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Red Cell Distribution Width as a Potential Diagnostic Biomarker for Diabetes Miletus: A Case-Control Study from Tarhuna Cit, Libya

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Abstract

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by hyperglycemia that leads to serious vascular and systemic complications. The red cell distribution width (RDW), a routinely measured hematological index reflecting erythrocyte size variability, has recently been proposed as a potential biomarker for metabolic and inflammatory disorders, including diabetes. This case–control study aimed to evaluate the diagnostic significance of RDW among diabetic and non–diabetic individuals in Tarhuna City, Libya. A total of 160 participants (80 diabetics and 80 non–diabetics) were enrolled, and their demographic, biochemical, and hematological data—including fasting blood glucose (FBS), glycated hemoglobin (HbA1c), and RDW indices (RDW–SD and RDW–CV)—were analyzed using SPSS version 23. While diabetic patients exhibited significantly higher mean values of FBS, HbA1c, triglycerides, and platelet counts ($p < 0.05$), no significant differences were observed in RDW–SD (41.78 ± 3.78 vs. 41.72 ± 4.06, $p = 0.915$) or RDW–CV (13.52 ± 1.80 vs. 14.11 ± 2.68, $p = 0.108$) between diabetic and non–diabetic groups. Correlation and regression analyses revealed no

significant association between RDW and glycemic parameters, and receiver operating characteristic (ROC) curve analysis demonstrated limited diagnostic performance (AUC = 0.509 for RDW-SD and 0.576 for RDW-CV). These findings indicate that RDW is not significantly associated with diabetes mellitus and lacks sufficient sensitivity or specificity as a diagnostic biomarker. Larger, multi-centered studies incorporating additional inflammatory and metabolic indicators are warranted to further explore the potential role of RDW in diabetes risk assessment and disease monitoring.

Keywords:

Red Cell Distribution Width, Diabetes Mellitus, HbA1c, Fasting Blood Glucose, Tarhuna, Biomarker, Case–Control Study.

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Introduction

Diabetes mellitus (DM) is a complex chronic metabolic disorder characterized by persistent hyperglycemia that results from defects in insulin secretion, insulin action, or both. It is associated with serious microvascular and macrovascular complications that affect multiple organs, including the eyes, kidneys, heart, and nervous system [1]. The global prevalence of diabetes has increased alarmingly during the past few decades, making it one of the most pressing public health challenges of the 21st century [2]. According to the World Health Organization (WHO), approximately 537 million adults were living with diabetes in 2021, and this number is projected to reach 783 million by 2045, with the greatest increase expected in low- and middle-income countries [3]. Libya, similar to other developing nations, has witnessed a rapid rise in diabetes prevalence, largely attributed to urbanization, changes in dietary habits, obesity, and physical inactivity [4-5].

The pathophysiological mechanisms of diabetes are multifactorial, involving chronic low-grade inflammation, oxidative stress, and endothelial dysfunction [6]. Persistent hyperglycemia triggers the production of reactive oxygen species and inflammatory cytokines such as interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP), all of which contribute to tissue damage and complications [7,8]. Given this chronic inflammatory state, several hematological indices have been proposed as cost-effective tools for assessing the inflammatory and metabolic alterations associated with diabetes [9].

Among these indices, red cell distribution width (RDW)—a routinely available parameter in the complete blood count (CBC)—has recently gained attention as a potential biomarker reflecting systemic inflammation and metabolic instability [10,11]. RDW represents the variation in the size of circulating red blood cells (anisocytosis), expressed as either standard deviation (RDW-SD) or coefficient of variation (RDW-CV) of red blood cell volume [12]. Traditionally, RDW has been used to differentiate types of anemia, such as iron deficiency or megaloblastic anemia [13]. However, increasing evidence suggests that elevated RDW values are associated with a wide range of non-hematological conditions, including cardiovascular diseases, metabolic syndrome, chronic kidney disease, and malignancies [14-16].

In the context of diabetes, several studies have examined the relationship between RDW and glycemic status, though results remain inconsistent. Some researchers reported that higher RDW values are significantly correlated with poor glycemic control, insulin resistance, and increased inflammatory activity in diabetic patients [17–20]. For instance, Veeranna et al. (2012) found that elevated RDW levels were independently associated with insulin resistance and higher cardiovascular risk among diabetic individuals [17], while Engström et al. (2014) observed that increased RDW predicted the onset of metabolic syndrome and type 2 diabetes [18]. Similarly, Wang et al. (2020) suggested that RDW could serve as an indicator of oxidative stress and systemic inflammation linked to poor metabolic control [19].

In contrast, other investigations failed to demonstrate a significant relationship between RDW and diabetes. Shirali et al. (2019) reported no substantial differences in RDW between diabetic and non-diabetic subjects [21], and Hassan et al. (2023) concluded that RDW lacks diagnostic sensitivity or specificity for distinguishing diabetic patients from healthy individuals [22]. These discrepancies may be due to variations in study design, sample size, ethnicity, disease duration, comorbid conditions, or laboratory methodologies [23].

Given these conflicting findings, the clinical value of RDW as a biomarker for diabetes mellitus remains uncertain. Nonetheless, because RDW measurement is inexpensive, widely accessible, and routinely included in CBC testing, it holds potential as a supplementary marker in resource-limited settings—especially in countries such as Libya, where advanced biochemical testing may not be readily available [24-25].

Despite the global focus on diabetes and its hematological correlates, data from North African and Libyan populations remain scarce. Understanding whether RDW can be linked to diabetes status in this region may help establish population-specific diagnostic strategies.

Therefore, the present study aimed to evaluate the association between red cell distribution width and diabetes mellitus among individuals attending medical facilities in Tarhuna City, Libya. Furthermore, it sought to determine whether RDW could serve as a potential diagnostic biomarker for diabetes within this population, providing a simple, cost-effective tool to support early detection and monitoring in clinical practice.

Material and Methods

Study Design and Population

This case–control study was conducted between February and May 2025 at the Diabetes and Endocrinology Center in Tarhuna City, Libya, in collaboration with several nearby outpatient clinics. A total of 160 participants were enrolled, including 80 diabetic patients diagnosed with type 2 diabetes mellitus and 80 non-diabetic controls matched for age and gender. The study was designed to evaluate the potential association between red cell distribution width (RDW) and diabetes mellitus and to assess its possible diagnostic value.

Ethical Considerations

The study protocol was reviewed and approved by the Research Ethics Committee of the Faculty of Medical Technology, Azzytouna University, Libya. Written informed consent was obtained from all participants prior to enrollment, and confidentiality of all personal and laboratory data was strictly maintained in accordance with ethical research principles and the Declaration of Helsinki [1].

Inclusion and Exclusion Criteria

Participants aged 30 to 70 years were included in the study. The diabetic group consisted of individuals previously diagnosed with type 2 diabetes mellitus according to the World Health Organization (WHO) diagnostic criteria (fasting plasma glucose ≥ 126 mg/dL or HbA1c ≥ 6.5%) [2]. The control group comprised apparently healthy individuals without a history of diabetes, cardiovascular diseases, renal impairment, hepatic dysfunction, anemia, or inflammatory conditions.

Subjects were excluded if they were:

Pregnant women, Individuals with known hematological disorders, Patients on medications affecting erythropoiesis or blood indices (e.g., iron supplements, vitamin B12, or folic acid), Individuals with acute infections or chronic inflammatory diseases.

Data Collection and Laboratory Analysis

A structured data collection sheet was used to record demographic information (age, gender, body mass index), clinical history, and laboratory findings. Five milliliters (5 mL) of venous blood were collected from each participant under aseptic conditions after an overnight fast of at least 8 hours. The blood samples were divided into two portions:

2mL collected in EDTA tubes for hematological analysis,

3 mL collected in plain tubes to obtain serum for biochemical tests.

