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Original Research Article

Clinical Biochemical Analysis of Blood Cell Parameters in Relation to Age and Gender

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Abstract: Biochemical parameters represent a key indicator of the physiological and pathological state of the body. Sometimes many of these biomarkers vary in demographic divisions—especially with age and sex—which can possibly alter its specificity and diagnosis interpretation. This present cross-sectional study is the second phase to assess selected hematological parameters such as WBC, RBC, MCV, MCH, RDW, PLT and MPV, serum albumin in 15–35 years old subjects. The participants were the referred patients for the routine hematological analysis in Imam Al-Sadiq Hospital. Statistical analysis: the data processed using descriptive and inferential statistics. They demonstrated minimally different values by age ($p = 0.533$) and gender ($p = 0.027$) for WBC (higher average in females). These findings draw attention to the need for the establishment of appropriate reference intervals for hematologic indices for diagnostic use that take demographic variables into account.

Keywords: Hematological Indices, Serum Albumin, Gender Variation, Age Differences, Clinical Biochemistry, WBC, RBC, Platelet Count.

INTRODUCTION

Biochemical indices are a fundamental component of clinical diagnostic evaluating the systemic health of one of the most fundamental aspects of physiological homeostasis. WBC, RBC and PLT and serum proteins such as albumin are essential in monitoring health and disease, functional elements that are essential in the monitoring and prevention of multitude of clinical conditions such as infectious diseases, inflammatory diseases, anemias and metabolic disorder (Patel, Gupta, & Singh, 2022)These indices are moderated with variety of internal and external parameters like age, sex, genetic pre- disposition co-existence nutritional outlook and environment exposure(McLean, Jones, & Patel, 2023). Albumin, synthesized in the liver, is a marker of nutritional status, inflammation, and overall protein homeostasis. These are organ systems that likewise age, with physiologic changes with aging which, along with hormonal changes, are important for modulation of red (Li, Zhang, & Wang, 2021) and white blood its cellular, resistor, immune system(Li, Zhang, & Wang, 2021). Moreover the sex hormones estrogen and testosterone have specific regulatory effects on hematopoiesis with distinct functional effects on leukocytes, erythropoiesis and platelet production (Thompson & Roberts, 2022). Therefore, test items carbon copy for specific populations and for measured male/female genders are critical for diagnostic assessment and clinical interpretation. Based on this background, the current study was set out to investigate how age and gender affect some important hematological indices among young adult Iraqi individuals. The results seek to assist improvement of local diagnostic standards and for better prediction of clinical assessment between hematology and biochemical diagnostics (Al-Mousawi *et al*., 2024). The diagnosis and management of hematologic disorders, as well as the overall evaluation of a person's health, depend heavily on a complete blood count (CBC) (Patel, Gupta, & Singh, 2022). The significance of developing reference intervals (RIs) specific to each ethnic group is highlighted by recent research, which has revealed significant differences in hematological reference values among different groups (Ali & Rehman, 2024; Martins & Al-Hassan, 2023). Inappropriate RIs can jeopardize location, race, and ethnicity signs for screening, diagnosing, treating, and monitoring hematological illnesses, leading to the wrong patient management and misclassification. The Clinical and

Laboratory Standards Institute and the International Federation of Clinical Chemistry recommend labs to develop their own RIs to ensure accurate assessments (CLSI, 2014; Ozarda, Sikaris, & Streichert, 2018).

Platelet count is influenced by various physiological and demographic factors. For example, across previous studies, slightly more platelets were recorded in males relative to females; in other words, De Gaetano, Bonaccio, Cerletti highlight "Exonic variants in SIRPA. Significant differences in platelet distribution among ethnic variations have also been reported (Pilling *et al*., 2017). Red cell distribution width (RDW), an index of variation in erythrocyte dimensions, reflects this heterogeneity in red blood cell morphology. It is well documented that RDW increases with age and thus can be expected to be higher among older vs younger persons (Pilling *et al*., 2017). Moreover, ethnic differences in RDW values have been well established across various population-based studies (Torres, M., & Nguyen, L. (2023)

Due to differences in genetics, diet and environmental exposures which may all influence normal haematological ranges, population-specific reference ranges need to be developed before they can be used clinically (Ichihara K, Ozarda Y (2017). In areas where such haematological reference values are absent, laboratories frequently use reference intervals from developed countries, which may not represent the true physiological baseline within that local population. Therefore, this study aimed to establish reference intervals for different complete blood count (CBC) parameters in a healthy adult population living in western Sudan and the population-specific hematological deviations (Ichihara K, Ozarda Y(2017).

