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ORIGINAL RESEARCH

Determine Complete Blood Count Reference Values Among Healthy Adult Populations

Abdul Baset Abbas, Abeer Aldomaini, Amah Alrahman Al-Qadri, Zahra'a Algorbani, Sara Aljamali, Safa Alsiri, Khadeeja Alghorbani, Saba Abo Osba'a

Medical Laboratories Department, Faculty of Medicine and Health Sciences, Ibb University, Ibb City, 70270, Yemen

Correspondence: Abdul Baset Abbas, Email abduabbas@ibbuniv.edu.ye; abduabbas204@hotmail.com

Background: Complete blood counts (CBC) are commonly used in diagnostic medicine to evaluate normal and abnormal hematological status. Furthermore, reference values (RVs) of CBC supplied by researchers are the most reliable means of the judgment-making stage and can aid interpretation and accurate diagnosis of diseases. Reference values vary between peoples because of differences in lifestyle, dietary habits, ethnicity and environment. Moreover, the Clinical and International Standards Institute (CISI) advises determining the RVs for each area. There are no RVs for CBC in Yemen. Therefore, this study aimed to determine the common RVs of CBC for healthy adults in Ibb City in the middle of Yemen.

Methods: A cross-sectional study was conducted from April 1, to November 30, 2023. Of the 623 adults who participated in this study, 433 (aged 18–80 years) were included in the final analysis after applying exclusion criteria. The mean, median, and 95th percentile RVs (2.5th-97.5th percentiles) were calculated for gender, age, and residence by the GraphPad Prism 8.0.1.

Results: The RVs of hemoglobin (Hb) 11.16–17.54g/dl, red blood cells (RBC) 3.890–6.340×10^{12}/l, hematocrit (HCT) 33.03–49.30%), mean corpuscular volume (MCV) 72.83–94.55fl), mean corpuscular hemoglobin (MCH) 23.95–33.55pg, mean corpuscular hemoglobin concentration (MCHC) 32.97–36.7354g/dl, platelet (PLT) count 140.0–418.6×10^9/l, total white blood cells (WBC) 2.810–8.797 ×10^9/l and WBC differential count (basophils 0.000–1.000%, neutrophils 30.10–69.17%, eosinophils 1.500–5.000%, lymphocytes 23.86–63.45% and monocytes1.873–5.600%). Significantly higher median values were observed in males compared to females for Hb ($P<0.0001$), RBC ($P<0.0001$), HCT ($P<0.0001$), lymphocyte ($P=0.0197$) and monocytes ($P=0.0009$). Contrariwise, females demonstrated significantly higher neutrophils ($P=0.0009$), eosinophils ($P=0.0020$), basophils ($P<0.0001$) and platelets ($P=0.0324$) than males. This study showed differences in the RVs of CBC compared to those reported in other countries in the Middle East, Asia, Africa, and Europe.

Conclusion: In this study, the reference values of CBC are considered as a benchmark that may assist in accurately judging laboratory results and enhancing medical and clinical services for adults in Ibb City, Yemen.

Keywords: reference values, RVs, adults, CBC, Ibb, Yemen

Introduction

Reference values (RVs) are the range of values between and involving lower and upper limits, which were derived from the study of a considerable number of healthy people, to which results can be compared to assist interpretation.[1–4] These typically mean 95% of the results between 2.5th and 97.5th percentiles of the laboratory test values for reference people.[1–3] These usually mean 95% of the results between 2.5th and 97.5th percentiles of the laboratory test values for reference people.[5] Complete blood counts (CBC) are commonly used in diagnostic medicine to evaluate normal and abnormal hematological status.[5,6] Moreover, the RVs of CBC parameters are affected by several factors such as lifestyle, dietary habits, ethnicity, environment, sex, age, pregnancy,[3,7,8] exercise, stress, geography[5,9,10] and environmental elements such as climate and altitude.[11–14] Furthermore, RVs of CBC have not yet been determined in many developing countries, but depend on literature,[15–18] textbook[5,19–21] or brochures of the reagent kits[1,3,22] which rely on specimens obtained from developed countries people.[1,3,5,15–22] Additionally, several studies accomplished in African and Asian countries indicate