Hematological parameters, including RDW-CV and RDW-SD, were measured using an automated hematology analyzer (Sysmex KX-21N, Japan).

Biochemical parameters such as fasting blood glucose (FBS), glycated hemoglobin (HbA1c), triglycerides (TG), and total cholesterol were measured using an automated chemistry analyzer (Mindray BS-380, China) following the manufacturer's instructions. Quality control procedures were performed daily to ensure the accuracy and reliability of laboratory results

Statistical Analysis

All data were analyzed using Statistical Package for Social Sciences (SPSS) version 23 (IBM Corp., USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. The Mann–Whitney U test was applied to compare differences between diabetic and non-diabetic groups for non-normally distributed data. Correlations between RDW parameters and biochemical variables (FBS, HbA1c, and lipid profile) were evaluated using Spearman's correlation coefficient.

Multiple regression analyses were performed to identify independent predictors of glycemic status. The diagnostic performance of RDW was assessed using receiver operating characteristic (ROC) curve analysis, and the area under the curve (AUC) was calculated. Statistical significance was considered at $p < 0.05$ [5].

Results

This study included 160 participants: 80 individuals diagnosed with diabetes and 80 healthy controls. The average age in the diabetic group was 56 years, while in the non-diabetic group, it was 44 years. Females constituted55.6% of the total sample, and males 44.4%. The majority of diabetic participants had Type 2 diabetes (36.9%), and 11.9% had Type 1 diabetes. The

remaining participants either had no diabetes or were unaware of their type. Regarding treatment, 30% of diabetic patients were on Metformin and 20% on insulin, while 50% of the total sample did not receive any diabetes medication. Physical activity was reported by only 2.5% of participants, with 43.2% engaging in it sometimes.

When comparing the RDW values:

- RDW-SD: 41.78 ± 3.78 (diabetic) vs. 41.72 ± 4.06 (non-diabetic); p = 0.915
- RDW-CV: 13.52 ± 1.80 (diabetic) vs. 14.11 ± 2.68 (non-diabetic); p = 0.108

No statistically significant difference was observed in RDW values between diabetic and non-diabetic participants.

Regression analysis showed:

- Diabetes status was significantly associated with higher RDW-CV (p = 0.046) but not RDW-SD.
- Neither RDW-SD nor RDW-CV was a significant predictor of diabetes in logistic regression models (p > 0.05).
- ROC analysis for diagnostic value yielded AUCs of 0.509 (RDW-SD) and 0.576 (RDW-CV), indicating weak discriminatory power.

Table 1.1. Gender Distribution of Participants

GENDER		
	FREQUENCY	**PERCENT**
MALE	71	44.4
FEMALE	89	55.6
TOTAL	160	100.0

The gender distribution of the sample indicates that out of 160 individuals, 55.6% are female (89 individuals) and 44.4% are male (71 individuals). This reflects a slightly higher representation of females in the dataset.

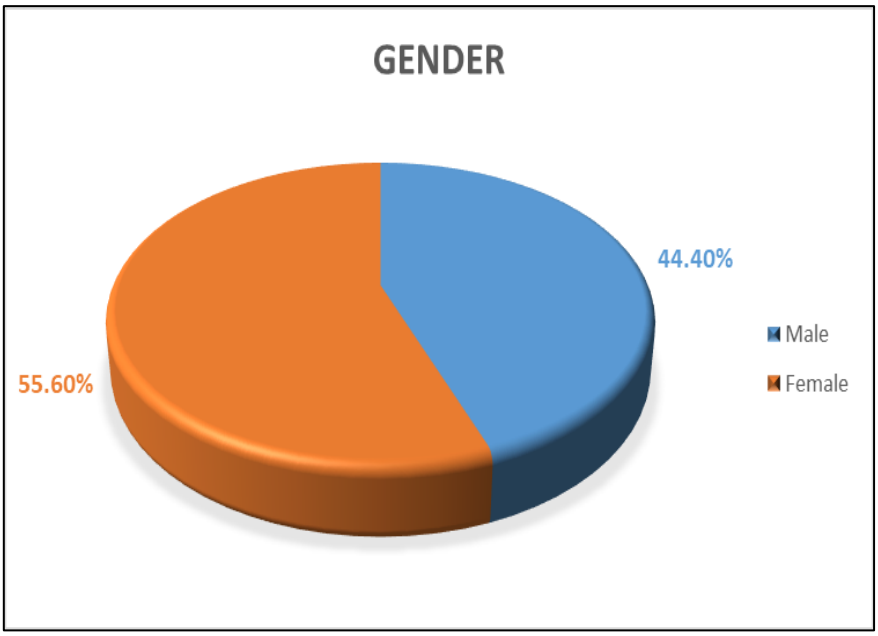

Figure 1.1. Distribution of the sample

Table 4.2. Diabetes Status of Participants

	FREQUENCY	PERCENT
NO	80	50.0
YES	80	50.0
TOTAL	160	100.0

The data shows an equal distribution of individuals with and without diabetes in the sample. Out of 160 individuals, 80 (50.0%) have diabetes, while the remaining 80 (50.0%) do not. This perfectly balanced distribution allows for unbiased comparisons between the two groups in subsequent analyses and provides a solid foundation for examining the impact of diabetes on other variables within the dataset.

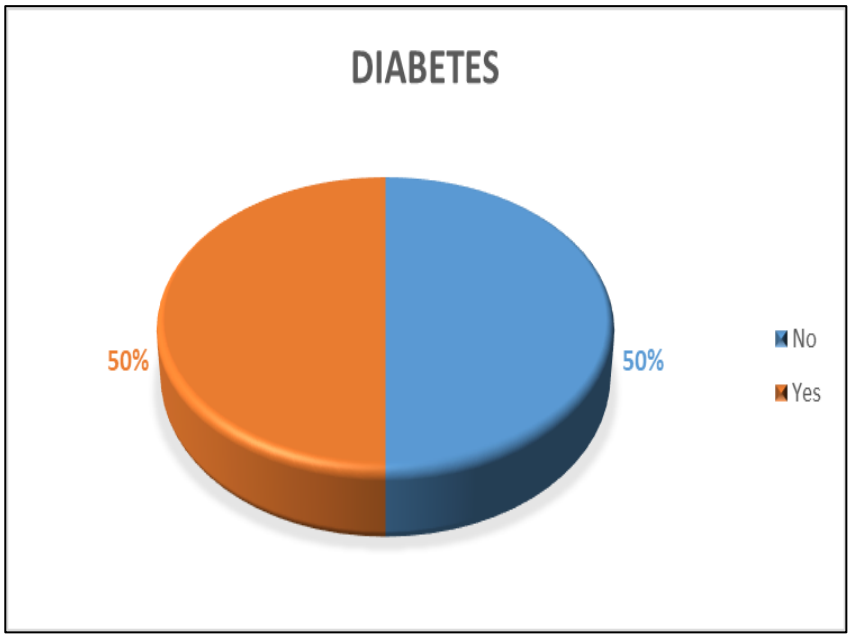

Figure 1.2. Pie Chart – Gender Distribution

Table 1.3. Types of Diabetes Among Diabetic Participants

	FREQUENCY	PERCENT
NO DIABEATS	80	50.0
TYPE 1	19	11.9
TYPE 2	61	38.2
TOTAL	160	100.0

The data regarding the type of diabetes reveals that out of 160 individuals, half of the sample (50.0%) do not have diabetes, while 38.2% have Type 2 diabetes and 11.9% have Type 1 diabetes. This distribution indicates that among those diagnosed with diabetes, Type 2 is significantly more prevalent than Type 1, which aligns with general population trends.