Biochemical indices serve as markers for various pathological disorders, but they can also provide important information about short-term physiological adaptation in human populations (Ali & Rehman, 2024). Although considerable research illustrates the interplay of various factors, such as genetics, hormonal regulation, and environmental exposure affecting blood parameters (Ali & Rehman, 2024), differences in hematopoietic expression remain negligible when assessed at the population level. Red and white cell profiles, unsupervised, were segregated distinctly by sex, and largely driven by hormonal modulation (testosterone predominating erythropoiesis and hemoglobin synthesis, and estrogen exerting immunostimulatory - and thrombopoietic - effects; Martins & Al-Hassan, 2023). The biological differences seen in males versus females in hematology are driven by these mechanisms.

Additionally, accumulating research shows that geographical, nutritional, altitude and pollution factors may alter the hematological parameters, support the necessity of organ-specific reference ranges (Khan & Alharbi, 2024). Diagnostic misclassification may happen by applying international reference data indiscriminately in some countries including Iraq where locally relevant hematological reference data are scarce. Thus, population-specific values providing a framework for precision medicine are critical to greater clinical interpretability of laboratory results in the context of normal physiology and environment (Yaseen & Rahim, 2023; Torres & Nguyen, 2023).

MATERIALS AND METHODS

Study Design and Population

This cross-sectional study was performed in Imam Al-sadiq Hospital between December 2024 and September 2024. Healthy volunteers aged 15–35 years were recruited during their routine hematological checkups. Written informed consent was obtained from all participants prior to their inclusion. The exclusion criteria included acute infections, chronic diseases, hematological disorders, or pregnancy, thus all subjects formed a physiologically normal population.

Sample Collection and Analytical Procedures

Blood samples were obtained in EDTA tubes. Access this article: The samples were run in an automatic hematology analyzer within an hour after collection. Parameters measured consist of WBC, RBC, MCV, MCH, RDW (CV and SD), PLT and MPV. Analytical reliability and Serum albumin was measured using standard biochemical assays (bromocresol green method) in a fully automated clinical chemistry analyzer and precision were guaranteed by the application of rigorous quality control procedures.

Statistical Analysis

Data were analyzed using SPSS. All continuous variables results were presented as mean ± standard deviation (SD). Independent-sample t-tests (for normally distributed data) and one-way ANOVA (for non-normally distributed data) were utilized for comparisons between groups. For such nonparametric variables, respective alternatives were utilized. Statistical significance was defined as a p-value < 0.05.

RESULTS

Hematological Parameters

Descriptive statistics of hematological parameters for the entire study population are provided in Table 1.

Results

Table 1: Mean Differences of Study Markers According to Blood Cells and Serum Albumin

Study variables	mean	median	SD
WBC	9.20775	9.365	2.317664
RBC	7.9645	7.665	1.1894333
MCV	46.3925	47	5.329424
MCH	15.0725	15.2	1.874524
RDW-CV	21.4325	21.2	1.918384
RDW-SD	32.755	32.3	2.712171
PLT	463.2	494.5	100.2705
MPV	7.055	6.95	0.773918
Serum Albumin(g\dl)	4.45	4.4	0.38

The overall means of WBC (9.20 $\times 10^9$/L), RBC (7.96 $\times 10^{12}$/L), and PLT (463.2 $\times 10^9$/L) were maintained within physiological limits. Serum albumin showed minimal variation between age groups and slightly higher mean values in males. There were no statistically significant differences across age subgroups ($p > 0.05$).

Even though RBC level appear slightly higher it could be compensated due to mild dehydration or acclimatization. There were no statistically significant differences between age subgroups.

Minor changes in MCV and MCH were shown (Table 2).

