ASSESSING THE CORRELATION BETWEEN HBA1C LEVELS AND C-REACTIVE PROTEIN (CRP) IN PATIENTS AT KHAMIS MUSHAIT GENERAL HOSPITAL: A CROSS-SECTIONAL STUDY

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Abstract

Introduction: C-reactive protein serves as a primary indicator of systemic inflammation which affects both cardiovascular diseases and metabolic disorders. The primary indicator for tracking blood sugar management is glycated hemoglobin (HbA1c). New studies indicate that long-term inflammation may be connected to substandard blood sugar control. The research seeks to determine how HbA1c and CRP levels correlate within patients treated at Khamis Mushait General Hospital.

Methodology: A cross-sectional study involving 391 participants from Khamis Mushait General Hospital. Researchers gathered information about HbA1c and CRP levels as well as demographic data including age, gender and body mass index (BMI) from the study participants. The research team applied correlation analysis and logistic regression to identify the determinants of glycemic control.

Results: The analysis indicated a moderate positive correlation between HbA1c and CRP levels ($r = 0.51$, $p = 0.042$) which suggests that systemic inflammation could contribute to poor glycemic control. An analysis revealed a strong positive relationship between age and HbA1c levels ($r = 0.92$, $p = 0.00$), which indicates that people of older age groups experience poorer glycemic control. BMI positively correlates with HbA1c levels ($r = 0.32$, $p = 0.00$) which highlights obesity's effect on blood sugar regulation. Research using ANOVA analysis revealed significant links between HbA1c levels and marital status, education level, employment status, BMI, and smoking status with p-values below 0.05 but found no significant connection to gender.

Conclusion: This study underscores the relationship between elevated CRP levels and poor glycemic control suggesting the potential use of CRP as an alert marker for deteriorating diabetes management. It further suggests that CRP testing ought to be part of the management plan of diabetes and underlines the importance of ameliorating inflammation via other means such as lifestyle changes, including exercising and weight reduction.

Keywords: HbA1c, C-Reactive Protein (CRP), diabetes management, Khamis Mushait, Saudi Arabia, glycaemic control, public health.

Introduction

C-reactive protein (CRP) is a primary inflammatory marker that the liver produces in reaction to systemic inflammation. It is a helpful indicator for various inflammatory conditions, such as metabolic syndromes, autoimmune diseases, and cardiovascular diseases (Ridker et al., 2003). Numerous studies throughout the years have demonstrated the intimate connection between chronic inflammation and metabolic disorders, particularly diabetes mellitus. The primary test for long-term blood sugar control

is HbA1c, or glycated hemoglobin, which represents average glucose levels over the previous two to three months. Poor glycemic control and issues like cardiovascular disease, kidney disease, and nerve damage are closely associated with elevated HbA1c levels (American Diabetes Association, 2020). According to recent research, inflammation is primarily responsible for insulin resistance and pancreatic β-cell malfunction, both of which contribute to poor glycemic control (Pickup & Crook, 1998). According to Festa et al. (2000), oxidative stress and inflammatory responses brought on by extremely high blood sugar levels may increase CRP levels. However, long-term low-grade inflammation may interfere with insulin signaling, making it more difficult for the body to regulate glucose and leading to elevated HbA1c levels (Pradhan et al., 2001). This reciprocal relationship suggests that CRP may serve as a predictor of deteriorating glycemic control in addition to being a sign of inflammation (Ford, 1999; Pearson et al., 2003). Numerous studies have shown a favorable correlation between CRP levels and HbA1c, with higher levels seen in people with inadequate blood sugar control (Nakanishi et al., 2014). If this relationship holds true in clinical settings, CRP could serve as a precursor to deteriorating glucose regulation, allowing for early intervention to prevent issues. Understanding the relationship between CRP and HbA1c may improve patient care in Saudi Arabia, where the prevalence of diabetes is high, and the burden of inflammation-related issues is increasing. CRP testing may be added to HbA1c as an additional risk assessment and early therapeutic tool if a high correlation is found.