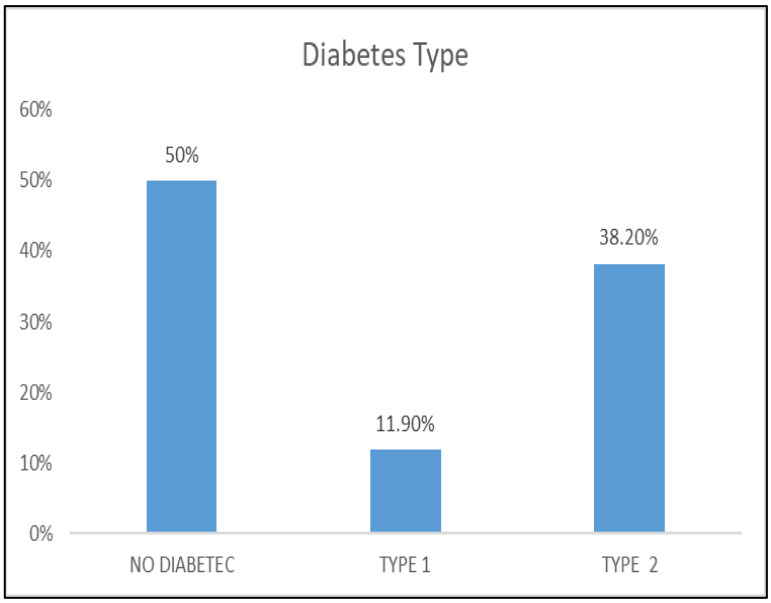

Figure 1.3. Bar Chart – Diabetes Status

Table 1.4. Duration of Diabetes

	FREQUENCY	PERCENT
NO	80	50.0
1-5 YEARS	36	22.5
6-10 YEARS	11	6.9
MORE THAN 10 YEARS	18	11.3
LESS THAN 1 YEAR	15	9.37
TOTAL	160	100.0

The data on diabetes duration shows that out of 160 individuals, 50.6% (81 individuals) do not have diabetes. Among those who do, 22.5% have been diagnosed for 1–5 years, 11.3% for more than 10 years, 8.8% for less than 1 year, and 6.9% for 6–10 years. This distribution suggests that the majority of diabetic individuals have had the condition for a relatively short period (less than 5 years), while a smaller portion have been managing it for over a decade.

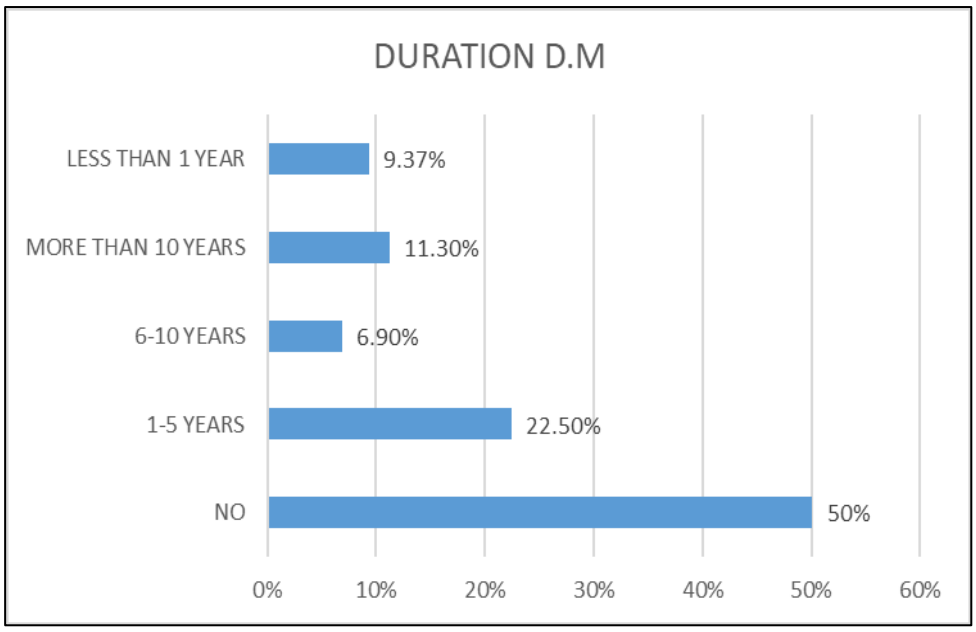

Figure 1.4. Bar Chart – Other Diseases

Table 1.5. Types of Treatment for Diabetes

	FREQUENCY	PERCENT
INSULIN	32	20.0
METFORMIN	48	30.0
NON-DIABETIC	80	50.0
TOTAL	160	100.0

The treatment data shows that half of the individuals in the sample (50.0%) are not receiving any form of diabetes treatment, while 30.0% are using Metformin and 20.0% are on insulin therapy. This suggests that among those diagnosed with diabetes, Metformin is the most commonly used treatment, followed by insulin.

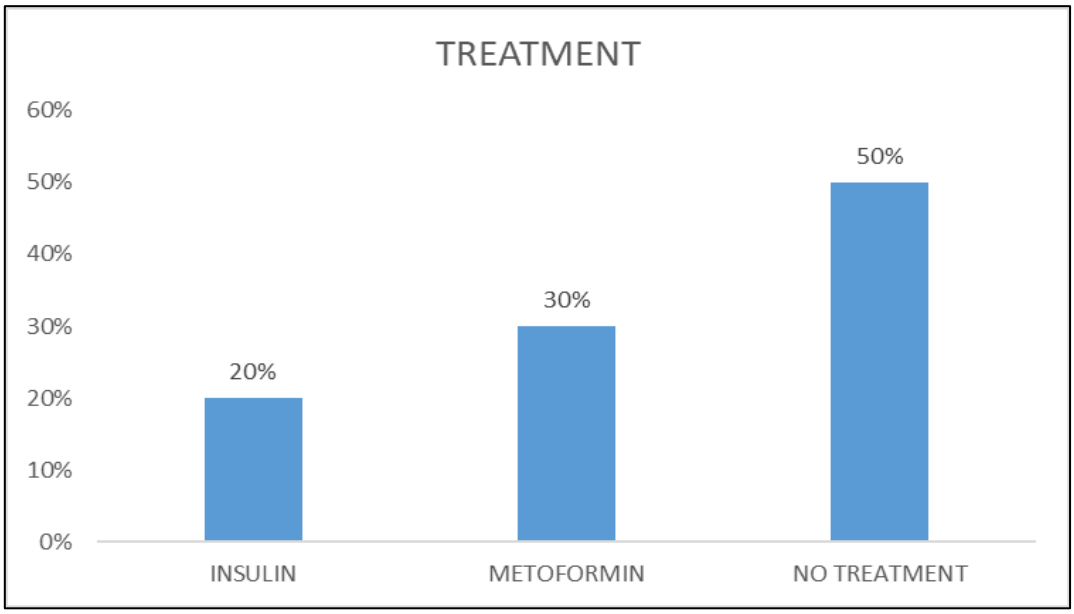

Figure 1.5. Pie Chart –Regular Medication Use

Table 1.6. Presence of Other Diseases

	FREQUENCY	PERCENT
NO	114	71.3
YES	46	28.7
TOTAL	160	100.0

The data on the presence of other diseases indicates that 71.3% of the individuals (114 out of 160) reported no additional health conditions, while 28.7% (46 individuals) reported having other diseases alongside or apart from diabetes.