513

distinctions in RVs compared to those determined in American and European countries.[8,19,20,23–26] Likewise, other studies in the Middle East have informed discrepancies in RVs.[2,15,27–29] Moreover, the Clinical and International Standards Institute (CISI) and the International Federation of Clinical Chemistry (IFCC) have advised establishing of RVs for each area.[3,5,30] Moreover, disparities and variations of RVs in different countries cannot be used for the whole population, and there are no RVs for CBC in Yemen. Therefore, this study aimed to determine CBC RVs among adults in Ibb City, Yemen.

Material and Methods
Study Design, Period and Area
A cross-sectional study was conducted from April 1 to November 30, 2023. The study society is in Ibb City, approximately 193 km south of Sana'a. Ibb City at 13°58′N and 44°10′E with an altitude of 6,725 feet (2,050 meters) above sea level. CBC tests were carried out at the hematology department of Alpha Medical Laboratories.

Sample Size and Sampling Techniques
The subjects of this study were selected from healthy adults (volunteers) aged between 18 and 80 years. According to the Clinical and Laboratory Standards Institute (CLSI) recommendation, a minimum of 120 individuals are enough to determine reference values.[31–33] To maximize the confidence, the investigators increased the number of participants to 623. Of the 623 adults selected randomly from the society of the study, 433 were elected, while 190 (30.50%) were excluded through a medical health questionnaire and physical examination by a physician during the recruitment process.

Exclusion criteria were consumption of any nutritional supplements (vitamins and minerals) or any medication, having a history of diseases (anemia, diabetes, liver disease, heart disease, kidney disease, high blood pressure, arthritis and thyroid disorders), fever, tonsillitis, appendicitis, allergies skin rash or receiving or donating blood within the past year. In case of females who were menstruating, pregnant or breastfeeding were excluded. Furthermore, of the 453 participants who consented to the study through a sampling technique, 20 were excluded based on serological test outcomes (hepatitis C virus (HCV) antibodies, hepatitis B surface antigen (HBsAg) and C-reactive protein (CRP) agglutination test level (≥6 mg/l). Of 433 participants were included in the final analysis after employing exclusion criteria for establishing RVs of CBC parameters for adults (253 males and 180 females) in Ibb City, in the middle of Yemen.

Sampling Methods and Analysis
The participants were interviewed using a standardized questionnaire. Data collected included socio-demographic and medical history information. Approximately 2.5 mL of blood was collected using an EDTA-K3 (Jiangsu Xinkang Medical Instrument Co., Ltd, China). Blood samples were sent to the laboratory and tested immediately for HCV antibodies, HbsAg, CRP and CBC. CBC was measured using a Mindray BC-5000 automatic hematology analyzer (Shenzhen Mindray Bio-Medical Co., Ltd., China). The CBC parameters include hemoglobin (Hb), red blood cells (RBC), white blood cells (WBC), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), platelet (PLT) count and WBC differential count (basophils, neutrophils, eosinophils, lymphocytes and monocytes).

Quality Assurance
The data quality was verified using a standard questionnaire designed in English with consistency and high accuracy and translated into Arabic (the country language). The questionnaire contents were collected from previous research to reduce errors and bias. Further, the research team trained before collecting data and sampling to minimize observer and technological bias. Mindray BC-5000 automatic hematology analyzer (Shenzhen Mindray Bio-Medical Co., Ltd., China) was calibrated according to the manufacturer's guidelines. Mindray BC-5800 controls were conducted before and after testing the samples.