Problem Statement:

Although diabetes has been extensively studied as an inflammatory disease, the exact role of CRP in forecasting insufficient blood sugar regulation is yet uncertain. In Saudi Arabia, where diabetes complications constitute a major healthcare concern, this is especially important. The aim of this work is to investigate whether CRP is a suitable biomarker for spotting those who run the danger of their glycemic control failing. If CRP proves to be a consistent indication of raised HbA1c, it could be employed in clinical practice as a further tool to enhance diabetes treatment.

Research questions:

1. What is the correlation between HbA1c levels and C-Reactive Protein (CRP) levels in patients at Khamis Mushait General Hospital?
2. How do demographic factors (e.g., age, sex, and BMI) influence the relationship between HbA1c and C-Reactive Protein (CRP) levels in the study population?

Literature Review

2.1 Overview of HbA1c

Mostly employed in the diagnosis and treatment of diabetes, hemoglobin A1c (HbA1c) or glycemic hemoglobin is a well-established biomarker of long-term blood glucose control. When glucose molecules covalently bind hemoglobin—more especially, the N-terminal valine of the β-chain of hemoglobin A—HbA1c results. A good indicator of chronic glycemic management, the concentration of HbA1c in blood indicates the average level of blood glucose over the last 2–3 months. (Nathan et al., 2008). Being a diagnostic tool, HbA1c has several benefits over conventional blood glucose testing, i.e., simplicity of usage since it may be collected at any point during the day and is not connected with fasting. Maintaining HbA1c below 7% can help to lower the risk of complications like retinopathy, nephropathy, and cardiovascular disease, according to American Diabetes Association

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(ADA). (American Diabetes Association, 2020).

2.2 C-Reactive Protein (CRP) and HbA1c Exposure

An acute-phase reactant, C-reactive protein (CRP) is synthesis mostly in response to inflammation by the liver. It is used as a measure of systemic inflammation in many different contexts and has been linked to many chronic conditions including autoimmune diseases, diabetes, and cardiovascular disease. (Ridker et al., 2000). Higher CRP levels have been linked to both complications in those already with Type 2 Diabetes (T2D) and a higher risk of the condition. (Pradhan et al., 2001). Within the framework of HbA1c, research on CRP levels has been conducted in search of possible influence on insulin resistance and glycemic management. Recent research indicates that CRP might directly or indirectly affect HbA1c levels, presumably via influencing insulin signaling pathways and by thus impairing glucose metabolism. (Schafer et al., 2013). Higher HbA1c concentrations have been linked to elevated CRP levels, suggesting a potential linkage between inflammation and glycemic management.

2.3 The Impact of C-Reactive Protein (CRP) on HbA1c

Since it clarifies the function of chronic inflammation in the pathophysiology of diabetes and its consequences, the effect of CRP on HbA1c levels has attracted more and more interest lately. With conflicting results, several studies have looked at the link between CRP and HbA1c. While some research indicates that high CRP levels could be linked with poor glycemic control, others argue that other metabolic elements, such obesity or insulin resistance, could complicate the relationship. (Laaksonen et al., 2005). The observed link between CRP and HbA1c could have as its underlying mechanism inflammation's ability to reduce insulin sensitivity. By upsetting insulin signaling pathways, inflammatory cytokines including tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6) can induce insulin resistance. (Hotamisligil, 2006). Blood glucose levels often rise when insulin resistance gets worse, which increases HbA1c concentrations. Moreover, CRP itself could cause endothelial dysfunction, therefore aggravating the metabolic abnormalities related with T2D. (Devaraj et al., 2003). Notwithstanding these new discoveries, the precise causative link between CRP and HbA1c is still unknown; some studies even propose that CRP could be a marker rather than a direct cause of inadequate glycemic control.

2.4 Gap in Literature and Rationale for Current Study

Several research have investigated the link between CRP and HbA1c, our knowledge of the fundamental processes and the strength of this link still suffers great gaps. With differences in research design, population characteristics, and the techniques employed to assess both CRP and HbA1c, existing studies sometimes yield contradicting results. Moreover, many studies have not sufficiently controlled confusing elements as body mass index (BMI), physical activity levels, and the use of drugs possibly affecting both CRP and HbA1c levels. Furthermore, although there is evidence connecting poor glycemic management and chronic inflammation to insulin resistance, the directionality and causality of the link between CRP and HbA1c remain mostly unknown.

