameters were created according to gestational age and birth-weight. Additionally, the relationships between these hematological parameters, gestational age, and birth weight were investigated.

Newborn infants with maternal gestational diabetes and/or hypertensive disorder, intrauterine growth retardation (IUGR), blood group incompatibility, perinatal asphyxia, cyanotic congenital heart disease and congenital anomalies (congenital diaphragmatic hernia, neural tube defects, etc.) were excluded from the study. Similarly, newborn infants with conditions such as premature rupture of membranes (PROM), preterm PROM (PPROM) and early neonatal sepsis were also excluded from the study. Additionally, newborns with gestational ages <24 weeks and >40 weeks were excluded from the study due to insufficient number of cases for statistical analysis. Recalling the last menstrual period (LMP, Naegele formula) and new Ballard scoring were used to determine gestational age. Cases with discordance between LPM and the new Ballard scoring were excluded from the study.

Newborn infants were divided into 5 groups according to their gestational age: i) extremely preterm (<28 weeks of gestation), ii) very preterm ($28^{+0/7}$-$31^{+6/7}$ weeks of gestation), iii) moderately preterm ($32^{+0/7}$-$33^{+6/7}$ weeks of gestation), iv) late preterm ($34^{+0/7}$-$36^{+6/7}$ weeks of gestation) and v) full-term ($37^{+0/7}$-$42^{+0/7}$ weeks of gestation). Prematurity refers to births occurring before $37^{0/7}$ weeks of gestation. Newborns were also divided into 4 groups according to birth-weight: i) extremely low birth-weight (ELBW, <1000 g), ii) very low birth-weight (VLBW, 1000-1500 g), iii) low birthweight (LBW, 1500-2500 g) and iv) normal birthweight (NBW, >2500 g) (11,12).

Statistical analysis

Data were analyzed using SPSS for Windows, version 25.0 (SPSS Inc., Chicago, IL). Data were expressed as mean±standard deviation (SD) for normally distributed data, as median (minimum-maximum) for non-normally distributed continuous variables, and as number of cases (%) for nominal variables. Since the sample size was >50, the conformity of continuous variables to normal distribution was determined by the Kolmogorov-Smirnov test. Student's t test was used for comparing means, and Mann Whitney-U test was used for comparing medians. ANOVA test or Kruskal-Wallis test was used for comparing continuous variables belonging to two or more independent sample groups. According to the ANOVA test results, Post Hoc test was performed using Tukey and Bonferronni when the variances were homogeneous, and Tamhane's T2 test was performed when the variances were not homogeneous. After the Kruskal-Wallis test, Kruskal Wallis One-Way ANOVA test was used for Post Hoc tests. According to the Kruskal-Wallis test results, Post Hoc test was performed using Kruskal-Wallis One-Way ANOVA. Spearman correlation analysis and Pearson correlation analysis were used to evaluate the relationships between quantitative variables. Accordingly, correlation coefficient r value <0.5 was evaluat-

ed as weak, 0.5-0.7 as moderate, and ≥0.7 as strong. A two-tailed p-value of <0.05 was accepted as significant.

RESULTS

Overall, 340 newborn infants were studied, and the demographic characteristics of all babies were shown in table 1.

Table 1. *Demographic characteristics of cases.*

Variables	Data
Gestational age (weeks, (mean±SD))	**32.0 ± 4.9**
Birth-weight (g, (mean±SD))	**1821.7 ± 924**
Cesarean section (n, %)	**294 (86.5)**
Female/Male (n, %)	**148 (43.5) / 192 (56.5)**
Preterm infants (n, %)	**280 (82.4)**
Extremely preterm	***100 (35.7)***
Very preterm	***80 (28.6)***
Moderate preterm	***40 (14.3)***
Late preterm	***60 (21.4)***
Term infants (n, %)	**60 (17.7)**

The general distribution of hematological indices was given in table 2. When these hematological indices were evaluated according to gender, only the RDW values were found to show a statistically significant difference between female (17.5±1.4) and male (16.9±1.3) infants (p <0.05) (Table 2).