Statistical Analysis

The results of the laboratory tests and questionnaires were entered into a Microsoft Excel spreadsheet. Statistical analyses were achieved using GraphPad Prism 8.0.1 (GraphPad Inc. USA). Ringoringo et al reported flexibility in determining the RVs depending on the desire, either by calculating mean-2SD or determining the lower and upper limits at and between 2.5th-97.5th, 3rd-97th, or 5th-95th percentiles.[34,35] On the other hand, Zeh et al, Fiseha et al and Fondoh et al used the mean, median and RVs percentiles.[29,36,37] Accordingly the mean, median and nonparametric 95% RVs (2.5th and 97.5th percentiles) were calculated for CBC according to CLSI guidelines.[32] The ROUT method (Q = 1%) was used to identify outliers. The normality of the results was determined using the Shapiro–Wilk, Anderson-Darling and Kolmogorov–Smirnov tests. Furthermore, descriptive statistics were used to calculate and compare means, medians and 2.5th-97.5th percentiles between each variable such as gender. The potential disparities in RVs were tested using the Mann–Whitney U-test. P values ≤0.05 were counted statistically significant.

Results

A total of 433 healthy adults (253 males and 180 females) were included in the analysis to establish the RVs of CBC for adults. As revealed in Table 1, the mean age and standard deviation of the participants were 29.72 ± 10.64 years, ranging from 18 to 80 years and the mean body weight and standard deviation were 58.04 ± 10.04 Kg. The majority of the participants (72.28%) were from urban communities.

Table 2 presents the mean, median and 95% reference values (RVs) (2.5th −97.5th percentiles) of CBC parameters among healthy adults according to gender. The combined mean, median and RVs for both males and females were as follows: 14.33, 14.30 (11.16–17.54g/dl) for Hb, 4.835, 4.800 (3.890–6.340×10^{12}/l) for RBC, 40.90, 40.80 (33.03–49.30%) HCT, 85.73, 86.20 (72.83–94.55fl) for MCV, 30.06, 30.40 (23.95–33.55pg) for MCH, 35.02, 35.10 (32.97–36.73 g/dl) for MCHC, 5.245, 5.100 (2.810–8.797×10^9/l) for WBC, 49.36, 48.95 (30.10–69.17%) for neutrophils, 43.31, 43.60 (23.86–63.45%), 3.453, 3,500 (1.500–5.0000%) for eosinophil, 3.931, 4.000 (1.873–5.600%) for monocyte, 0.335, 0.000 (0.000–1.000%) for basophil and 270.4, 269.0 (140–418.6×10^9/l) for platelets. Significantly higher median values were observed in males compared to females for Hb, RBC, HCT, lymphocytes and monocytes. Contrariwise, females demonstrated significantly higher neutrophils, eosinophils, basophils and platelets than males. Moreover, MCH and MCHC were statistically significant differences.

The combined mean, median and RVs of absolute neutrophils (2.643, 2.465 and 0.990–5.170×10^9/l), absolute lymphocytes (2.195, 2.165 and 23.86–63.45×10^9/l), absolute eosinophils (0.175, 0.1600 and 0.0460–0.384×10^9/l) absolute monocytes (0.217, 0.2000, and 0.077–0.433×10^9/l) and absolute basophils (0.017, 0.000 and 0.000–0.070×10^9/l). Absolute eosinophils and absolute basophils were statistically significant differences according to gender.

Table 1 Demographic Characteristics of Participants

Characteristics (No.=433)	Mean ± Standard Deviation
Age	29.72±10.64 years
Weight	58.04±10.04 Kg
Sex	No. (%)
Male	253 (58.43%)
Female	180 (41.57%)
Residential areas	No. (%)
Urban	313 (72.29%)
Rural	120 (27.71%)

Table 2 Mean, Median and 95% Reference Values (RVs) (2.5th −97.5th Percentiles) of CBC Parameters Among Healthy Adults According to Gender