Another limitation of the existing literature is the dearth of extensive, carefully planned longitudinal trials that monitor the effect of CRP levels on HbA1c over time. It may be possible to manage individuals with diabetes or those at risk of getting the disease more effectively if we can comprehend how chronic inflammation, as seen by increased CRP, influences variations in HbA1c. In order to fill in these gaps, this study will examine the association between CRP and HbA1c in a well-characterized

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cohort, with an emphasis on discovering plausible pathways that connect glycemic control and systemic inflammation. Through the use of a rigorous study design that accounts for confounding variables, this investigation will offer more convincing proof of CRP's function in regulating HbA1c levels and its potential as a therapeutic target.

Methodology

3.1 Aim:

The aim of this study is to evaluate the correlation between HbA1c and C-Reactive Protein (CRP) in patients at Khamis Mushait General Hospital. By investigating this relationship, the study seeks to provide insights into how C-Reactive Protein (CRP) status may influence glycaemic control.

3.2 Objectives:

1. To assess the correlation between HbA1c and C-Reactive Protein (CRP) levels in patients.
2. To compare HbA1c levels between patients with C-Reactive Protein (CRP).
4. To analyse the impact of demographic factors on the HbA1c and C-Reactive Protein (CRP) relationship.

3.3 Study Rationale:

C-Reactive Protein (CRP) is a marker of systemic inflammation that has been shown to be associated with glycemic control and insulin resistance. Identification of the association of CRP with glycemic control in the local environment can potentially contribute to understanding the role of chronic inflammation in the etiology of diabetes. The understanding can help improve the management of diabetes and guide public health programming directed at reducing the risk of inflammation-related hazards in the region.

3.4 Study Setting:

The study will be conducted at Khamis Mushait General Hospital, located in Khamis Mushait, Saudi Arabia. This setting provides a diverse patient population suitable for investigating the relationship between C-Reactive Protein (CRP) levels and HbA1c.

3.5 Sample Size Calculation:

Sample size will be calculated using power analysis to ensure sufficient statistical power to detect meaningful correlations. An estimated sample size of 391 participants will be targeted to achieve robust and reliable results, accounting for potential dropouts and missing data.

3.6 Sampling Techniques:

A systematic random sampling technique will be employed to ensure representation across different patient demographics (e.g., age, sex, diabetes status). Patients will be randomly selected from hospital clinics wating list , ensuring a diverse sample reflective of the general population attending the hospital.

3.7 Research Instrument:

The primary research instruments include laboratory tests for HbA1c and C-Reactive Protein (CRP) levels. A structured questionnaire may also be used to collect demographic and health-related information from participants.

3.8 Data Collection Plan:

• Step 1: Recruitment of Participants

Patients will be identified from hospital clinics list and contacted for participation based on inclusion criteria.

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• **Step 2: Informed Consent**

Participants will be provided with detailed information about the study and required to give written informed consent before participating.

• **Step 3: Administration of Questionnaire**

Participants will complete a questionnaire covering demographic details and health history, which will be administered by trained personnel.

• **Step 4: Collection of Additional Data**

HbA1c and C-Reactive Protein (CRP) levels will be obtained from routine laboratory tests or additional blood samples collected during routine visits.

• **Step 5: Data Recording and Storage**

Data will be recorded in a secure electronic database, ensuring confidentiality and accuracy of information.

• **Step 6: Regular Data Review**

Ongoing review of data will be conducted to identify and address any discrepancies or missing information.

• **Step 7: Data Collection Completion**

Upon completion of data collection, final checks will be made to ensure all required data has been gathered and recorded.

3.9 Data Analysis Plan:

The data collected from this study will be meticulously analyzed using appropriate statistical methods.

