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RESEARCH ARTICLE **MEDICAL MICROBIOLOGY**

Study of Some Haematological and Biochemical Parameters in Diabetic and Non-Diabetic Individuals in Western Libya: A Cross-Sectional Study

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ABSTRACT

Background: Diabetes mellitus (DM) is a major global public health concern, characterised primarily by persistent hyperglycaemia that contributes to chronic vascular complications. Emerging evidence suggests that DM may also be associated with haematological alterations; however, findings remain inconsistent. **Objective:** To evaluate selected haematological parameters in individuals with DM in Western Libya in comparison with non-diabetic controls. **Methods:** A cross-sectional analytical study was conducted between November 2024 and May 2025 in three clinical laboratories in Al-Zintan, Abu Salim, and Al Rayina. The study included 444 participants: 222 patients with DM (72 males, 150 females) and 222 non-diabetic controls (62 males, 160 females). Venous blood samples were analysed for haemoglobin (HGB), red blood cell count (RBC), white blood cell count (WBC), and platelet count (PLT), together with fasting blood glucose (FBG) and glycated haemoglobin (HbA1c). Groups were compared using independent-samples t-tests in SPSS. **Results:** Values are mean ± SE. Diabetic participants had significantly higher FBG (179.88 ± 5.15 mg/dL) and HbA1c (8.06 ± 0.10%) than controls (99.27 ± 1.45 mg/dL and 5.31 ± 0.03%; $p < 0.001$). Platelet count was modestly but significantly lower in diabetic participants (268.05 ± 6.28 × 10^9/L) than in controls (288.10 ± 6.51 × 10^9/L; $p = 0.027$). HGB, RBC, and WBC did not differ significantly between the groups. Among diabetic participants, males had higher HGB than females ($p = 0.002$), and those aged ≥40 years had higher HbA1c and FBG than younger participants ($p < 0.001$). **Conclusion:** In this sample, DM was associated with a slightly lower platelet count, whereas HGB, RBC, and WBC did not differ significantly from controls. The higher HGB in males is consistent with known physiological sex differences, and older age was associated with poorer glycaemic indices. These cross-sectional associations require confirmation in larger studies that account for glycaemic control, disease duration, treatment, and comorbidities.

دراسة بعض المؤشرات الدموية والبيوكيميائية لدى الأفراد المصابين بالسكري وغير المصابين به في غرب ليبيا: دراسة مقطعية

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الكلمات المفتاحية

داء السكري
المؤشرات الدموية
الصفائح الدموية
المنطقة الغربية
ليبيا

الملخص

الخلفية:يعد مرض الداء السكري من أبرز المشكلات الصحية العالمية، ويتميز بفرط سكر الدم المزمن، مما يؤدي إلى تطور مضاعفات وعائية كبيرة وصغيرة على المدى الطويل. وتكتسب دراسة التغيرات الدموية المصاحبة للسكري أهمية متزايدة لفهم آليات حدوث هذه المضاعفات بشكل أدق.

الهدف: تهدف هذه الدراسة إلى تحليل مجموعة من المؤشرات الدموية لدى مرضى السكري في المنطقة الغربية من ليبيا، ومقارنتها مع مجموعة ضابطة من غير المصابين.

الطرق: أُجريت دراسة مقطعية شملت 444 مشاركاً، منهم 222 مريضاً بداء السكري (72 ذكراً و150 أنثى)، و222 فرداً من الأصحاء كمجموعة ضابطة (62 ذكراً و160 أنثى). تم جمع عينات دم وريدي من المشاركين في ثلاث مختبرات طبية: مركز الغدد الصماء والسكري بالزنتان، المركز الليبي للمختبرات في أبو سليم، ومختبر الإتقان بالرياينة. تم تحليل العينات لقياس تركيز خضاب الدم(HGB) ، وعدد خلايا الدم الحمراء(RBC) ، وخلايا الدم البيضاء(WBC) ، والصفائح الدموية .(PLT) أُجريت التحليلات الإحصائية باستخدام برنامج SPSS .