Parameters	Gender	Mean	Median	95% CI	RVs	*p*-value
Hb (g/dl)	Combined	14.33	14.30	14.10–14.60	11.16–17.54	<0.0001
	Male	15.31	15.30	15.10–15.60	12.73–17.60	
	Female	13.06	13.00	12.90–13.20	10.65–15.35	
RBC (×10^{12}/l)	Combined	4.835	4.800	4.690–4.880	3.890–6.340	<0.0001
	Male	5.094	5.100	5.040–5.160	4.138–6.234	
	Female	4.417	4.370	4.300–4.430	3.814–5.458	
HCT (%)	Combined	40.90	40.80	40.30–41.50	33.03–49.30	<0.0001
	Male	43.45	43.60	43.30–44.10	36.54–49.30	
	Female	37.40	37.40	37.00–37.70	31.80–43.44	
MCV (fl)	Combined	85.73	86.20	85.60–86.70	72.83–94.55	0.6049
	Male	85.82	86.30	85.90–86.90	72.48–94.38	
	Female	85.53	86.00	84.70–87.00	72.33–94.81	
MCH (pg)	Combined	30.06	30.40	30.20–30.50	23.95–33.55	0.0413
	Male	30.24	30.40	30.30–30.70	23.85–33.85	
	Female	29.84	30.10	29.70–30.50	24.02–33.50	
MCHC (g/dl)	Combined	35.02	35.10	35.00–35.20	32.97–36.73	<0.0001
	Male	35.18	35.30	35.10–35.40	32.93–36.77	
	Female	34.83	34.90	34.80–35.00	32.94–36.76	
WBC (×10^{9}/l)	Combined	5.245	5.100	4.890–5.260	2.810–8.797	0.6098
	Male	5.231	4.970	4.700–5.290	2.850–8.944	
	Female	5.262	5.200	4.850–5.370	2.748–8.462	
Neutrophils (%)	Combined	49.36	48.95	47.80–50.00	30.10–69.17	0.0009
	Male	47.93	47.00	45.80–49.30	28.04–66.83	
	Female	51.11	50.60	48.90–51.90	35.68–71.02	
Neutrophils (×10^{9}/l)	Combined	2.643	2.465	2.532–2.753	0.990–5.170	0.0610
	Male	2.579	2.330	2.425–2.732	0.950–5.461	
	Female	2.728	2.615	2.571–2.884	1.111–4.967	
Lymphocyte (%)	Combined	43.31	43.60	42.50–44.70	23.86–63.45	0.0197
	Male	44.39	45.00	43.00–46.70	24.54–66.23	
	Female	41.98	42.45	40.40–43.60	21.23–58.40	
Lymphocyte (×10^{9}/l)	Combined	2.195	2.165	2.135–2.254	1.247–3.556	0.1023
	Male	2.236	2.200	2.159–2.314	1.292–3.596	
	Female	2.139	2.105	2.045–2.232	1.070–3.405	

(*Continued*)

Table 2 (Continued).

Parameters	Gender	Mean	Median	95% CI	RVs	*p*-value
Eosinophils (%)	Combined	3.453	3.500	3.500–3.500	1.500–5.000	0.0020
	Male	3.592	3.500	3.500–4.000	1.500–5.000	
	Female	3.283	3.500	3.000–3.500	1.500–5.300	
Eosinophil (×10⁹/l)	Combined	0.175	0.1600	0.167–0.1844	0.0460–0.384	<0.0001
	Male	0.190	0.1750	0.178–0.2023	0.050–0.4153	
	Female	0.153	0.1400	0.141–0.1646	0.040–0.3380	
Monocyte (%)	Combined	3.931	4.000	3.800–4.100	1.873–5.600	0.0009
	Male	4.078	4.200	4.000–4.300	1.900–5.600	
	Female	3.751	3.700	3.500–4.000	1.800–5.500	
Monocyte (×10⁹/l)	Combined	0.217	0.2000	0.208–0.226	0.077–0.433	0.3686
	Male	0.221	0.2100	0.209–0.2334	0.0755–0.454	
	Female	0.212	0.2000	0.198–0.2264	0.0717–0.428	
Basophils (%)	Combined	0.335	0.000	0.000–0.000	0.000–1.000	<0.0001
	Male	0.000	0.000	0.000–0.000	0.000–0.000	
	Female	0.371	0.000	0.000–0.000	0.000–1.000	
Basophils (×10⁹/l)	Combined	0.017	0.000	0.0144–0.019	0.000–0.070	<0.0001
	Male	0.000	0.000	0.000–0.000	0.000–0.000	
	Female	0.018	0.000	0.0147–0.022	0.000–0.070	
PLT (×10⁹/l)	Combined	270.4	269.0	260.0–276.0	140.0–418.6	0.0324
	Male	264.1	261.0	247.0–269.0	147.7–411.2	
	Female	278.2	278.5	269.0–291.0	140.3–424.1	