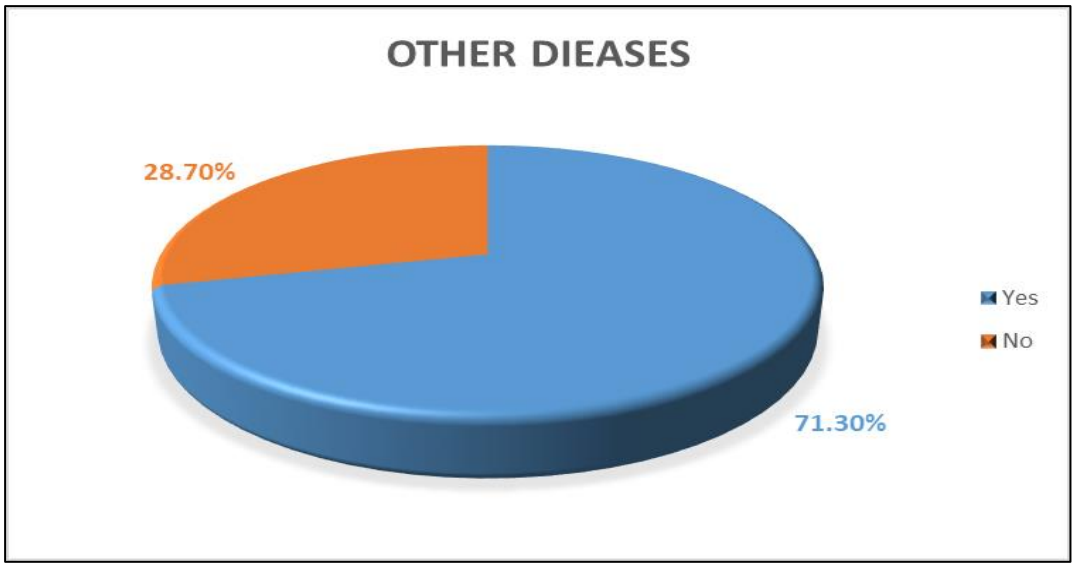

Figure 1.6. Histogram – Blood Group Distribution

Table 1.7. Use of Regular Medications

	FREQUENCY	PERCENT
NO	41	25.6
YES	119	74.4
TOTAL	160	100.0

The data on regular medication use reveals that a majority of the individuals, 74.4% (119 out of 160), take medication regularly, while 25.6% (41 individuals) do not. This indicates that most participants are engaged in ongoing medical treatment, which may reflect the presence of chronic conditions such as diabetes or other health issues. Understanding the prevalence of regular medication use is important for assessing adherence to treatment and its potential impact on health outcomes within the sample.

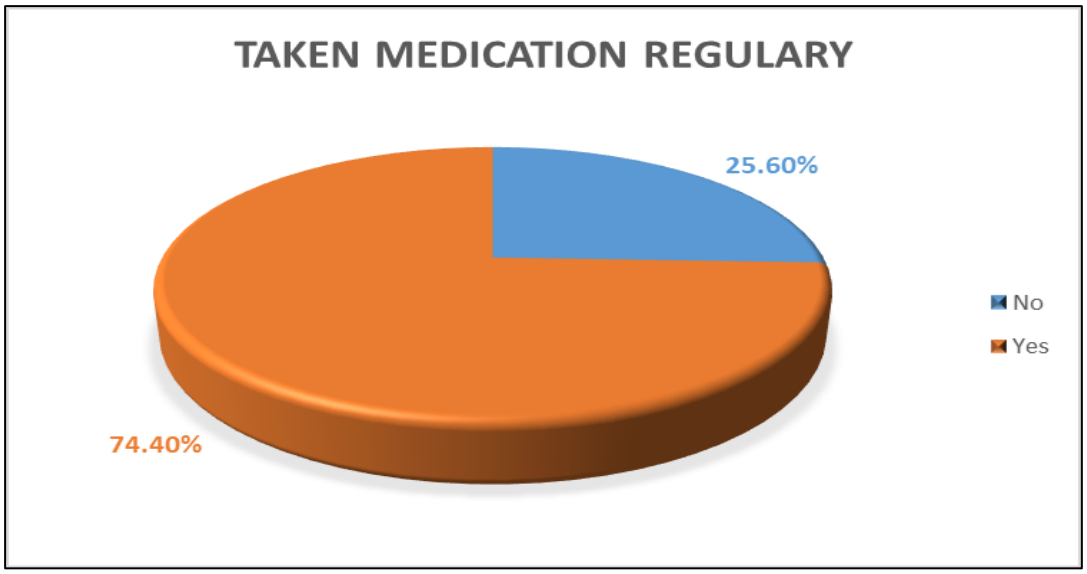

Figure 1.7. Boxplot – RDW-CV in Study Groups

Table 1.8. Types of Medications Used

	DIABETEC		NON - DIABETEC	
	FREQUENCY	**PERCENT**	**FREQUENCY**	**PERCENT**
NO MEDICATION	1	1.3	41	51.2
DIABETES MEDICATION	48	60.0	0	0.0
DIABETES MEDICATION PLUS OTHER MEDICATIONS	31	38.7	0	0.0
OTHER MEDICATION	0	0.0	14	17.5
VITAMINS	0	0.0	25	31.3
TOTAL	80	100.0	80	100.0
TOTAL	80	100.0	80	100.0

The results show a clear difference between diabetic and non-diabetic participants. Among diabetics, almost all were taking diabetes-related medications (60% diabetes medication only and 38.7% with other treatment), while only 1.3% reported no medication. In contrast, over half of the non-diabetics (51.2%) took no medication, 31.3% used vitamins, and 17.5% used other

medications. None of the non-diabetics used diabetes medication. This indicates that medication use among diabetics is dominated by diabetes treatments, whereas non-diabetics rely mainly on vitamins or no medication at all.

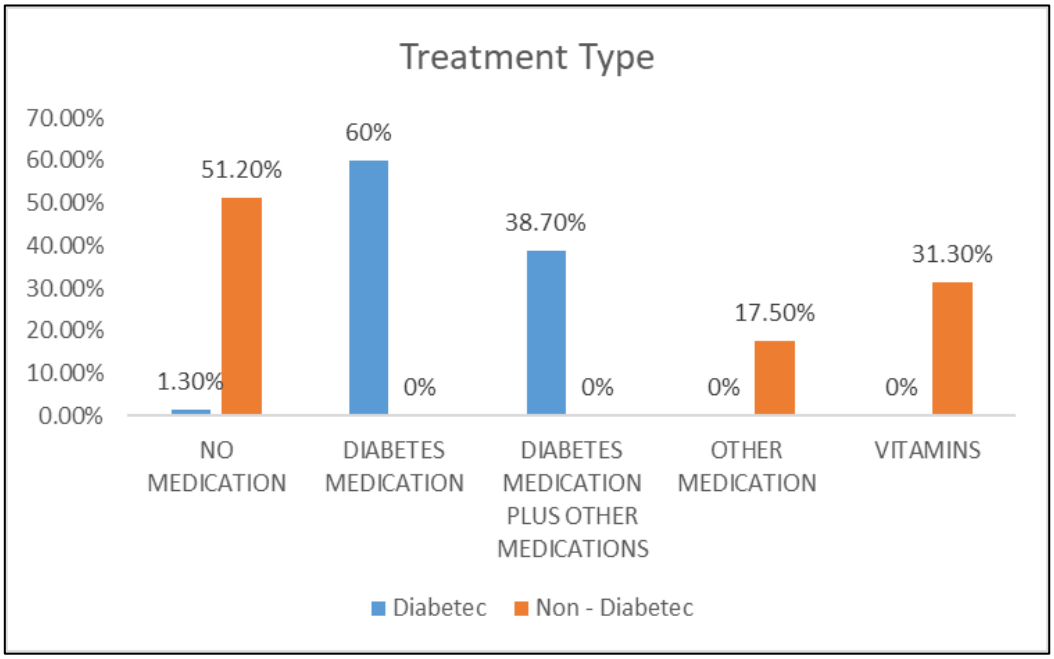

Figure 1.8. ROC Curve – RDW-CV

Table 1.9. Level of Physical Activity

	FREQUENCY	PERCENT
NO	87	54.3
YES	4	2.5
SOMETIMES	69	43.2
TOTAL	160	100.0

The data on physical activity indicates that 36.4% of individuals do not engage in any physical activity, while only 2.5% participate regularly. The largest group, 43.2%, engage in physical activity sometimes. This suggests that while a significant portion of the population is at least occasionally active, regular exercise is uncommon. These findings highlight potential areas for health promotion, as increased physical activity is often linked to better management of chronic conditions such as diabetes and overall well-being.