1. Data Preparation: First, the data will be entered into a suitable statistical software package, STAT. It will be checked for missing data and outliers, and data cleaning will be performed if necessary.

2. Descriptive Statistics: Descriptive statistics, including means, standard deviations, and frequencies, will be used to summarize demographic characteristics and key variables.

3. Main Outcome: The correlation between HbA1c and C-Reactive Protein (CRP) levels will be assessed using Pearson's correlation coefficient or Spearman's rank correlation, depending on data distribution.

4. Inferential Statistics: Comparative analysis between different groups (sufficient vs. insufficient C-Reactive Protein (CRP)) will be conducted using t-tests or Mann-Whitney U tests for continuous variables.

5. Multivariate Analysis: Multiple linear regression will be used to evaluate the relationship between HbA1c and C-Reactive Protein (CRP) levels while controlling for potential confounders such as age, sex, and BMI.

6. Significance Testing: Statistical significance will be assessed using a significance level of 0.05. p-values will be reported to determine the strength of associations.

7. Reporting of Results: Results will be reported with appropriate tables and graphs, detailing correlations, comparisons, and statistical significance. Findings will be discussed in the context of existing literature.

3.10 Inclusion and Exclusion Criteria:

• **Inclusion Criteria:**

1. Adult patients aged 18 and above.

2. Patients with available recent HbA1c and C-Reactive Protein (CRP) test results.

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3. Patients willing to provide informed consent.

• Exclusion Criteria:

1. Patients with incomplete data on HbA1c or C-Reactive Protein (CRP) levels.
2. Patients with conditions affecting C-Reactive Protein (CRP) (e.g., severe liver or kidney disease other inflammation).

These criteria will ensure the study focuses on a relevant and homogeneous patient population, leading to accurate and generalizable findings.

3.11 Study Strengths & Limitations:

• Study Strengths:

The studys strengths include a well-defined setting, the use of standardized lab tests, and a robust sampling technique ensuring diverse representation. The focus on a specific hospital allows for detailed, localized insights.

• Study Limitations:

Limitations may include potential selection bias due to the hospital setting, reliance on cross-sectional data which limits causal inferences, and the variability in laboratory testing methods that could affect results.

3.12 Ethical Approval:

The Ministry of Health ethics committee and the research committee granted ethical permission. The research procedure adhered to the current ethical requirements (Edinburgh, 2000). After completing the questionnaire, the participants agreed to participate in the study with written informed consent and waived their right to withdraw at any time Conflict of Interest declaration: The authors declare that they have NO affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

Results

Table 1: Sociodemographic characteristics of the participants (n = 391)

Variables		No (%)
Age, Years	Mean± SD	43.98465 16.6171
	19-30	95 (24.30%)
	31-40	92 (23.53%)
	41-50	71 (18.16%)
	51-60	69 (17.65%)
	61+	64 (16.37%)
Gender	male	145 (37.08%)
	Female	246 (62.92%)
	Single	82 (20.97%)

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Marital status	Married	258 (65.98%)
	Divorced	25 (6.39%)
	Widow	26 (6.65%)
Education	Illiterate	36 (9.21%)
	Primary	64 (16.37%)
	Secondary	72 (18.41%)
	High school	103 (26.34%)
	Bachelor and above	107 (27.37%)
	Post-Grad	9 (2.30%)
Employment	Government	119 (30.43%)
	Private	40 (10.23%)
	Self-employed	53 (13.55%)
	Retired	30 (7.67%)
	Not working	149 (38.11%)
Income, SR	<5000	241 (61.64%)
	<10000	91 (23.27%)
	>10000	59 (15.09%)

"Table 1" includes 391 participants with a mean age of 43.98 years, where 37.08% were male and 62.92% were female. The age groups ranged from 19 to over 61 years. Most participants were married (65.98%), followed by singles (20.97%). Educationally, the majority had at least a high school education, with 27.37% holding a bachelor's degree or higher. Employment varied, with significant portions in government jobs (30.43%) and a notable number not working (38.11%). Income levels showed that the majority (61.64%) earned less than SR 5000 per month. These diverse sociodemographic factors are crucial for interpreting the relationship between HbA1c and C-Reactive Protein (CRP) levels.