النتائج: أظهرت النتائج ارتفاعاً معنوياً في متوسط سكر الدم الصائم (179.88 ± 5.15 ملغم/ديسيلتر) ومستوى الهيموجلوبين السكري (HbA1c)(8.06±0.10) لدى مرضى السكري مقارنةً بالمجموعة الضابطة (P<0.001) .كما لوحظ انخفاض طفيف في عدد الصفائح الدموية لدى المرضى (268.05 ± 6.28 × 10^9/لتر) و (288.10 ± 6.51 × 10^9/لتر) مقارنة بالأصحاء على التوالي .(p = 0.027) لم تُسجَّل فروق معنوية في مستويات الهيموجلوبين (HGB)وعدد الخلايا الحمراء (RBC)وعدد الخلايا البيضاء (WBC) بين المجموعتين. ومع ذلك، أظهر الذكور من مرضى السكري مستويات أعلى في مستوى الهيموجلوبين

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مقارنة بالإناث .(p = 0.002) كما ارتبط التقدم في العمر لدى مرضى السكري بارتفاع مستويات HbA1c وسكر الدم الصائم بشكل ملحوظ.(p < 0.001)

الاستنتاج: تشير نتائج الدراسة إلى وجود انخفاض طفيف في عدد الصفائح الدموية لدى مرضى السكري، في حين لم تختلف باقي المؤشرات الدموية (HGB وRBC وWBC) معنوياً عن المجموعة الضابطة. كما جاءت الفروق بين الجنسين في تركيز خضاب الدم متسقة مع الفروق الفسيولوجية المعروفة، وارتبط العمر المتقدم بزيادة اضطراب تنظيم الجلوكوز. وتحتاج دلالة هذا الفرق الطفيف في الصفائح الدموية إلى تأكيدها في دراسات أوسع تأخذ في الحسبان مستوى ضبط السكر ومدة المرض والأمراض المصاحبة.

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterised by persistent hyperglycaemia resulting from defects in insulin secretion, insulin action, or both [1]. The global burden of diabetes has risen dramatically: the number of adults living with diabetes increased from approximately 200 million in 1990 to nearly 830 million in 2022, with the steepest rise in low- and middle-income countries [2]. The rising prevalence of diabetes, most of it type 2 diabetes mellitus (T2DM), places a substantial burden on health systems and on the quality of life of millions of people worldwide [3], underscoring the need for further clinical and laboratory assessment of the disease and its complications. Chronic hyperglycaemia contributes to a range of physiological disturbances, including altered vasodilation, dysregulated inflammatory responses, and modifications in haematological parameters [4].

Effective diabetes management relies on achieving stable glycaemic control through both pharmacological and lifestyle strategies. Biomarkers such as glycated haemoglobin (HbA1c) and fasting blood glucose (FBG) are essential tools for assessing glycaemic status over long and short periods, respectively. Elevated HbA1c is associated with an increased likelihood of long-term complications, including retinopathy, nephropathy, and neuropathy [5]. Recent Libyan studies have likewise examined glycaemic control in relation to atherogenic risk and microalbuminuria among patients with diabetes [6,7].

Beyond glycaemic markers, haematological parameters commonly assessed in clinical practice, such as haematocrit (Hct) and white blood cell count (WBC), have been associated in multiple studies with the development of T2DM and insulin resistance across diverse populations. These associations suggest a potential role for haematological indices in the pathophysiological mechanisms underlying metabolic disorders [8,9].

In a cross-sectional study at the Endocrinology and Diabetes Center in Al-Zintan, Libya, 99 diabetic and 45 non-diabetic participants were examined for ABO and Rhesus (Rh) blood-group distribution, and no significant association between blood group and diabetes mellitus was found [10]. A recent systematic review of national evidence likewise found that the association between ABO/Rh blood groups and diabetes mellitus in Libya remains inconsistent and inconclusive [11]. These findings argue for cautious interpretation of blood-group distributions and highlight the need to examine other routinely measured haematological indices in Libyan patients with diabetes.

Taken together, these observations highlight the need for region-specific evidence on how diabetes affects routinely measured haematological indices, particularly in Libyan populations, where such data remain limited. This study therefore aimed to evaluate alterations in selected haematological parameters among individuals with diabetes mellitus and to compare them with those of non-diabetic controls, in order to improve understanding of diabetes-associated haematological changes and their potential clinical implications.