Table 2. *General distribution of hematological parameters.*

Variables	Data (mean ± SD)	*p*
WBC (x10^3/μL)	9.9 ± 4.4	
Female	9.9 ± 4.4	>0.05
Male	9.9 ± 4.4	
PLT All infants (x10^3/μL)	237.6 ± 78.5	
Female	231.8 ± 78.3	>0.05
Male	245.0 ± 78.5	
RBC (x10^3/μL)	4.6 ± 0.7	
Female	4.6 ± 0.8	>0.05
Male	4.6 ± 0.7	
HGB (gr/dL)	16.9 ± 2.4	
Female	17.0 ± 2.3	>0.05
Male	16.8 ± 2.6	
HCT (%)	53.2 ± 7.9	
Female	53.6 ± 7.5	>0.05
Male	52.8 ± 8.5	
MCV (fL)	116.2 ± 9.6	
Female	116.0 ± 10.4	>0.05
Male	116.4 ± 9.1	
MCH (pg)	36.9 ± 2.9	
Female	36.9 ± 2.8	>0.05
Male	36.9 ± 3.1	
MCHC (g/dL)	31.8 ± 1.6	
Female	31.7 ± 1.7	>0.05
Male	31.8 ± 1.5	
RDW (%)	17.2 ± 1.4	
Female	17.5 ± 1.4	**<0.05**
Male	16.9 ± 1.3	

WBC; White blood cell, PLT; Platelet, RBC; Red blood cell, HGB; Hemoglobin, HCT; Hematocrit, MCV; Mean corpuscular volume, MCH; Mean corpuscular hemoglobin, MCHC; Mean corpuscular hemoglobin concentration, RDW; Red cell distribution width.

Table 3 showed comparisons of newborn infants' hematological indices on the first day of life based on the weeks of their gestation. In table 3, there was a statistically significant difference between the hematologic indices that had the same letter (p <0.05).

Table 3. *Comparisons of hematological indices of newborns on the first day of life according to their gestational ages.*

	Weeks of Gestation					
Variables	**Extremely preterm infants n =100 (29.4%)**	**Very preterm infants n =80 (23.5%)**	**Moderate preterm infants n =40 (11.8%)**	**Late preterm infants n =60 (17.7%)**	**Term infants n =60 (17.7%)**	***p***
WBC (x10^3/μL)	9.1 ± 5.1$^{(a)}$	8.7 ± 3.8$^{(b)}$	11.1 ± 4.5	9.9 ± 2.8	11.7 ± 4.5$^{(a,b)}$	**<0.05**
PLT (x10^3/μL)	206.7 ± 85.7$^{(a,b,c)}$	227.0 ± 67.5$^{(d,e)}$	252.3 ± 57.3$^{(a)}$	263.9 ± 77.6$^{(b,d)}$	267.0 ± 72.8$^{(c,e)}$	**<0.05**
RBC (x10^3/μL)	4.1 ± 0.6$^{(a,b,c,d)}$	4.9 ± 0.6$^{(a)}$	5.1 ± 0.5$^{(b,e)}$	4.8 ± 0.7$^{(c)}$	4.6 ± 0.7$^{(d,e)}$	**<0.05**
HGB (g/dL)	*16.0 ± 2.1*	*18.1 ± 2.3*$^{(a)}$	*18.2 ± 1.6*$^{(b)}$	*17.0 ± 2.4*	*15.9 ± 2.6*$^{(a,b)}$	***<0.05***
HCT (%)	*57.8 ± 6.8*$^{(a,b)}$	*56.9 ± 7.4*$^{(a,c)}$	*57.0 ± 5.2*$^{(b,d)}$	*53.6 ± 8.7*	*49.5 ± 8.0*$^{(c,d)}$	***<0.05***
MCV (fL)	*124.0 ± 9.3*$^{(a,b,c,d)}$	*117.2 ± 7.9*$^{(a,e,f)}$	*113.5 ± 5.7*$^{(b)}$	*111.3 ± 7.1*$^{(c,e)}$	*108.7 ± 6.5*$^{(d,f)}$	***<0.05***
MCH (pg)	*39.1 ± 2.6*$^{(a,b,c,d)}$	*37.2 ± 2.6*$^{(a,e,f)}$	*36.1 ± 1.8*$^{(b)}$	*35.3 ± 2.1*$^{(c,e)}$	*34.8 ± 2.4*$^{(d,f)}$	***<0.05***
MCHC (g/dL)	*31.6 ± 1.6*	*31.8 ± 1.6*	*31.8 ± 1.6*	*31.8 ± 1.6*	*32.0 ± 1.7*	*>0.05*
RDW (%)	*17.1 ± 1.7*	*17.3 ± 1.2*	*17.5 ± 1.4*	*17.3 ± 1.4*	*17.0 ± 1.3*	*>0.05*