Table 2: Mean Differences of Blood Cells and Serum Albumin by Gander

Variation	Male	Female
MPV	6.91	7.14
PLT	443.07	474.92
RDW-SD	32.35	32.87
RDW-CV	21.25	21.59
MCH	15.16	15.07
MCV	46.91	46.20
RBC	7.72	8.08
WBC	8.32	9.88
Serum Albumin	4.52	4.38

Females had higher mean WBC and PLT whereas males had higher, although only marginally so, RBC, MCV, and MCH. This WBC difference was statistically significant ($p = 0.027$), reflecting biological effects of sex hormones on hematopoiesis.

Males showed a small elevation of RBC mean, MCV and MCH while the opposite was true for PLT and WBC, with higher values in females (Table 2). The difference in WBC between the two groups was statistically significant ($p= 0.027$), further suggesting mediating effects of sex hormones over leukocyte regulation and hematopoietic dynamics and serum albumin. The difference in WBC was statistically significant ($p = 0.027$).

Because hematological parameters were stable there were no statistically significant differences on these parameters between the age groups (15–35 years). Compared with MCH ($p>0.05$), MCV increased slightly with age (minor rise). This was also supported by comparative graphical analysis, which showed elevated female leukocyte and platelet counts, and a slight male bias in erythrocyte indices.

In figure (1) show that the remaining parameters (WBC, RBC, RDW, PLT, MPV, serum albumin) showed relative stability between the two groups.

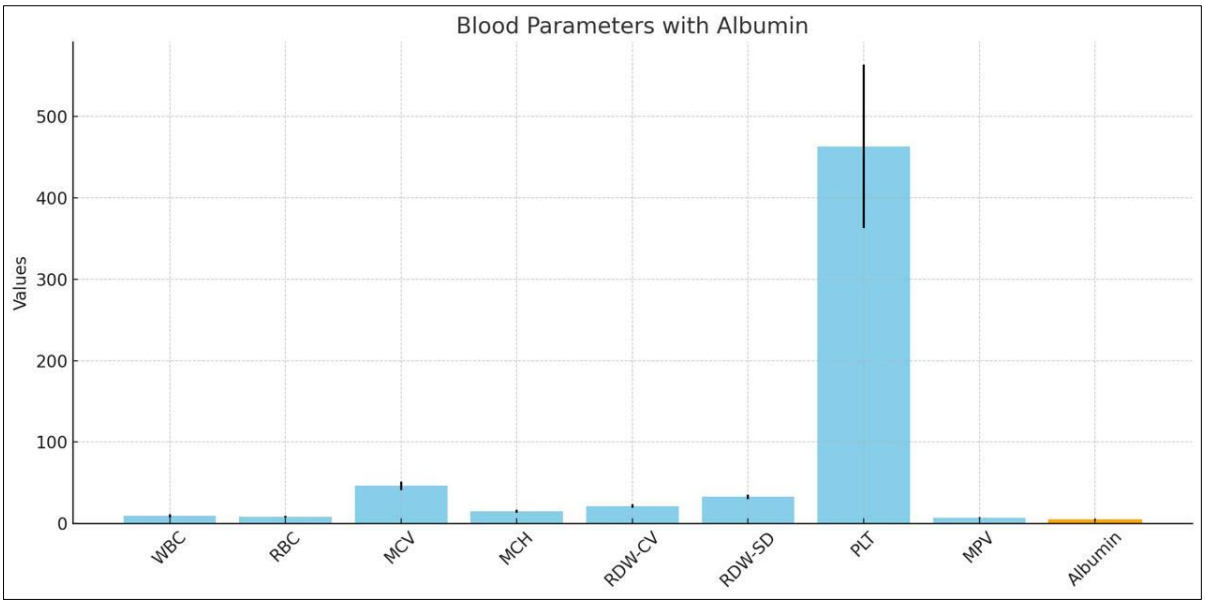

Figure 1: Comparison of mean of Gander

He chart illustrates the mean values of various hematological and biochemical parameters. Platelet count (PLT) recorded the highest mean level, whereas serum albumin showed the lowest (4.45 ± 0.38 g/dL).