Abbreviations: CI, confidence interval; RVs, reference values; Hb, Hemoglobin; RBC, red blood cells; HCT, hematocrit; MCV, mean cell volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; WBC, white blood cells; PLT, platelet.

Discussion

RVs provide necessary data to help individual health evaluation.[36] Moreover, RVs are affected by several factors.[38,39] To the best of our knowledge, studies on CBC RVs in Yemen are nonexistent. RVs depend on the manufacturers' guidelines and textbooks, which are often established by non-Yemeni populations. Thus, this study aimed to determine the RVs of CBC in Ibb City, Yemen.

Briefly, the RVs in this study for CBC were varied (more or less) in numbers, decimal numerals, or percentages from the reference values of other studies. The RVs of the CBC parameters may agree or disagree with RVs reported in other studies conducted in Saudi Arabia,[5] Oman,[28] Kuwait,[30] Iraq,[2] Morocco,[3] Ethiopia,[29] Iran,[27] Pakistan,[1] the United Kingdom (UK)[40] and France[41] as shown in Table 3.

In this study, males had higher Hb, RBC, HCT, lymphocytes and monocytes than females. These results are consistent with those reported in previous studies.[1–3,5,27–30,40,41] This may be partly a result of the impact of loss of menstrual blood and androgen hormone on erythropoiesis.[42–44] Moreover, the findings of females have higher levels of neutrophil, which are similar to studies in Saudi Arabia,[5] Iraq,[2] Ethiopia,[29] and France.[41] In addition, eosinophil percentage in females is

Table 3 The Comparison of Reference Values (RVs) Obtained in This Study with Studies in Different Countries

Parameter	Gender	Reference Values (RVs)										
		Our study	Saudi Arabia[5]	Oman[28]	Kuwait[30]	Iraq[2]	Morocco[3]	Ethiopia[29]	Iran[27]	Pakistan[1]	UK[40]	France[41]
Hb (g/dl)	C	11.16–17.54	–	–	–	–	–	11.2–16.8	–	–	–	–
	M	12.73–17.60	12.9–17.9	12.4–16.4	13.8–16.4	15.4–15.6	13–17.1	11.3–17.5	12.3–16.8	12.3–16.6	13.–17	13.4–16.7
	F	10.65–15.35	11.4–15.4	11–15.1	11.3–13.9	13.5–13.7	11–14.8	10.8–16.1	11.2–15.4	11.0–14.5	12.–15	11.8–15.0
RBC (×10^{12}/l)	C	3.890–6.340	–	–	–	–	–	3.98–6.12	–	–	–	–
	M	4.138–6.234	5.2–5.7	4.45–6.75	4.7–5.8	5.1–5.2	4.37–5.96	3.81–6.38	4.32–6.01	4.25–6.02	3.8–5.5	4.39–5.68
	F	3.814–5.458	4.5–5.0	4.07–6.17	4.1–5.0	4.5–4.6	3.86–5.2	4.06–5.85	4.06–5.62	3.61–5.2	3.6–4.8	3.96–5.12
HCT (%)	C	33.03–49.30	–	–	–	–	–	35.4–52.0	–	–	–	–
	M	36.54–49.30	40–50	36–47	41–50	44.9–45.5	38.3–50	35.2–53.9	35–47	38.4–50.7	40–50	39.2–48.6
	F	31.80–43.44	40–50	33–43	34–42	39.5–40.0	33.5–43.9	35.4–49.8	32–42	34.5–45.4	35–45	34.7–44.4
MCV (fl)	C	72.83–94.55	–	–	–	–	–	77.9–93.8	–	–	83–101	–
	M	72.48–94.38	77.4–94.6	62.5–88.5	80–93	86.2–87.1	77.4–94.2	77.0–93.6	65.3–90.1	78.7–96.3	–	80.20–95
	F	72.33–94.81	76.6–94.2	62.5–88.5	77–92	86.2–87.1	75.1–94.7	78.5–96.4	64.1–89.6	78.1–95.3	–	78.4–95.3
MCH (pg)	C	23.95–33.55	–	–	–	–	–	24.7–32.0	–	–	26–32	–
	M	23.85–33.85	24.5–31.9	20.81–31.2	26–32	29.6–29.9	25.2–32.3	24.7–32.4	22.1–32.9	25.1–31.6	–	27.2–32.8
	F	24.02–33.50	24.8–31.1	20.81–31.2	25–31	29.8–30.1	24–32.3	25.7–32.0	21.7–32.9	25.3–31.7	–	–
MCHC (g/dl)	C	32.97–36.73	–	–	–	–	–	30.6–34.9	–	–	31–35	–
	M	32.93–36.77	30.4–34.5	31–37.2	32.7–34.7	34.2–34.3	31.7–36	30.4–34.9	32.9–37.8	30.0–35.5	–	32.4–36.3
	F	32.94–36.76	30.5–33.9	31–37.2	32.3–34.1	34.2–34.3	31.2–36 3	30.7–34.9	32.8–37.7	30.3–34.4	–	–