Methodology

Study Design and Setting

A cross-sectional study was carried out between November 2024 and May 2025 at three clinical laboratory sites in Western Libya: The Endocrinology and Diabetes Center in Al-Zintan, the Libyan Center Laboratory in Abu Salim, and the Al-Itqan Laboratory in Al Rayina. These facilities provided the infrastructure for participant recruitment, sample collection, and haematological analysis.

Participants

Participants were selected randomly. The study enrolled 444 individuals: 222 patients clinically diagnosed with diabetes mellitus and 222 apparently healthy subjects who served as the control group. The diabetic group comprised 72 males and 150 females, and the control group comprised 62 males and 160 females; the sex distribution did not differ significantly between the groups ($\chi^2 = 1.07$, df = 1, $p = 0.30$). Participant ages ranged from 10 to 90 years.

Sample Collection and Laboratory Analysis

A 5 mL sample of venous blood was collected from each participant into ethylenediaminetetraacetic acid (EDTA) tubes to prevent coagulation. Haematological parameters, namely haemoglobin concentration (HGB), red blood cell count (RBC), white blood cell count (WBC), and platelet count (PLT), were measured using a Sysmex XP-300 automated haematology analyser. Fasting blood glucose (FBG) was determined by standard spectrophotometric methods, and glycated haemoglobin (HbA1c) was measured using the Afinion™ 2 point-of-care analyser. Participants were screened by FBG measurement, and those without diabetes formed the control group.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. All participants were thoroughly informed about the study's objectives, procedures, and potential risks and benefits. Participants were assured that their participation was entirely voluntary and that they had the right to withdraw from the study at any time without affecting their medical care. All patient data were anonymised and handled with strict confidentiality.

Statistical Analysis

Data were analysed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA), version 2021. Continuous variables are presented as mean ± standard error of the mean (SEM). Groups were compared using independent-samples t-tests for continuous variables and chi-square (χ^2) tests for categorical variables. A two-sided p-value of less than 0.05 was considered statistically significant.

Results

A total of 444 participants were included: 222 individuals with diabetes mellitus (72 males and 150 females) and 222 apparently healthy controls (62 males and 160 females), aged

10 to 90 years.

Table 1 compares the glycaemic markers of diabetic participants and controls. Mean fasting blood glucose (FBG) was markedly higher in the diabetic group (179.88 ± 5.15 mg/dL) than in the control group (99.27 ± 1.45 mg/dL). Similarly, mean glycated haemoglobin (HbA1c) was higher in diabetic participants (8.06 ± 0.10%) than in non-diabetic participants (5.31 ± 0.03%). Independent-samples t-tests gave t = 15.03 for FBG and t = 24.79 for HbA1c (both $p < 0.001$).

Table 1: Comparison of biochemical parameters between patients and controls (mean ± SE)

	Mean ± SE	
Group	**HbA1c (%)**	**FBG (mg/dL)**
Patients	8.06 ± 0.10	179.88 ± 5.15
Control	5.31 ± 0.03	99.27 ± 1.45
t-value	24.79	15.03
P-value	<0.001	<0.001

Differences between patients and controls were statistically significant for both parameters ($p < 0.001$; independent-samples t-test).

Table 2 compares the haematological indices of the two groups. HGB did not differ significantly between diabetic participants and controls (12.97 ± 0.15 vs 13.00 ± 0.53 g/dL; $p = 0.94$). Platelet count (PLT), however, was significantly lower in diabetic participants (268.05 ± 6.28 × 10^9/L) than in controls (288.10 ± 6.51 × 10^9/L; $p = 0.027$), a difference of about 7%.

RBC count was slightly lower in diabetic participants (4.70 ± 0.04 × 10^{12}/L) than in controls (5.36 ± 0.80 × 10^{12}/L), but the difference was not statistically significant ($p = 0.418$). WBC counts were comparable between groups (7.52 ± 0.17 × 10^9/L in diabetic participants vs 7.63 ± 0.19 × 10^9/L in controls; $p = 0.67$).