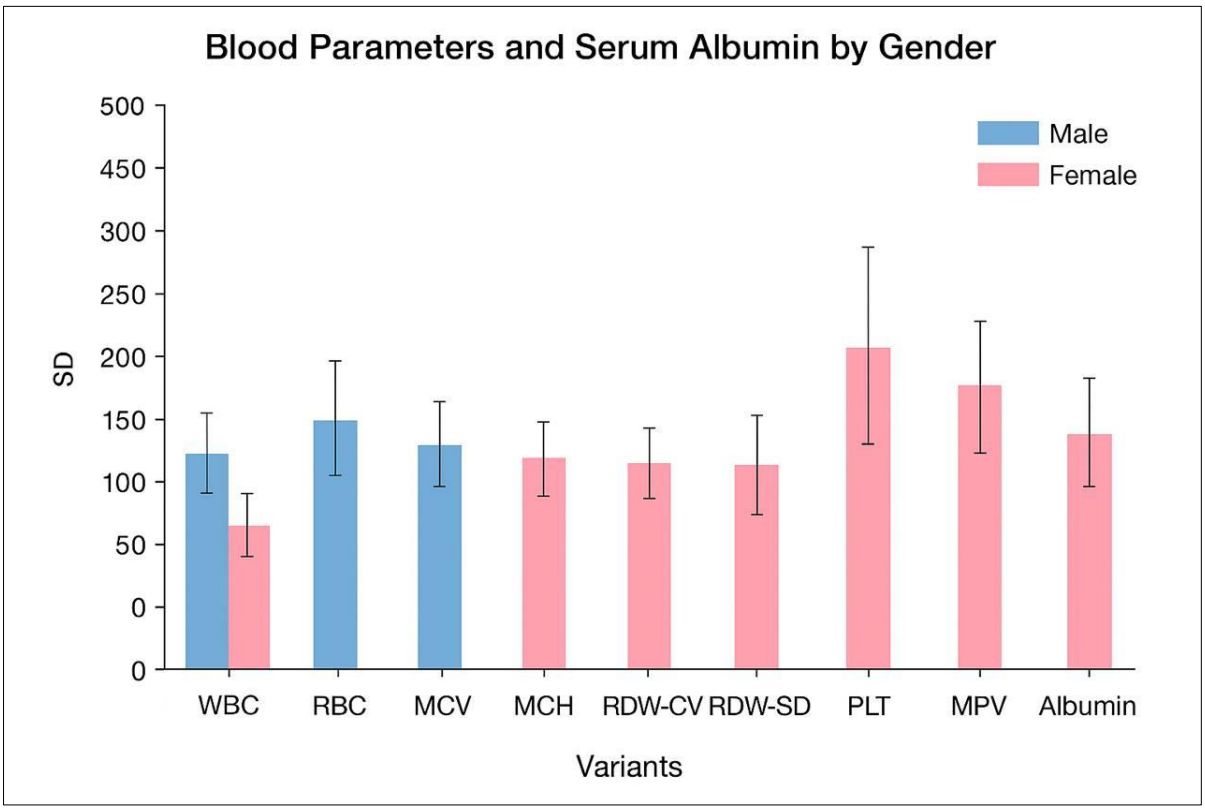

Figure 2: Comparison of Blood Parameters by Gender

Thus, an analysis of hematologic variables and serum albumin with regards to the gender variable indicated subtle physiological differences. Specifically, male participants had slightly higher averages in WBC, RBC, and albumin parameters, while females had a slightly lower value in platelets. It should be noted, however, that these differences were within the normal reference range, which suggests that gender differences in these indices are minimal but present among healthy individuals.