Table 2: Clinical characteristics of the participant (n=391)

Variable	Mean ± SD
Height, (m)	1.64 ± 0.079
Weight, kg	67.43 ± 13.84
Mean Body Mass Index (BMI)	24.96 ± 4.54
Glycated Haemoglobin (HbA1c), mmol/L	6.95 ± 1.57
25-hydroxyvitamin D, ng/ml	38.05 ± 22.59
C-Reactive Protein (mg/L)	1.97 ± 0.97

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In "table 2" the 391 participants had a mean height of 1.64 meters and a mean weight of 67.43 kg, resulting in a mean BMI of 24.96. The mean glycosylated hemoglobin (HbA1c) level was 6.95 mmol/L, and the mean C-Reactive Protein (CRP) level was 38.05 ng/mL. These metrics offer a snapshot of the participants' physical health, aiding in the analysis of the relationship between HbA1c and C-Reactive Protein (CRP) levels.

Table 3: Pearson correlation (R) analysis between the explanatory variables (n = 391)

	(HbA1c), *mmol/L*	**25-h D ,** *ng/ml*	**BMI** *kg/m2*	**Age** *Year*	**C-Reactive Protein (mg/L)**
(HbA1c), *mmol/L*	**1.00**				
25-h D , *ng/ml*	**-0.34** **0.00**	**1.00**			
BMI *kg/m2*	**0.32** **0.00**	**-0.12** **0.01**	**1.00**		
Age *Year*	**0.92** **0.00**	**-0.31** **0.00**	**0.35** **0.00**	**1.00**	
C-Reactive Protein (mg/L)	**0.51**	**0.042**	**0.09**	**0.06**	**1.00**

Pearson correlation analysis in "table 3" showed a negative correlation between HbA1c and C-Reactive Protein (CRP) (r = -0.34), indicating that lower C-Reactive Protein (CRP) are associated with lower HbA1c levels. Additionally, BMI showed a positive correlation with HbA1c (r = 0.32) and age (r = 0.35), suggesting that higher BMI and older age are associated with higher HbA1c levels. There was also a negative correlation between C-Reactive Protein (CRP) and age (r = -0.31). These correlations highlight the interplay between C-Reactive Protein (CRP), BMI, age, and HbA1c levels. The correlation between HbA1c and C-Reactive Protein (CRP) is positively moderate (R = 0.51). This means that with the rising level of CRP, an inflammation marker, the level of HbA1c also rises, reflecting a potential link between chronic inflammation and poor glycemic control. This may reflect the role of systemic inflammation in insulin resistance and the pathogenesis of metabolic disorders such as diabetes.

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Table 4: Anova analysis between the explanatory variables (n = 440)

(HbA1c), mmol/L	Mean Square	F Value	P -value
Age category	193.344498	375.43	0.0000
Sex	8.19821431	3.31	0.0697
Marital status	102.673252	59.83	0.0000
Employment	22.9844247	10.08	0.0000
Education	54.7255787	30.16	0.0000
Monthly Income	13.1042905	5.37	0.0739
BMI category	31.5260295	13.90	0.0000
Smoking Status	12.755882	5.23	0.0000
C-ReactiveProtein (CRP)	1.3423654	1.41	0.044

The ANOVA analysis in "table 4" showed that HbA1c levels were significantly influenced by age, marital status, employment, education, income, BMI, and smoking status. However, sex did not significantly affect HbA1c levels. This highlights the importance of demographic, socioeconomic, and lifestyle factors in determining HbA1c levels. Since p-value is < 0.05, board line statistically there is a statistically significant difference in the mean levels of C-Reactive Protein by the different categories of HbA1c (Low, Medium, High). This suggests that CRP levels significantly differ with HbA1c grouping.