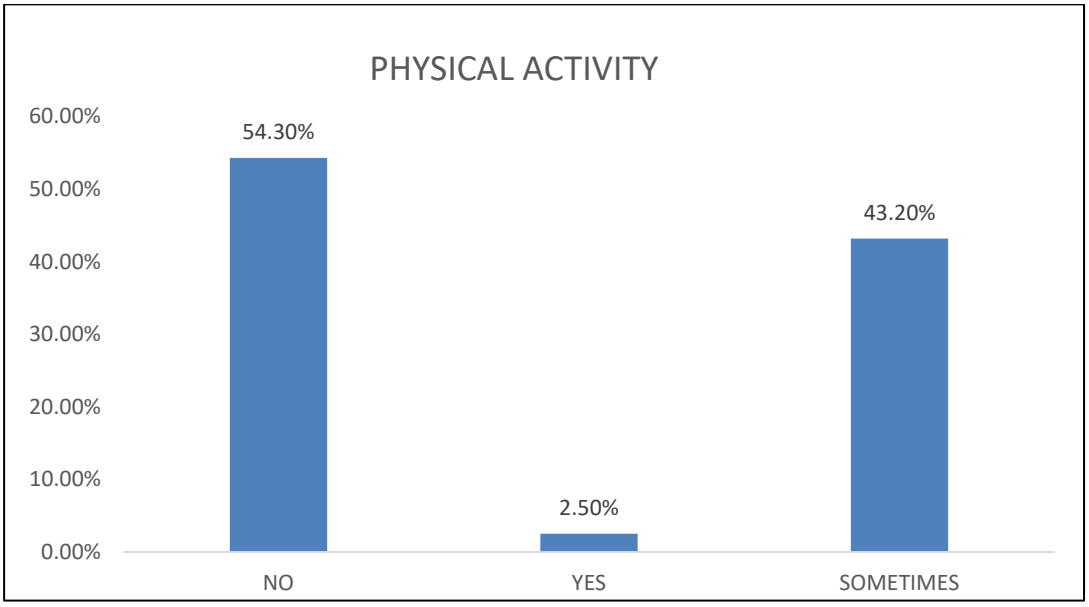

Figure 1.9. ROC Curve – RDW-SD

Table 1.10. Eating Habits

	FREQUENCY	PERCENT
HEALTHY	8	5.0
NORMAL	145	90.6
UNHEALTHY	7	4.2
TOTAL	160	100.0

The data on eating habits shows that the vast majority of individuals, 90.6%, describe their diet as normal, while only a small percentage consider their eating habits to be healthy (5.0%) or unhealthy (4.2%). This suggests that most of the sample maintains an average or typical diet, with relatively few reporting distinctly healthy or unhealthy patterns.

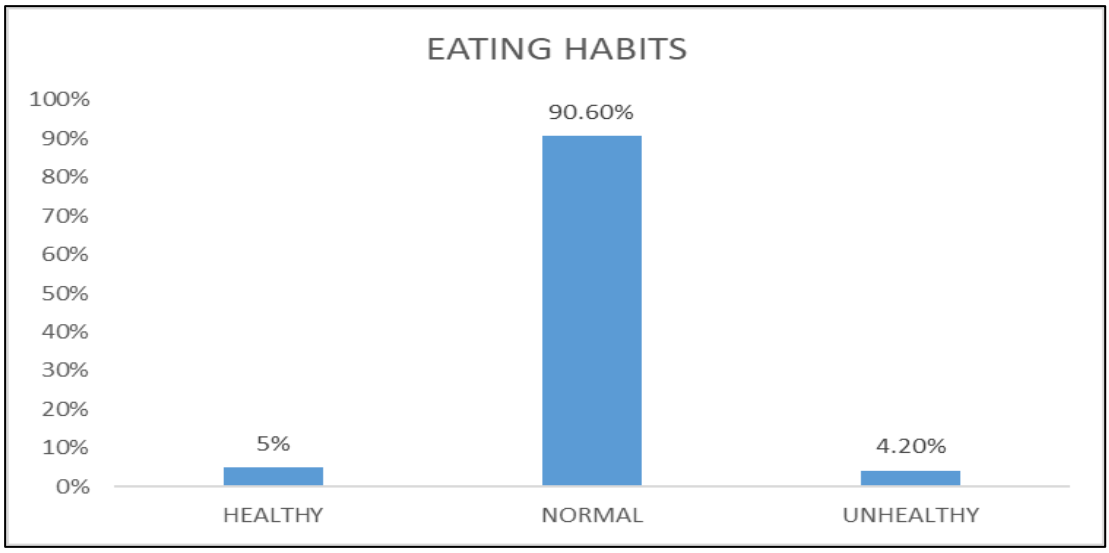

Figure 1.10. Distribution of eating habits among participants.

Table 1.11. Distribution of Blood Groups

A-	8	5.0
A+	84	52.5
AB-	1	0.64
AB+	8	5.0
B-	2	1.25
B+	13	8.13
O-	11	6.88
O+	33	20.6
Total	160	100.0

The blood group data shows that the most common type is A+ with 84 individuals (52.5%), followed by O+ with 33 individuals (20.6%). Other blood groups are less frequent in the sample. This distribution aligns with common global patterns and provides useful information for health-related analyses.

1.2. Comparison of CBC Indices by HbA1c Levels in Diabetic Patients

1.2.1. Criteria of diabetic patients and healthy controls

Table 4.12. Comparison of CBC Parameters (Diabetic vs. Non-Diabetic)

	Healthy controls (n = 80)	**Diabetics (n = 80)**	**P-Value**
AGE	57.51 ± 12.66	43.47 ± 15.83	0.000**
HbA1C	5.46 ± 0.55	7.46 ± 1.32	0.000**
FBS	99.73 ± 15.56	145.88 ± 41.71	0.000**
WBC	7.47 ± 2.37	8.06 ± 2.83	0.152
MCV	82.22 ± 11.03	82.86 ± 6.71	0.659
MCH	29.11 ± 6.77	28.62 ± 2.71	0.549
RDW_SD	41.72 ± 4.06	41.78 ± 3.78	0.915
RDW_CV	14.11 ± 2.68	13.52 ± 1.80	0.108
HDL (mg/dl)	51.93 ± 16.96	48.38 ± 16.81	0.187
PLT	231.56 ± 69.20	257.98 ± 73.15	0 .020*
RBC	4.61 ± .057	10.82 ± 54.82	0.313
HGB	13.18 ± 1.89	13.32 ± 1.98	0.650
HCT	38.62 ± 9.04	38.74 ± 5.64	0.919
Cholesterol	171.56 ± 43.94	178.67 ± 40.07	0.286
Triglycerides	115.09 ±48.41	138.89 ±57 .32	0.005*

The comparison between diabetics and healthy controls revealed significant differences in several parameters. Diabetic patients had higher HbA1C (7.46 ± 1.32 vs. 5.46 ± 0.55; p = 0.000), fasting blood sugar (145.88 ± 41.71 vs. 99.73 ± 15.56; p = 0.000), triglycerides (138.89 ± 57.32 vs. 115.09 ± 48.41; p = 0.005), and platelet count (257.98 ± 73.15 vs. 231.56 ± 69.20; p = 0.020). In contrast, no significant differences were observed in WBC, MCV, MCH, RDW-SD, RDW-CV, HDL, RBC, HGB, HCT, or cholesterol levels (p > 0.05 for all). These findings indicate that diabetes is associated with marked alterations in glycemic control, lipid profile, and platelet count, which may contribute to increased cardiovascular risk.