Table 2: Comparison of haematological parameters between the diabetic and control groups (mean ± SE)

Parameter	Diabetic group (n=222) (72 males and 150 females)	Control group (n= 222) (62 males and 160 females)	P-value
HGB (g/dL)	0.15 ± 12.97	13.00 ± 0.53	**0.94**
PLT (×10^9/L)	268.05 ± 6.28	288.10 ± 6.51	**0.027**
RBC (×10^{12}/L)	4.70 ± 0.04	5.36 ± 0.80	**0.418**
WBC (×10^9/L)	7.52 ± 0.17	7.63 ± 0.19	**0.67**

Table 3 compares male and female participants with diabetes. No significant differences were found in HbA1c or FBG, indicating similar glycaemic control in the two sexes. HGB, however, was significantly higher in males than in females (14.25 ± 0.20 vs 12.44 ± 0.38 g/dL; $p = 0.002$), consistent with known physiological differences in iron metabolism and erythropoietic activity. No significant sex differences were found in PLT, RBC, or WBC.

Table 4 compares diabetic participants younger than 40 years with those aged 40 years and above. Participants aged ≥40 years had significantly higher HbA1c (7.06 ± 0.10 vs 6.15 ± 0.13%; $p < 0.001$) and FBG (154.67 ± 4.51 vs 118.44 ± 4.29 mg/dL; $p < 0.001$). This association between older age and poorer glycaemic indices is consistent with age-related changes in glucose metabolism, although causality cannot be inferred from cross-sectional data.

Table 3: Comparison of haematological and biochemical parameters between male and female diabetic participants (mean ± SE)

	Mean ± SE		
Parameter	**Male (n = 72)**	**Female (n = 150)**	**P-value**
HbA1c (%)	6.90 ± 0.15	6.59 ± 0.10	**0.09**
FBG (mg/dL)	146.62 ± 6.49	136.53 ± 3.78	**0.16**
HGB (g/dL)	14.25 ± 0.20	12.44 ± 0.38	**0.002**
PLT (×10^9/L)	271.64 ± 9.13	280.85 ± 5.18	**0.35**
RBC (×10^{12}/L)	4.99 ± 0.05	5.05 ± 0.58	**0.94**
WBC (×10^9/L)	7.56 ± 0.26	7.59 ± 0.10	**0.90**

In contrast, no significant differences between the age groups were observed in HGB ($p = 0.745$), PLT ($p = 0.443$), RBC ($p = 0.277$), or WBC ($p = 0.333$). No age-related difference in these haematological parameters was therefore detected in this sample.

Table 4: Haematological and biochemical parameters by age group among diabetic participants (mean ± SE)

	Mean ± SE		
Parameter	Age < 40 **(n=56) (16 males and 40 females)**	Age ≥ 40 **(n=166) (56 males and 110 females)**	**P-value**
HbA1c (%)	6.15 ± 0.13	7.06 ± 0.10	<0.001
FBG (mg/dL)	118.44 ± 4.29	154.67 ± 4.51	<0.001
HGB (g/dL)	13.09 ± 0.63	12.91 ± 0.14	0.745
PLT (×10^9/L)	282.20 ± 7.06	275.12 ± 5.94	0.443
RBC (×10^{12}/L)	5.55 ± 0.97	4.66 ± 0.39	0.277
WBC (×10^9/L)	7.73 ± 0.17	7.47 ± 0.19	0.333

Discussion

This study examined glycaemic and haematological parameters in diabetic participants and controls, as well as differences by sex and age within the diabetic group. The principal findings were that diabetic participants had significantly lower platelet counts than controls, whereas haemoglobin (HGB), red blood cell count (RBC), and white blood cell count (WBC) did not differ significantly between groups; that, among diabetic participants, males had higher HGB than females; that diabetic participants aged ≥40 years had higher fasting blood glucose (FBG) and glycated haemoglobin (HbA1c) than younger diabetic participants; and that the haematological indices examined did not differ significantly by age. These findings are interpreted below in relation to previous evidence and the study's design.