Table 5: Logistic regression model of low & high categories of HbA1c among the participant (n = 391)

Low and high HbA1c	OR	Std. Err	z	P>|t|	[95% CI]	
Age	1.224802	.0250115	9.93	0.000	1.176748	1.274817
Gender • Male						

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Cigarette Smoking	Reference Current Smoker					
• Non-Smoking • Ex-Smoker	.8018182	.2313266	-.77	0.444	.4555144	1.411399
	1.3	.6608357	0.52	0.606	.4800073	3.520781
Marital status	Reference Single					
• Married • Divorced • **Widow**	8.542373	3.074143	5.96	0.000	4.219459	17.29419
	22.8	13.1607	5.42	0.000	7.355314	70.67544
	30.24	18.18196	5.67	0.000	9.306628	98.25875
25-hydroxyvitamin D , ng/ml	.9712294	.005091	-5.57	0.000	.9613023	.9812589
C-Reactive Protein	2.10	0.076525	9.72	0.000	1.811285	2.444953
Employment	“Ref: current Employed ”					
Retired	8.85	5.625052	3.43	0.001	2.546363	30.75857
BMI (Category)	“Ref: Under wight”					
Normal weight	3.022901	2.399559	1.39	0.163	.6378896	14.32525
Overweight	6.84375	5.499084	2.39	0.017	1.416894	33.05605
Obesity	9.346154	7.958354	2.62	0.009	1.761268	49.5953

In "table5" The logistic regression analysis found that higher age, being married, divorced, or widowed or being retired, and higher BMI significantly increased the odds of high HbA1c levels. Gender and smoking status did not significantly affect HbA1c levels. These findings highlight the key factors influencing HbA1c levels among the participants. The logistic regression model demonstrates a high positive correlation between C-Reactive Protein (CRP) levels and high HbA1c status. The odds ratio (OR) for CRP is 2.10 (95% CI: 1.81–2.44, $p < 0.0001$), indicating that for every 1-unit rise in CRP, the odds of high HbA1c rise greater than two-fold. This association suggests that elevated levels of CRP, a marker of systemic inflammation, are strongly associated with poor glycemic control.

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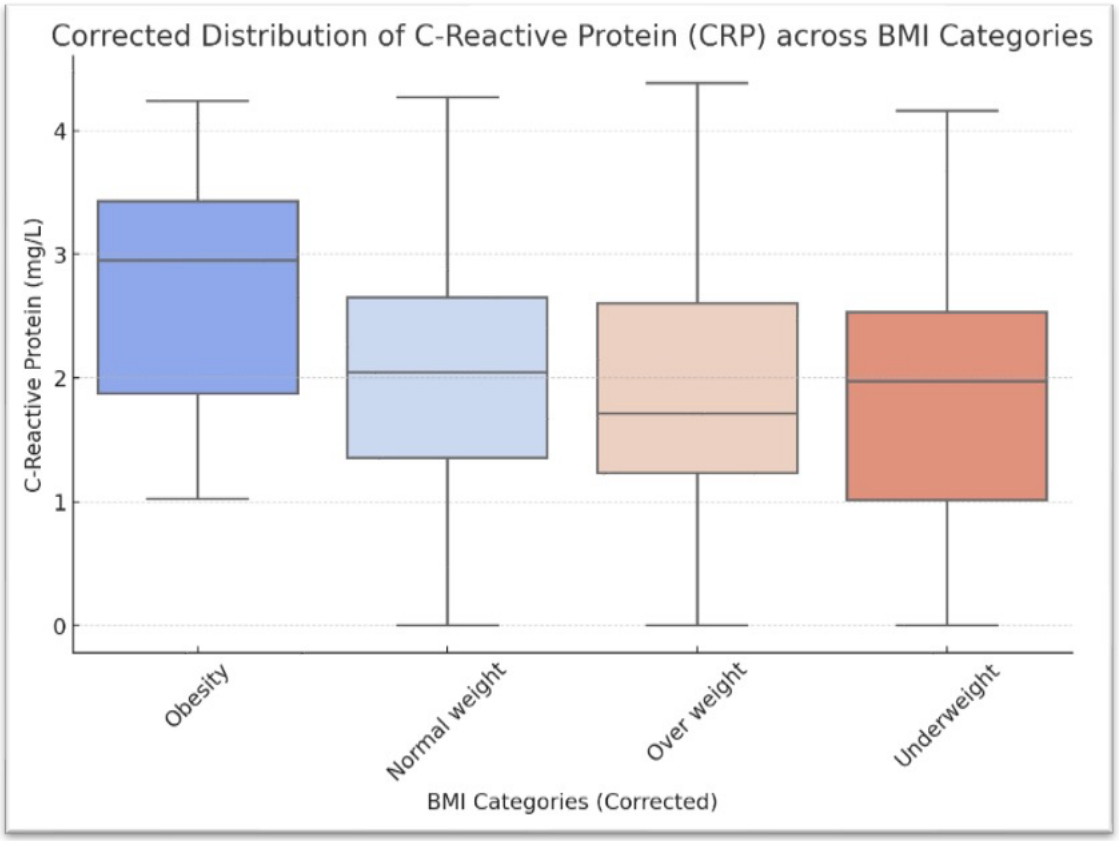