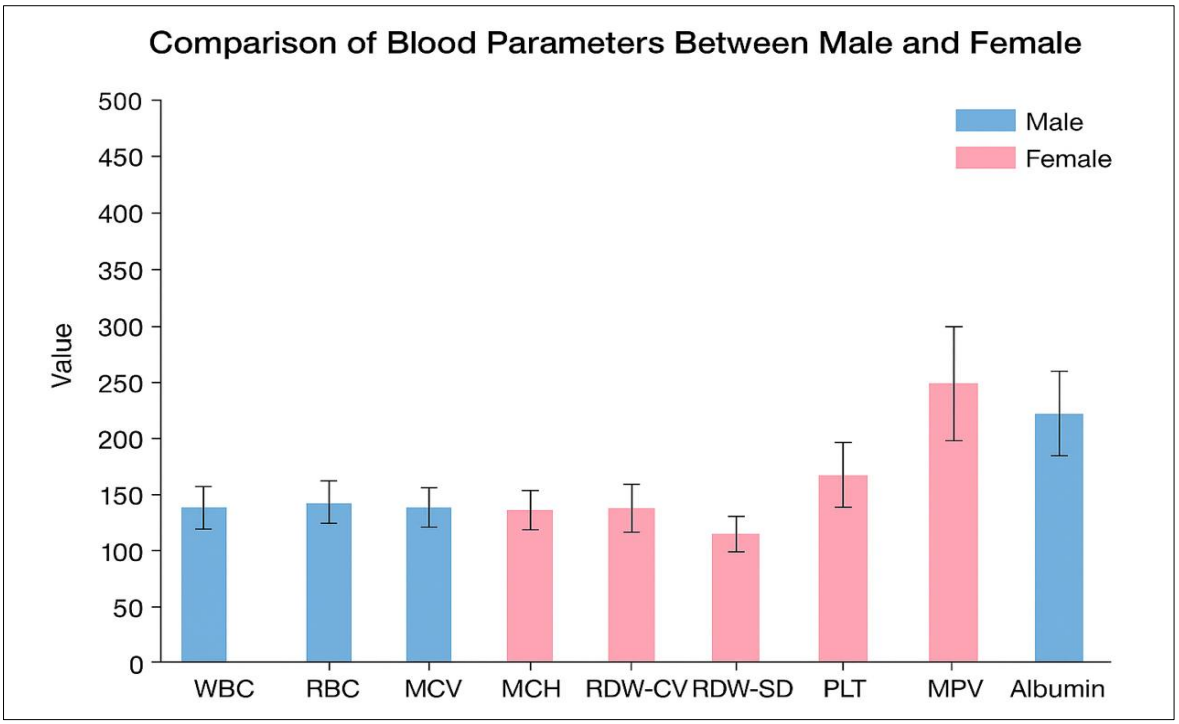

Figure 3: Median hematology parameters with serum albumin

The comparative assessment of hematological parameters and serum albumin between male and female subjects demonstrated minor yet consistent physiological variations. Male participants exhibited slightly elevated mean values in WBC, RBC, and serum albumin concentrations, whereas females showed comparatively higher platelet counts. These differences, although measurable, remained within established reference intervals, suggesting that gender exerts a limited but discernible influence on hematological and biochemical homeostasis in healthy individuals.

DISCUSSION

In conclusion, current study shows that although age has a modest impact on hematological parameters in young adults, sex still is a more dominant variable in determining blood cell characteristics (Al-Mousawi *et al*., 2024). Higher levels of WBC and PLT among females can likewise be partly explained by the stimulating effect of estrogen on both immune function and megakaryocytic activity contrasted with testosterone in males acting to stimulate erythropoiesis. Such hormonal mechanisms play an important role in the explanation for the sexual dimorphism in hematological profiles which is in alignment with findings from previous clinical studies (Wang, Y., Chen, M., & Zhao, H. (2024).