WBC; White blood cell, PLT; Platelet, RBC; Red blood cell, HGB; Hemoglobin, HCT; Hematocrit, MCV; Mean corpuscular volume, MCH; Mean corpuscular hemoglobin, MCHC; Mean corpuscular hemoglobin concentration, RDW; Red cell distribution width.

To illustrate the situation described above with an example, in table 3, the letter "a" for the WBC value is found in both extremely preterm infants and term infants. This situation will be interpreted as a statistically significant difference in WBC values between extremely preterm infants and term infants (p <0.05). Similarly, the letter "b" is present in both very preterm infants and term infants. This situation will be interpreted as indicating a statistically significant difference in WBC values between very preterm infants and term infants (p <0.05).

Correlation between gestational age and hematological indices

A weak positive correlation was found between gestational age and WBC, PLT and RBC counts (r =0.245, r =0.347, r =0.310, respectively) (p <0.05 for all comparisons) (Figure 1).

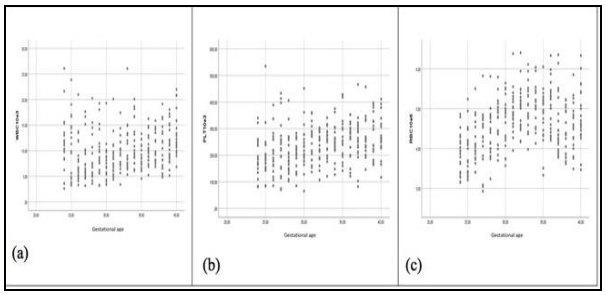

Figure 1. *Correlation between gestational age and WBC (a), PLT (b) and RBC (c).*

There was no correlation between gestational age and HGB, HCT, MCHC and RDW values (p >0.05 for all comparisons).

There was a moderate negative correlation between gestational age and MCV and MCHC values (r =-0.611, r =-0.564, respectively), (p <0.05 for all comparisons) (Figure 2).

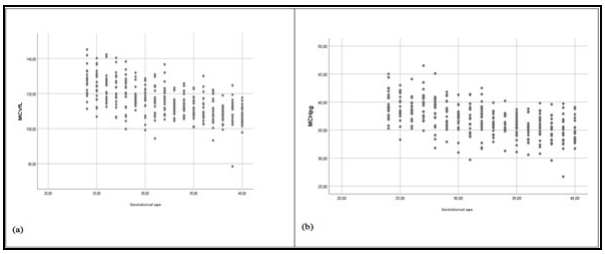

Figure 2. *Correlation between gestational age and MCV (a) and MCH (b).*

Comparisons of hematological indices of newborn infants on the first day of life according to their birth-weights were shown in table 4. The difference between the hematologic indices with the same letter in table 4 was statistically significant (p <0.05).

Table 4. *Comparisons of hematological indices of newborns on the first day of life according to their birth-weights.*