1.2.2. The studied CBC indices in diabetic patients with a1c #7% vs patients with a1c .7%

Table 1.13. RDW in Controlled vs. Uncontrolled Diabetes

	Controlled a1c ≥ 7, (n = 114)	**Uncontrolled a1c < 7, (n = 46)**	**P-Value**
AGE	46.84 ± 16.18	59.54 ± 11.01	0.000**
HbA1C	5.72 ± 0.65	8.30 ± 1.13	0.000**
FBS	107.05 ± 22.15	161.86 ± 44.19	0.000**
WBC	7.94 ± 2.82	7.33 ± 1.98	0.184
MCV	82.55 ± 7.69	82.51 ± 12.02	0.980
MCH	28.90 ± 5.84	28.75 ± 2.80	0.867
RDW_SD	41.49 ± 3.84	42.40 ± 4.05	0.182
RDW_CV	13.89 ± 2.55	13.63 ± 1.48	0.430
PLT	251.31 ± 76.15	228.58 ± 59.03	0.072
RBC	8.87 ± 45.93	4.84 ± 0.61	0.553
HGB	13.05 ± 2.00	13.76 ± 1.66	0.037*
HCT	38.06 ± 8.37	40.20 ± 4.47	0.104
Cholesterol	170.96 ± 42.18	185.43 ± 40.41	0.049*
Triglycerides	119.19 ± 47.61	146.32 ± 64.47	0.004*

The results show significant differences between the controlled (HbA1c ≥ 7) and uncontrolled (HbA1c < 7) groups across several variables. Participants with uncontrolled diabetes were significantly older (59.54 ± 11.01 years) compared to those with controlled diabetes (46.84 ± 16.18 years, p = 0.000), suggesting age may be associated with poorer glycemic control. As expected, the uncontrolled group had higher HbA1c (8.30 ± 1.13 vs. 5.72 ± 0.65, p = 0.000) and fasting blood sugar levels (161.86 ± 44.19 vs. 107.05 ± 22.15, p = 0.000), confirming the categorization. Hemoglobin (HGB) levels were also higher in the uncontrolled group (13.76 ± 1.66) compared to the controlled group (13.05 ± 2.00, p = 0.037). Cholesterol and triglyceride levels were significantly elevated in the uncontrolled group (p = 0.049 and p = 0.004, respectively), indicating a possible link between poor glycemic control and dyslipidemia. Other parameters, including WBC, MCV, MCH, RDW (SD and CV), PLT, RBC, and HCT, showed

no statistically significant differences between the groups ($p > 0.05$). These findings highlight the metabolic differences related to glycemic control and underline the importance of comprehensive management in diabetic patients.

1.3. Statistical Hypothesis Testing

1.3.1. Assessing The Effect of Diabetes Status on RDW_SD and RDW_CV After Adjusting for Age

This analysis examines the relationship between diabetes status and RDW parameters (RDW_CV and RDW_SD) while controlling for the effect of age. The goal is to determine whether diabetes is associated with changes in RDW independent of age differences.

Table 1.14. Linear Regression Analysis for RDW

Dependent Variable	Predictor	B	Std. Error	Beta	t	p-value
RDW_SD	Constant	40.723	1.044	_	39.008	0.000
	Diabetes	-0.409	0.692	-0.052	-0.592	0.555
	Age	0.024	0.022	0.099	1.122	0.264
RDW_CV	Constant	14.227	0.607	_	23.434	0.000
	Diabetes	0.811	0.402	0.177	2.015	0.046
	Age	0.016	0.013	-0.111	-1.269	0.206

The multiple linear regression analysis assessed the effect of diabetes status on RDW_SD and RDW_CV after adjusting for age. For RDW_SD, the regression equation was:

RDW_SD = 40.723 – 0.409 (Diabetes) + 0.024 (Age)

This model showed no statistically significant effect of diabetes status ($p = 0.555$) or age ($p = 0.264$) on RDW_SD. For RDW_CV, the regression equation was:

RDW_CV = 14.227 + 0.811 (Diabetes) – 0.016 (Age)

In this model, diabetes status was a significant predictor ($p = 0.046$), indicating that individuals with diabetes had, on average, RDW_CV values higher by 0.811 units compared to non-diabetics after controlling for age. Age was not a significant predictor of RDW_CV ($p = 0.206$).

Overall, the results suggest that diabetes is associated with higher RDW_CV independent of age, while no significant association was found between diabetes and RDW_SD.

The results indicate that diabetes status is significantly associated with an increase in RDW_CV, but not with RDW_SD, after controlling for the effect of age. This suggests that RDW_CV may be more sensitive to diabetes-related changes. The lack of a significant age effect could be due to the fact that variations in RDW are more influenced by disease status than by age in the studied sample.

1.3.2. Exploring if RDW (whether RDW_CV or RDW_SD) can be used as a biological marker to predict diabetes status

Table 4.15. Logistic Regression Analysis – Predicting Diabetes

Variable	B	S.E.	Wald	Df	Sig.	Exp (B)
RDW_SD	-0.022	0.043	0.262	1	0.609	0.978
RDW_CV	0.141	0.090	2.491	1	0.115	1.152
Constant	- 1.036	1.884	0.303	1	0.582	0.355

The logistic regression model testing the effect of the variables RDW_SD and RDW_CV on the presence of diabetes shows a weak predictive ability. In the "Variables in the Equation" table, neither variable had a statistically significant effect. The regression coefficient for RDW_SD was -0.022 with a p-value of 0.609, indicating non-significance, while the coefficient for RDW_CV was positive (0.141) with a p-value of 0.115, also non-significant.

The odds ratio (Exp (B)) for RDW_CV was 1.152, suggesting a weak and non-significant positive association with the likelihood of having diabetes.

In summary, the variables RDW_SD and RDW_CV do not show statistically significant predictive effects for the presence of diabetes in this sample.

This indicates that RDW, whether RDW_CV or RDW_SD, cannot be considered an effective biological marker for predicting.

Diabetes status in this study. Based on the current results, we conclude that RDW is not a suitable variable to be used as a biological marker for diagnosing or predicting diabetes in this sample.

1.3.3. Effect of Insulin and Metformin Treatments on Red Cell Distribution Width (RDW)

Table 1.16. ROC Curve Results for RDW Parameters

Variable	Treatment Group	N	Mean Rank	Mann-Whitney U	Z	p-value (2-tailed)
RDW_SD	Insulin	32	39.50	736.00	-0.314	0.753
	Metformin	48	41.17			
RDW_CV	Insulin	32	38.94	718.00	-0.491	0.623
	Metformin	48	41.54			

The Mann-Whitney U test was conducted to examine the effect of treatment type (Insulin vs. Metformin) on RDW_SD and RDW_CV values. The results showed no statistically significant differences between the two treatment groups for RDW_SD (U = 736.00, Z = -0.314, p = 0.753) or RDW_CV (U = 718.00, Z = -0.491, p = 0.623). Although the Metformin group had slightly higher mean ranks compared to the Insulin group for both RDW measures, these differences were not significant. Therefore, it can be concluded that the type of treatment (Insulin or Metformin) does not have a significant impact on RDW values in the studied sample- RDW_SD and RDW_CV Levels in Type 1 and Type 2 Diabetes: A Comparative Analysis.