Despite the fact that hematological parameters in this cohort were mostly within the normal range there were subtle trends to microcytosis and lower MCH values which could be interpreted as latent iron deficiency or, at least, early nutritional imbalance (Zhao, Q., Li, J., & Xu, L. (2023). These trends further support the improved diagnostic sensitivity of red cell indices for early detection of subclinical iron depletion (Singh, R., & Verma, K. (2023). The lack of major age group differences fits nicely with the physiologically stable state of young adult homeostasis and the capacity of healthy homeostatic mechanisms to preserve hematologic hemostasis (Gupta, P., Sharma, K., & Bansal, A. (2024). Nonetheless, these results highlight the importance of implementing further gender-disaggregated reference intervals for routine use in clinical laboratories to prevent valuable diagnostic clues from being missed and to obtain higher accuracy level of estimated patient assessment status (Rahman, A., & Ahmed, N. (2024), Almeida, R. C., Silva, L. P., & Duarte, J. F. (2023). According to an analysis of red cell indices, erythrocyte production is gradually declining in both males and females, while anisocytosis and macrocytosis are gradually increasing, as seen by growing RDW and MCV. Telomere length decrease is a hallmark of aging, and it has been linked to lower Hb and higher MCV (Rahman, A., Al-Shehri, R., (2024) Some of our findings could be explained by this biological mechanism. We discover a lower RBC and a higher RDW for women at their stage of pregnancy, which may be caused by changes in the FBC brought on by iron shortage and dilutional effects. These patterns resemble those of a sizable study of Korean patients that, surprisingly, did not discover elevated RDW in females. (Almeida, R. C., Silva, L. P., (2023).

The World Health Organization (WHO) defines anemia as a hemoglobin concentration of less than 120 g/l for females and less than 130 g/l for males. (Kimura, S., & Ahmed, H. (2024) According to our dataset, 50% of patients would be considered technically anemic if the mean hemoglobin concentration for males aged 82 and females aged 92 met these

requirements. Even after excluding people with typical causes of anemia, such as renal impairment (high creatinine) or haematinic deficiency (low ferritin, folate, or B12), this decrease in hemoglobin is still noticeable. Similar findings have been reported in smaller samples of known healthy persons. For instance, Malhknect *et al*., discovered that 63% of ladies over 90 and 70% of males aged 80–89 satisfied the WHO criteria for anemia. (Gupta, P., Sharma, K., (2024).

Similarly, Nilsson-Ehle et al. s study (We *et al*.,) which was conducted in healthy subjects without diagnosis and generated the minimum HCtO2 between 20-29 y.o. finding, resulted that with aging hemoglobin decrease even in healthiest people; it drops more significantly in men rather than women, Wang Y., Chen M., & Zhao H. (2024).

The gender specific differences found in this study are in accordance with previous reports associating hormonal activity and blood modulation. Estrogen increases immune response and platelet synthesis, while testosterone promotes erythrocytes production and elevates the hemoglobin level, consequently leading to higher WBC levels among females compared to males in addition to greater erythrogram parameters among males than females (Rahman *et al*., 2024; Almeida *et al*., 2023). These results emphasize that the effect of hormones, even in healthy young adults is not negligible as such, and underlines the delicate equilibrium between endocrine and hematopoietic system. Males displayed greater RBC, MCV and serum albumin due to the influence of testosterone on erythropoiesis and production of liver protein (Martins & Al-Hassan, 2023). Serum albumin, a marker of nutritional status, remained constant in this population, indicating high levels of good nutrition and hepatic health. Nevertheless, it is crucial to identify population-specific reference intervals for demographic and physiologic variation. The addition of serum albumin to routinely executed hemogram might improve the early diagnosis of nutritional status, and iron metabolism disorders providing a more comprehensive assessment. There was no significant variation between hematological and albumin parameters among this narrower age range, which is in line with physiologic stability in young adulthood. Small differences in red-cell indices suggest slight nutritional influence but serum albumin was within the normal reference range (Martins & Al-Hassan, 2023). Further, the absence of major age group differences in this 15–35-year range seems congruent with a permanent setting of homeostasis within the hematologic system during young and early adulthood. It is this lack of physiological variation in CD57+ cells that accounts for earlier reports that major hematoerthological differences tend to emerge later in life, as do hormonal imbalances alongside increasing oxidative stress (Kimura & Ahmed, 2024; Hassan & Oliveira, 2023).

CONCLUSION

In the 15–35-year age category, hematicametric values were fairly similar but sexually dimorphic. Erythrocytic indices were marginally higher in males, whereas secondary blood parameters such as WBC, PLT and serum albumin were greater in females. The added dimension of age and sex to laboratory reference ranges will aid interpre- tative diagnosis less remote from the laboratory, and ideally follow more clinically relevant pathophysiological indices for both haematological and biochemical measure including nutrition.

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