	Birth-weight				
Variables	**Extremely low birth-weight infants n=88 (25%)**	**Very low birth-weight infants n=63 (18.5%)**	**Low birth-weight infants n=95 (28%)**	**Normal birth-weight infants n=94 (27.6%)**	***p***
WBC (x10^3/µL)	9.0 ± 5.3$^{(a,c)}$	8.3 ± 3.5$^{(b,d)}$	10.5 ± 3.9$^{(c,d)}$	11.1 ± 4.1$^{(a,b)}$	**<0.05**
PLT (x10^3/µL)	199.0 ± 78.9$^{(a,c)}$	214.3 ± 74.6$^{(b,d)}$	252.9 ± 64.4$^{(c,d)}$	273.8 ± 73.5$^{(a,b)}$	**<0.05**
RBC (x10^3/µL)	4.1 ± 0.6$^{(a,b,c)}$	4.8 ± 0.6$^{(a)}$	4.9 ± 0.6$^{(b,d)}$	4.6 ± 0.7$^{(c,d)}$	**<0.05**
HGB (g/dL)	*15.9 ± 2.1*$^{(a,b)}$	*18.1 ± 2.4*$^{(a,c)}$	*17.8 ± 2.1*$^{(b,d)}$	*16.1 ± 2.5*$^{(c,d)}$	***<0.05***
HCT (%)	*50.5 ± 6.6*$^{(a,b)}$	*57.3 ± 7.9*$^{(a,c)}$	*55.7 ± 6.7*$^{(b,d)}$	*50.5 ± 8.3*$^{(c,d)}$	***<0.05***
MCV (fL)	*125.6 ± 8.3*$^{(a,b,c)}$	*118.4 ± 8.2*$^{(a,d,e)}$	*113.5 ± 6.4*$^{(b,d,f)}$	*108.9 ± 6.3*$^{(c,e,f)}$	***<0.05***
MCH (pg)	*39.5 ± 2.5*$^{(a,b,c)}$	*37.3 ± 2.3*$^{(a,d,e)}$	*36.2 ± 2.2*$^{(b,d,f)}$	*34.8 ± 2.2*$^{(c,e,f)}$	***<0.05***
MCHC (g/dL)	*31.5 ± 1.6*	*31.7 ± 1.6*	*31.9 ± 1.6*	*32.0 ± 1.6*	*>0.05*
RDW (%)	*17.2 ± 1.7*	*17.3 ± 1.4*	*17.4 ± 1.4*	*17.0 ± 1.1*	*>0.05*

WBC; White blood cell, PLT; Platelet, RBC; Red blood cell, HGB; Hemoglobin, HCT; Hematocrit, MCV; Mean corpuscular volume, MCH; Mean corpuscular hemoglobin, MCHC; Mean corpuscular hemoglobin concentration, RDW; Red cell distribution width.

To illustrate the above situation with an example, in table 4, the letter "a" is found in the WBC values of both extremely low birth weight infants and normal birth weight infants, the letter "b' is found in the values of both very low birth weight infants and normal birth weight infants, the letter "c" is used for both extremely low birth weight infants and low birth weight infants, and finally, the letter "d" is used for both very low birth weight infants and low birth weight infants. These situations will be interpreted as follows:

- There is a statistically significant difference in WBC values between normal birth weight infants and extremely low and very low birth weight infants (p <0.05).
- There is a statistically significant difference in WBC values between low birth weight infants and extremely low and very low birth weight infants (p <0.05).

Correlation between birth-weight and hematological indices

A weak positive correlation was found between birth-weight and WBC, PLT and RBC counts (r =0.299, r =0.416, r =0.237, respectively) (p <0.05 for all comparisons) (Figure 3).

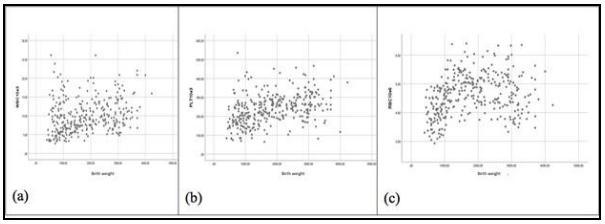

Figure 3. *Correlation between birth-weight and WBC (a), PLT (b) and RBC (c).*

There was no correlation between birth-weight and HGB, HCT and RDW values (p >0.05 for all comparisons).

There was a moderate negative correlation between birth-weight and MCV and MCHC values (r =-0.675, r =-0.586, respectively), (p <0.05 for all comparisons). A weak positive correlation was found between birth-weight and MCHC value (r =0.132, p <0.05) (Figure 4).

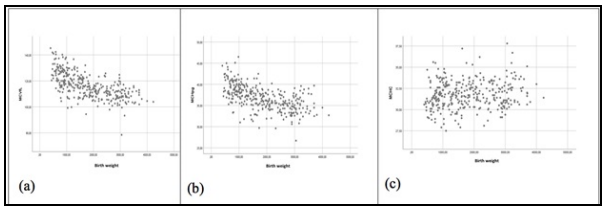

Figure 4. *Correlation between birth-weight and MCV (a), MCH (b) and MCHC (c).*

DISCUSSION

Neonatal hematology involves a complex and dynamic process. Therefore, having sufficient knowledge about maternal/fetal and neonatal physiology makes this topic more understandable. Newborn infants often face specific hematological problems due to certain clinical conditions such as maternal-fetal blood group incompatibilities, effects of maternal medication use, prematurity, perinatal asphyxia and other systemic diseases (13, 14). Knowing the normal reference ranges of hematological parameters of newborn babies at different gestational ages and birth-weights will allow the correct identification of pathological processes.