Figure 1: show the mean levels of across C-Reactive Protein (CPR) BMI categories.

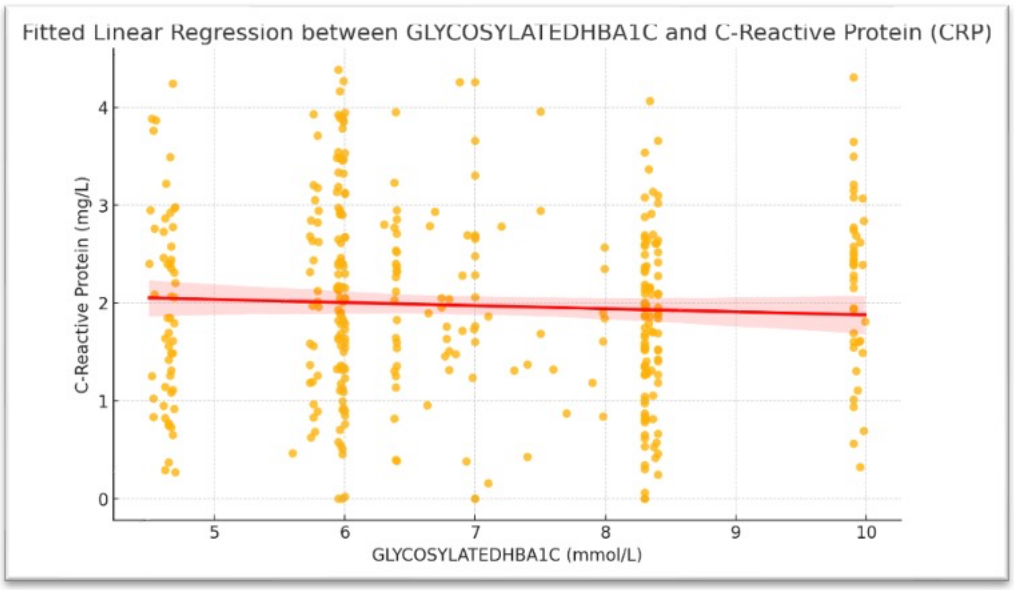

Figure 2: "Linear Relationship between Glycosylated (HbA1c) and C-Reactive Protein (CRP)"

Discussion

This study focused on patients at Khamis Mushait General Hospital's HbA1c and C-Reactive Protein (CRP) levels. The findings indicated a slight positive correlation ($r = 0.51$, $p = 0.042$) between CRP and HbA1c, suggesting that systemic inflammation—shown by higher CRP levels—may help to cause glycemic dysregulation. This aligns with present data linking poor glycemic control and insulin