Table 1.17. Comparison of RDW by Treatment Type

Variable	Diabetes Type	N	Mean Rank	Mann-Whitney U	Z	p-value (2-tailed)
RDW_SD	Type 1	19	35.71	488.5	-0.838	0.402
	Type 2	59	40.72			
RDW_CV	Type 1	19	37.37	520.0	-0.472	0.637
	Type 2	59	40.19			

The study compared RDW_SD and RDW_CV values between patients with Type 1 (n=19) and Type 2 diabetes (n=59). The mean ranks of both RDW_SD and RDW_CV were slightly higher in Type 2 patients compared to Type 1, indicating a small difference between the groups. However, the p-values for both variables (0.402 for RDW_SD and 0.637 for RDW_CV) were greater than the conventional significance level of 0.05, suggesting that these differences are not statistically significant. Therefore, there is no sufficient evidence to conclude that RDW_SD or RDW_CV differs between Type 1 and Type 2 diabetes patients in this sample.

Correlation Between RDW Parameters, Lipid Profile, and HbA1C Levels

Table 1.18. Comparison of RDW in Type 1 vs. Type 2 Diabetes

Correlations					
			HDL (mg/dl)	**Cholesterol (mg/dl)**	**Triglycerides (mg/dl)**
Spearman's rho	**RWD_SD**	Correlation Coefficient	-0.020	0.139	-0.063
		Sig. (2-tailed)	0.805	0.079	0.431
		N	160	160	160
	RDW_CV	Correlation Coefficient	-0.018	0.142	0.055
		Sig. (2-tailed)	0.825	0.072	0.491
		N	160	160	160
	HbA1C(%)	Correlation Coefficient	0.056	0.243*	0.294*
		Sig. (2-tailed)	0.486	0.002	0.000
		N	160	160	160

The Spearman's correlation analysis revealed that HbA1C (%) was significantly and positively correlated with cholesterol ($\rho = 0.243$, $p = 0.002$) and triglycerides ($\rho = 0.294$, $p < 0.001$), indicating that higher HbA1C levels were associated with increased cholesterol and triglyceride levels. No significant correlations were observed between HbA1C and HDL ($p = 0.486$).

Similarly, neither RDW_SD nor RDW_CV demonstrated significant correlations with HDL, cholesterol, or triglycerides (all $p > 0.05$), suggesting no meaningful association between these red cell indices and lipid parameters in this sample.

A. Correlation Between RDW Parameters and Glycaemic and Inflammatory Markers

Table 1.19. Correlation Between RDW and Other Variables

Correlations				
			HbA1C(%)	**FBS(mg/dl) WBC**
Spearman's rho	**RWD_SD**	Correlation Coefficient	0.022	0.063
		Sig. (2-tailed)	0.784	0.426
		N	160	160
	RDW_CV	Correlation Coefficient	0.026	0.029
		Sig. (2-tailed)	0.748	0.714
		N	160	160

The results indicate that there is a very weak and statistically non-significant correlation between RDW_SD and RDW_CV on one side and HbA1C and FBS on the other. The Spearman's rho values were close to zero (RDW_SD with HbA1C = 0.022, with FBS = 0.063; RDW_CV with HbA1C = 0.026, with FBS = 0.029), with high p-values (all above 0.05), suggesting no meaningful statistical relationship between these variables.

Table 1.20. Correlation Between RDW Parameters, HbA1C, Physical Activity, and Eating Habits

Correlations				
			Physical Activities	**Eating habits**
Spearman's rho	**RWD_SD**	Correlation Coefficient	-0.028	0.036
		Sig. (2-tailed)	0.728	0.653
		N	160	160
	RDW_CV	Correlation Coefficient	0.059	0.051
		Sig. (2-tailed)	0.461	0.525
		N	160	160
	HbA1C (%)	Correlation Coefficient	-0.196*	0.073
		Sig. (2-tailed)	0.013	0.357
		N	160	160

The Spearman's rho correlation analysis showed no statistically significant associations between RDW_SD or RDW_CV and physical activity or eating habits, as all p-values exceeded 0.05. Specifically, RDW_SD demonstrated negligible correlations with physical activity ($r = -0.028$, $p = 0.728$) and eating habits ($r = 0.036$, $p = 0.653$), while RDW_CV showed similarly weak correlations with physical activity ($r = 0.059$, $p = 0.461$) and eating habits ($r = 0.051$, $p = 0.525$). However, a weak but statistically significant negative correlation was observed between HbA1C and physical activity ($r = -0.196$, $p = 0.013$), suggesting that higher levels of physical activity may be associated with slightly lower HbA1C values. No significant correlation was found between HbA1C and eating habits ($r = 0.073$, $p = 0.357$).

1.4 ROC Curve

1.4.1- Sensitivity and Specificity of RDW

The sensitivity of RDW (Red Cell Distribution Width) refers to its ability to correctly identify patients who have the condition (true positive rate). It measures how effectively RDW detects those with the disease. The specificity of RDW refers to its ability to correctly identify patients who do not have the condition (true negative rate). It measures how effectively RDW excludes those without the disease. In clinical diagnostics, evaluating both sensitivity and specificity is crucial to determine the accuracy and reliability of RDW as a biomarker for the targeted disease.

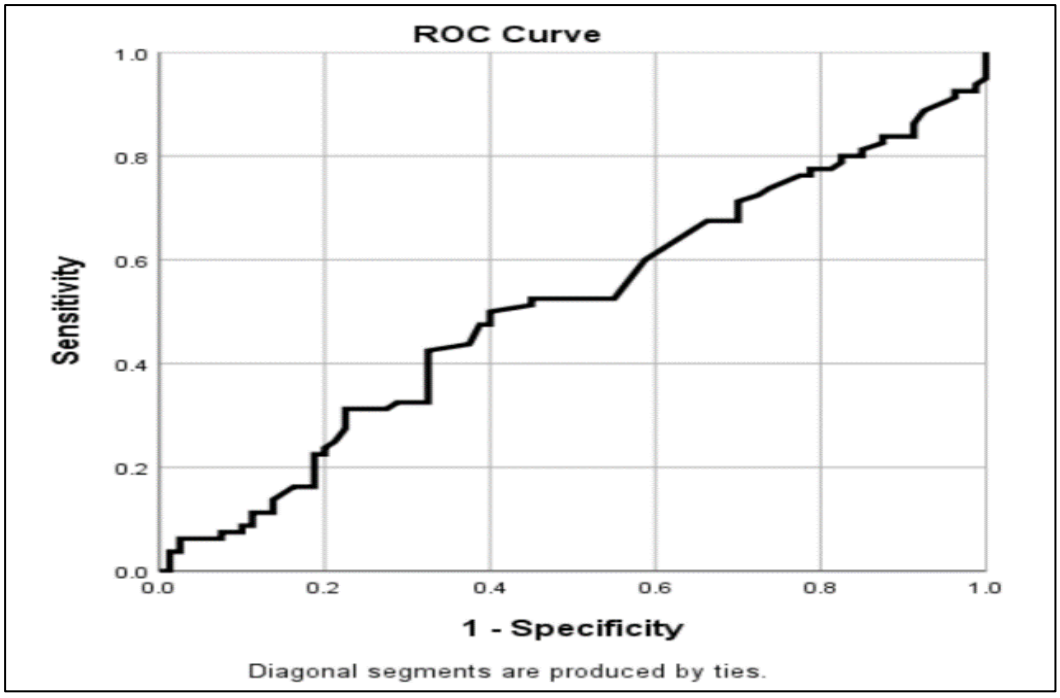

Figure 1.11. Sensitivity and Specificity of RDW_SD

Table 1.21. Area under the curve (AUC)

Test Result Variable(s): RDW_SD	
Area	**0.509**

The Area Under the Curve (AUC) is 0.509, which is very close to 0.5. This indicates that the ability of the variable RDW_SD to distinguish between individuals with and without diabetes is very weak or equivalent to random chance.