Diabetic participants had higher FBG (179.88 ± 5.15 mg/dL) and HbA1c (8.06 ± 0.10%) than controls (99.27 ± 1.45 mg/dL and 5.31 ± 0.03%, respectively; $p < 0.001$), consistent with impaired glycaemic regulation in the diabetic group. The mean HbA1c in this study lies within the range of mean values reported in several Libyan cohorts (approximately 7.6–9.6%). Khagkhag and Bousayf (2025) found that 68.3% of participants with type 2 diabetes mellitus (T2DM) in Derna had HbA1c above the recommended threshold of <7.0%, with a mean of 8.3 ± 2.1% and a positive correlation between HbA1c and fasting blood glucose (FBG) ($r = 0.72$) [12]. Mosbah et al. (2025) reported higher HbA1c (9.16 ± 1.70%) and FBG (164.1 ± 63.06 mg/dL) among diabetic males attending Brack Al-Shatti Hospital than among controls [13]. Abubaker and Eshnaf (2025) reported a mean

HbA1c of 9.60 ± 1.68% in Sebha [7], while Mabrouk and Yhmed (2025) reported mean HbA1c values of 7.59 ± 1.52% in females and 7.77 ± 1.74% in males in Benghazi [6]. In Tripoli, only 21.8% of 523 patients with T2DM achieved an HbA1c target of <7.0%, and the mean HbA1c was 8.9 ± 2.1% [14]. Taken together, these studies indicate that suboptimal glycaemic control has been reported across several Libyan settings, although differences in study populations and methods should be considered when comparing estimates.

Diabetic participants aged ≥40 years had higher FBG and HbA1c than younger diabetic participants ($p < 0.001$). Age-related changes in body composition, physical activity, insulin sensitivity, and β-cell function may contribute to this pattern, but these mechanisms were not measured in the present study and cannot be confirmed from cross-sectional data. The finding is consistent with reports of a positive relationship between age and HbA1c in Libyan cohorts [6,12,13]. In contrast, HGB, platelet count, RBC, and WBC did not differ significantly across age groups. Similar stability of haematological measures has been reported in other Libyan studies [13], although age-related changes have also been described [15].

The platelet count was lower in diabetic participants (268.05 ± 6.28 × 10^9/L) than in controls (288.10 ± 6.51 × 10^9/L; $p = 0.027$), a difference of about 7%, with both group means lying within the commonly used reference range (150–450 × 10^9/L). Previous research has described altered platelet function and activation in diabetes [16,17], and a systematic review and meta-analysis by Bambo et al. (2024), including 22 studies and 14,041 participants, reported alterations in several haematological parameters among people with type 1 and type 2 diabetes [18]. However, findings for platelet count itself have been inconsistent: a meta-analysis reported higher mean platelet volume and platelet distribution width, but no overall difference in platelet count, in T2DM [19]. Differences in glycaemic control, disease duration, comorbidities, and complication profiles may contribute to this variation. The present finding is an association with platelet count; it does not by itself demonstrate increased platelet activation or a higher risk of vascular events, and the mechanisms underlying the observed difference cannot be determined from this cross-sectional study.

HGB, RBC, and WBC did not differ significantly between diabetic participants and controls. This is consistent with studies from Libya and Ethiopia reporting limited or no differences in selected haematological parameters [13,20]. In Brack Al-Shatti, Mosbah et al. (2025) likewise found no significant differences in RBC, HGB, or haematocrit (HCT) between diabetic and control groups [13], while Al-Salhen and Mahmoud (2017) reported comparatively modest haematological changes among diabetic patients in El-Beida [15]. In contrast, the meta-analysis by Bambo et al. (2024) found lower RBC parameters in people with T2DM and lower haemoglobin and HCT in people with T1DM than in controls [18]. A systematic review of anaemia in diabetes in Africa also reported a substantial pooled prevalence of anaemia [21]. The difference between these results and the present study may relate to variation in population characteristics, diabetes type, disease duration, glycaemic control, comorbidities, or study methods; the current data do not establish which explanation is most likely.