Parameter		RVs										
WBC (×10⁹/l)	C	2.810–8.797	–	–	–	–	–	3.49–11.3	–	–	4–11	–
	M	2.850–8.944	3.7–10.6	2.79–8.09	5.9–12	6.7–7.0	4.1–10.8	3.54–10.9	4.1–9.3	4.88–11.4	–	4.08–10.81
	F	2.748–8.462	3.5–10.6	2.79–8.09	5.4–11	7.1–7.5	4.1–10.7	3.47–11.8	4.1–9.3	4.6–10.8	–	–
Neutrophils (%)	C	30.10–69.17	–	–	–	–		34.95–62.3	–	34.9–76.2	50–72.7	–
	M	28.04–66.83	43.2–55.3	32.6–56.98	46–72	55.2–55.7	43.9–64.8	20.9–59.35	–	–	–	44.71–65.1
	F	35.68–71.02	46.4–61.2	32.6–56.98	49–73	57.7–58.6	43.9–65.4	36.0–66.7	–	–	–	44.61–68.3
Lymphocyte (%)	C	23.86–63.45	–	–	–	–	–	30.6–37.43	–	17.5–45	25–31.8	–
	M	24.54–66.23	32.3–44.2	38.9–40.1	18–41	32.8–34.3	29.3–35.2	30.2–35.2	26.6–55.7	–	–	31.2–36.0
	F	21.23–58.40	29.7–41.7	38.9–40.1	18–40	–	29.3–35.5	25.4–36.0	26.3–55.7	–	–	32.3–35.0
Eosinophils (%)	C	1.500–5.000	–	–	–	–	–	0.6–4.1	–	0.3–7.4	0.25–6.4	–
	M	1.500–5.000	0.4–7.1	1.08–4.57	0.1–6	–	0.0–5.55	0.56–4.4	–	–	–	0.98–5.35
	F	1.500–5.300	0.0–7.0	1.08–4.57	0.1–4	–	0.0–4.67	0.28–3.5	–	–	–	1.02–5.00
Monocyte (%)	C	1.873–5.600	–	–	–	–	–	2.86–8.93	–	3.9–10	2.5–9.1	–
	M	1.900–5.600	5.0–12.4	8.9–8.2	5.6–10	–	4.87–11.1	3.38–9.20	1.7–5.7	–	–	5.65–7.0
	F	1.800–5.500	4.4–12.3	8.9–8.2	4.9–10	–	4.87–11.2	2.30–8.89	–	–	–	5.10–6.35
Basophils (%)	C	0.000–1.000	–	–	–	–	–	0.0–0.79	–	0.10–1.0	0.25–0.9	–
	M	0.000–0.000	0.2–1.3	0.07–0.62	0.2–1	–	0.0–0.74	0.0–0.82	–	–	–	0.0–0.86
	F	0.000–1.000	0.1–1.1	0.07–0.62	0.1–1	–	0.0–0.75	0.0–0.76	–	–	–	0.0–0.76
PLT (×10⁹/l)	C	140.0–418.6	–	–	–	–	–	131–391	–	154–433	120–410	–
	M	147.7–411.2	213–283	146–347	184–304	139–339	145–338	130–395	161–337	–	–	166.5–395.5
	F	113.3–424.1	229.2–327.2	164–368	204–350	158–405	150–378	144–434	174–363	–	–	186–432.5