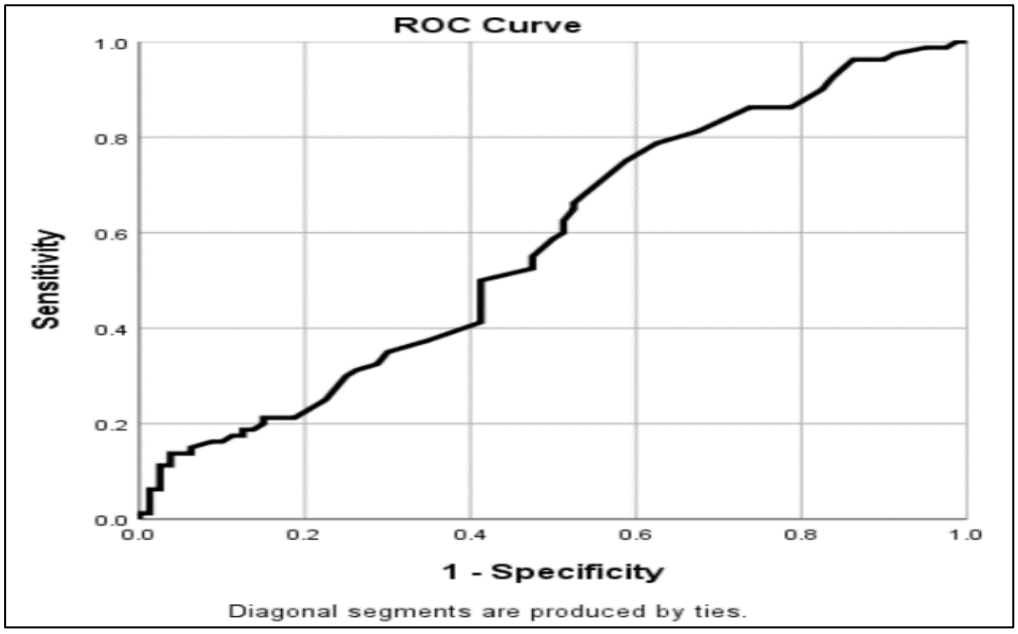

Figure 1.12. Sensitivity and Specificity of RDW_CV

Table 1.22. (AUC) Area under the curve

Test Result Variable(s): RDW_CV	
Area	**0.576**

An AUC value of 0.576 means that the variable used has a very weak ability to distinguish between affected and non-affected cases, as the value is very close to 0.5, which represents random performance.

This indicates that the variable is not effective as a diagnostic or predictive marker on its own, and it is advisable to consider using other variables or improving the model to increase its accuracy.

DISCUSSION

This study involved a total of 160 participants (80 diabetics and 80 non-diabetics), and was conducted in Tarhuna, Libya. The purpose was to compare red cell distribution width (RDW) and other hematological parameters between diabetic (DM) and non-diabetic (NDM) individuals. The analysis focused on RDW-SD, RDW-CV, HbA1c, FBS, and various complete blood count (CBC) indices using standard laboratory methods.

Our study showed that HbA1c and FBS levels were significantly elevated in diabetic participants compared to non-diabetics ($p < 0.001$), which aligns strongly with findings from Wang et al. (2020), Shirali et al. (2019), and Nada (2015). These studies also emphasized elevated HbA1c and FBS in diabetic patients, supporting the hyperglycemic status associated with

Additionally, the current study confirmed that PLT count was significantly higher in diabetic individuals ($p = 0.020$), which is consistent with Hassan et al. (2023), who also reported increased platelet activity in diabetics. However, other CBC parameters such as WBC, RBC, HGB, HCT, MCV, and MCH showed no statistically significant differences, which differs slightly from Alkout et al. (2020), who found MCV to be significantly higher in non-diabetics. Our findings also differ from Nada (2015), where other CBC indices showed significant variation between groups.

Crucially, the values of RDW-SD and RDW-CV in our study showed no significant difference between DM and NDM groups ($p = 0.915$ and $p = 0.108$ respectively), and both remained within normal reference ranges. This contrasts with the findings of Nada (2015), Devakoti & Rao (2020), and Hassan (2023), all of whom observed significantly elevated RDW in diabetic patients. Nada, in particular, highlighted higher RDW among those with poor glycemic control, suggesting its role as an inflammatory marker in uncontrolled diabetes.

When analyzing RDW values based on HbA1c control (controlled vs. uncontrolled), our results showed no significant variation in RDW-SD or RDW-CV. This contradicts Nada (2015) and Devakoti & Rao (2020), who found RDW to be significantly higher in patients with HbA1c > 7%.

Similarly, our results found no relationship between diabetes duration and RDW, consistent with Cakir et al. (2014), who reported no difference in RDW levels based on diabetes duration or HbA1c control.

In the regression analysis, diabetes status was associated with a slight increase in RDW-CV ($p = 0.046$), but RDW-SD showed no significant association.

ROC analysis confirmed the limited predictive power of RDW, with AUC values of 0.576 (RDW-CV) and 0.509 (RDW-SD), suggesting that RDW is not a reliable biomarker for diagnosing diabetes. These results challenge those of Wang et al. (2020), Shirali et al. (2019), and Engström et al. (2014), who proposed RDW as a possible predictive marker for diabetes or its complications. The absence of significant elevation in RDW in our diabetic sample may be due to the relatively short disease duration in many participants or the absence of severe complications such as nephropathy, which was not assessed in this study. In contrast, several of the aforementioned studies involved participants with known diabetic complications, which may explain the elevated RDW values they observed.

Lastly, treatment type (insulin vs. metformin) and diabetes type (Type 1 vs. Type 2) showed no significant effect on RDW levels in our study.

This further supports the idea that RDW may not be a sensitive indicator for disease progression or treatment response in uncomplicated diabetes, contrasting with studies that found RDW to be influenced by disease severity and control.

Finally, our study aligns with some of the literature regarding elevated glycemic markers and platelet count in diabetics but contradicts much of the evidence supporting RDW as a diagnostic or prognostic tool. These discrepancies underscore the importance of considering population characteristics, comorbidities, and study design when interpreting RDW values in the context of diabetes.

CONCLUSION

In this study, no statistically significant difference was found in RDW-SD or RDW-CV between diabetic and non-diabetic individuals. Although regression analysis suggested a potential link between RDW-CV and diabetes status, the weak performance in predictive models and ROC analysis limits the clinical utility of RDW as a diagnostic or prognostic biomarker.

RECOMMENDATIONS

1. Further studies with larger, more diverse populations and longitudinal designs are recommended to validate the role of RDW in diabetes detection and monitoring.
2. RDW should be studied alongside other inflammatory and haematological markers to improve diagnostic accuracy.
3. Future research should control for confounders such as medications, anaemia, nutritional status, and comorbidities.
4. Awareness and education about the significance of early diabetes indicators are essential, particularly in low-resource settings.

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