Among diabetic participants, males had significantly higher HGB than females ($p = 0.002$). This is consistent with established physiological differences in erythropoiesis and iron balance. A reference-interval study in southwest Ethiopia likewise reported lower haemoglobin in females across age groups, which was attributed in part to menstrual iron loss and androgen-related stimulation of erythropoietin production [22]. Sex-specific reference intervals should therefore be considered when interpreting haemoglobin values. No significant sex differences were observed in FBG or HbA1c in the present cohort. This agrees with Khagkhag and Bousayf (2025), who reported comparable glycaemic control between sexes in Derna [12], and Mabrouk and Yhmed (2025), who found no significant sex difference in HbA1c in Benghazi [6]. By contrast, the Tripoli study by Ashur et al. (2016) found that females had higher odds of uncontrolled glycaemic control (OR = 1.74, 95% CI: 1.03–2.91) [14]. These differences suggest that sex-related glycaemic patterns may vary between populations and warrant further investigation.

The findings sit within a wider Libyan literature describing coexisting metabolic and clinical disturbances in diabetes. In addition to reports of suboptimal glycaemic control [6,7,12–14], studies have described dyslipidaemia in Derna and an association between HbA1c and the Atherogenic Index of Plasma in Benghazi [6,12]. Almajdoub et al. (2023) reported an association between elevated copper and copper-to-zinc ratios and insulin resistance in Brack Al-Shatti [23]. Abubaker and Eshnaf (2025) reported a negative correlation between serum magnesium and microalbuminuria in Sebha [7], while Mosbah et al. (2025) described reduced estimated glomerular filtration rate (eGFR) and elevated urea, creatinine, and microalbuminuria among diabetic males [13]. Collectively, these studies support assessing diabetes within a broader clinical and laboratory picture. They do not, however, establish that any single haematological result can substitute for established glycaemic, renal, or cardiovascular assessment.

The lower platelet count observed in the diabetic group is compatible with including the complete blood count as one component of routine clinical assessment. Because this study did not evaluate platelet function, platelet indices as vascular-risk predictors, or subsequent vascular outcomes, the platelet-count difference should not be interpreted as a validated vascular-risk marker. The higher FBG and HbA1c in diabetic participants aged ≥40 years suggest that glycaemic status deserves particular attention in this age group in the studied population, while the absence of a significant age difference in haematological indices indicates that age-group-specific changes in those measures were not demonstrated here. The sex difference in HGB reinforces the need to interpret haemoglobin using appropriate sex-specific reference intervals. At the health-system level, the findings are consistent with the need for accessible biochemical and haematological monitoring alongside established diabetes-care assessments. The broader Libyan evidence of suboptimal glycaemic control [6,12–14] supports continued attention to access to laboratory testing and effective diabetes management.

Strengths and Limitations

Strengths of this study include its relatively large sample (444 participants) recruited from three laboratories in Western Libya and the combined assessment of glycaemic and haematological measures. Several limitations should be considered. First, the cross-sectional design precludes causal inference. Second, type 1 and type 2 diabetes were not

distinguished, and the age range (10–90 years) included children and adolescents, for whom haemoglobin and platelet reference values differ from those of adults. Third, disease duration, treatment (for example, metformin or antiplatelet agents), comorbidities, lifestyle, and iron or nutritional status were not evaluated, and no multivariable adjustment was performed. Fourth, inflammatory markers (for example, ESR and CRP) and platelet indices (for example, MPV and PDW) were not measured. Fifth, several comparisons were made without correction for multiple testing, so the modest platelet-count difference ($p = 0.027$) should be interpreted cautiously. Finally, recruitment from three laboratories limits generalisability to the wider Western Libyan population.

Conclusion

In this sample from Western Libya, diabetes mellitus was associated with a modestly lower platelet count, whereas HGB, RBC, and WBC did not differ significantly between diabetic participants and controls. Among diabetic participants, males had higher HGB than females, consistent with expected physiological differences, and those aged 40 years and above had higher HbA1c and FBG than younger participants. Because of the cross-sectional design and the limitations noted above, these findings should be regarded as associations. Larger studies that account for diabetes type, glycaemic control, disease duration, treatment, and comorbidities are needed to determine whether the platelet difference has clinical relevance.

Author Contributions: Ali and **Mohammed** participated in all stages of the study, including data collection, statistical analysis, and interpretation of the results. They reviewed the analysis and drafted the manuscript. **Abubakeer** supervised the research and edited the manuscript. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that they have no financial, personal, or professional conflicts of interest.

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Data Availability Statement: The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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