In our study, a weak positive correlation was found between gestational age and WBC count. In other words, a slight increase was seen in WBC count as gestational age increased. In a study examining the effect of gestational age and birth-weight on WBC count in newborns, it was reported that WBC counts were significantly lower in premature and small-for-gestational-age infants (15). Although this finding is consistent with our results, a weaker positive correlation was found in our study compared to that study. Chetana and Xiangying (16) reported that neutropenia was more common in premature infants due to maternal and antenatal conditions, congenital syndromes, immune-mediated processes, hospital infections, and idiopathic causes. Although some pathological causes that could affect hematological parameters were excluded from our study, the above-mentioned causes may help explain the low WBC count in low-birth-weight premature infants.

In our study, a weak positive correlation was found between gestational age and PLT count. In other words, as gestational age increases, PLT count also increases to some extent. However, in a single-center study conducted in Türkiye by Cantürk (17), it was determined that there was no significant difference in PLT count between full-term and preterm newborns. The difference between those findings and our results may be due to the characteristics of the study population, the exclusion criteria from the study, and the difference in sample size. In a study conducted on mice, similar to our results, it was shown that the PLT count was low and functions were hypo-reactive in the early fetal period (18). Accordingly, Cremer (19) reported a statistically significant but low correlation between gestational age and PLT count.

In our study, a weak positive correlation was observed between gestational age and RBC count. In other words, erythrocyte count slightly increased as gestational age increased. However, no correlation was found between gestational age and HGB and HCT values. On the other hand, a moderate negative correlation was found between gestational age and MCV and MCH values. Accordingly, MCV and MCH values decreased moderately as gestational age increased. However, no correlation was found between gestational age and MCHC and RDW values. In a study investigating the effects of race and gestational age on erythrocyte indices in very low birth-weight infants in the USA, it was shown that HGB and HCT values increased and MCV values decreased with advancing gestational age (20). Rasmussen and Oian (21) reported that the hemoglobin value of fetuses decreased as gestational age and weight increased. Morshed et al. (22) found that RBC count, HGB and HCT levels were higher in full-term infants than in preterm infants. However, they showed that MCV values were lower in full-term infants than in preterm infants. In our study, it was found that MCV values decreased similarly with advancing gestational age, while HGB and HCT values did not change differently. This difference may be due to the fact that our study was single-centered, the relatively low number of cases, differences in inclusion and exclusion criteria, and geographical and racial differences in our study population. In a multicenter study including 12,000 newborns in which erythrocyte indices were investigated, it was reported that MCV and MCH values decreased with increasing gestational age, but MCHC values did not change (8). The results of that study are consistent with the results of our study.

When the correlation between birth-weight and hematological indices was evaluated, it was seen that there was a weak positive correlation between birth-weight and WBC, PLT and RBC counts. However, no correlation was found between birth-weight and HGB and HCT values. But, a moderate negative correlation was found between birth-weight and MCV and MCH values. Contrary to the correlation between gestational age and MCHC, a weak positive correlation was found between birth-weight and MCHC. Consistent with the correlation between gestational age and RDW, no correlation was found between birth-weight and RDW value.

Factors limiting our study include the fact that our study was single-centered, the number of cases was relatively small, the number of babies with a gestational age below 24 weeks and above 40 weeks was not sufficient for statistical analysis, and the cases included in the study belonged to a single geographical region and a single race.

In conclusion, there was a weak to moderate correlation between gestational age and hematological indices. Since newborns with IUGR were excluded from the present study, the correlation between birth-weight and hematological parameters gave similar results to the

correlations between gestational age and hematological parameters. The reference values of hematological parameters determined according to different gestational age and birth-weight groups would be useful in neonatal practice.

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