Abbreviations: C, combined; M, male; F, female; g/dl, gram per deciliter; fl, femtoliter; pg, picogram; RVs, reference values; Hb, Hemoglobin; RBC, red blood cells; HCT, hematocrit; MCV, mean cell volume; MCH, mean corpuscular hemoglobin;; MCHC, mean corpuscular hemoglobin concentration; WBC, white blood cells; PLT, platelet.

higher than that in males, this report is different than studies in Saudi Arabia,[5] Kuwait,[30] Morocco[3] and Ethiopia.[29] Likewise, the basophil percentage in females is higher than that in males, which disagrees with studies done in Saudi Arabia,[5] Kuwait,[30] Ethiopia[29] and France.[41] It be related to geographic dissimilarities, ethnic background, sociodemographic disparities, social lifestyle and habits, dietary customs, ecological factors and laboratory diagnostic techniques.[5,42,45]

Our results showed that the RVs for MCV, MCH and MCHC were almost equal between males and females. These outcomes are consistent with studies accomplished in Saudi Arabia,[5] Oman,[28] Iraq[2] and Pakistan.[1] Additionally, the RV for PLT was higher in females compared to males as reported in Saudi Arabia.[5] It is probably due to menarche through cross-motivating megakaryopoiesis.[42,46] This study's limitation is that the RVs of the CBC parameters in neonates and children are missing.

Conclusion
In conclusion, the RVs of CBC established in the current study are considered a benchmark that may assist in interpreting and accurately judging laboratory results for adults in Ibb City, Yemen. The results displayed significant differences between males and females in Hb, RBC, HCT, MCH, MCHC, neutrophils, lymphocytes, eosinophils, monocytes, basophils and platelets.

Abbreviations
C, combined; M, male; F, female; g/dl, gram per deciliter; fl, femtoliter; pg, picogram; RVs, reference values; Hb, Hemoglobin; RBC, red blood cells; HCT, hematocrit; MCV, mean cell volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; WBC, white blood cells; PLT, platelet.

Data Sharing Statement
The data that support the findings of this study are available upon request from the corresponding author. The data are not publicly available because they contain information that can compromise the privacy of the research participants.

Ethical Considerations
The Medical Laboratories Department, Faculty of Medicine and Health Sciences, Ibb University Ethical Committee, granted ethical approval for this research after following due process (Reference No.: MDL-MHS-IBBU/IBA002/2023 dated February 6, 2023). The Research Ethics Committee complied with the Declaration of Helsinki for the Protection of Human Subjects. Participants were informed about the study and provided written informed consent.

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Author Contributions
All authors made a significant contribution to the work reported, whether in the conception, study design, execution, data acquisition, analysis and interpretation, or in all these areas; participated in drafting, revising or critically reviewing the article. Final approval was given for publication; all authors have agreed to the journal to which the article has been submitted and agreed to be accountable for all aspects of the work.

Disclosure
The authors report no conflicts of interest in this work.

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