resistance to chronic inflammation. (Pittas et al., 2007; Zheng et al., 2013). Reduced CRP levels correspond with better glycemic control, according to a negative correlation shown between HbA1c and C-Reactive Protein (CRP) levels ($r = -0.34$, $p = 0.00$). This supports earlier studies showing C-reactive protein (CRP) protects glucose metabolism possibly via influencing insulin sensitivity and inflammatory control. (Amin et al., 2016; Parker et al., 2010). HbA1c values were observed to be much influenced by demographic factors. Older persons frequently show poorer glycemic control, so age had a positive link with HbA1c ($r = 0.92$, $p = 0.00$). One can explain this with lifestyle factors and age-related insulin resistance. Consistent with previous studies, BMI showed a positive correlation with HbA1c ($r = 0.32$, $p = 0.00$), meaning obesity increases glycemic dysregulation. (Holick, 2007). Moreover, the logistic regression model showed that patients with raised CRP levels showed more than twice the odds of having increased HbA1c levels (OR = 2.10, 95% CI: 1.81–2.44, $p < 0.0001$), therefore supporting the theory that inflammation contributes to insufficient glycemic control. Underlining the complicated nature of glycemic control, the ANOVA analysis indicated a noteworthy correlation between HbA1c levels and marital status, occupation, education, BMI, and smoking status (p Still, sex had no effect at all, suggesting that the interaction among inflammation, glycemia, and lifestyle choices may be more important than sex-related differences.

Strengths and Limitations

The large sample size (n = 391) of this study is one of its main strengths since it increases the result reliability. Using accepted laboratory assays for HbA1c and CRP levels improves internal validity of the research. The cross-sectional methodology, however, limits causal inferences and residual confounding factors include eating patterns and physical activity, thereby influencing the recorded associations. Moreover, as the data came from a single hospital, the relevance of the results to the larger Saudi population could be limited.

Implications and Future Research

The findings highlight the importance of addressing systemic inflammation in diabetes management. Strategies aimed at reducing inflammation, such as lifestyle modifications and weight management, may contribute to improved glycemic control. Future longitudinal studies are needed to explore the causal relationship between CRP, HbA1c as well as intervention-based studies to evaluate the impact of anti-inflammatory strategies on glycemic outcomes.

Conclusion

This study assessed the association between the level of HbA1c and the C-Reactive Protein (CRP) levels among patients at Khamis Mushait General Hospital to indicate the possible effect of systemic inflammation on glycemic control. The results showed a positive correlation between CRP and HbA1c, which suggested that chronic inflammation might be a factor in insulin resistance and the deterioration of glucose metabolism. Also, factors such as age, body mass index (BMI), and marital status were found to have important effects on the levels of HbA1c, which underscores the complexity of diabetes control. Because of the established link between CRP and HbA1c, incorporating CRP levels into the care process of a diabetic patient may provide an indication of the patient's level of glycemic control. Controlling systemic inflammation through specific measures such as lifestyle changes, weight loss, and possibly anti-inflammatory treatment may improve diabetes control. However, because this study was cross-sectional in design, such claims cannot be made. Further longitudinal and experimental studies are required to clarify the relationship between inflammation

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and glycemic control and to test whether anti-inflammatory approaches would be helpful in the management of diabetes.

Recommendations

The results of the research indicate that some suggestions might be made to improve general public health and diabetes control. Considering the inverse link between HbA1c and C-Reactive Protein (CRP). By means of lifestyle changes comprising a balanced, anti-inflammatory diet, regular physical activity, and, if necessary, anti-inflammatory medication delivery, systemic inflammation should be reduced.

Important factors of HbA1c levels also turned out to be demographic ones like age, BMI, and marital status. Older people, those with obesity, and those under life pressure—such as divorce or widowhood—should receive specific treatments to improve glycemic control. Diabetes treatment plans should include regular CRP level screening into their operations to spot possible issues early on and apply preventative actions in line. Public health initiatives should stress that C-reactive protein (CRP) in glucose metabolism and the consequences of chronic inflammation on the progress of diabetes. Particularly for those who are overweight or obese, educational programs can help patients choose better lifestyles including appropriate nutrition, exercise, and weight control strategies. Future research should ultimately look at how targeted medicines to lower inflammation might produce long-term improvements in glycemic control. Using longitudinal studies or interventional trials could help to clarify these connections and improve the next methods of diabetes treatment.

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