ORIGINAL RESEARCH ARTICLE

Evaluation of Urinary C-peptide as a Non-invasive Biomarker for the Diagnosis of Type 2 Diabetes Mellitus at Kenyatta National Hospital, Kenya

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Abstract

Diabetes mellitus, a noncommunicable disease affecting over 589 million people worldwide, and nearly 50% remain undiagnosed. It is characterized by hyperglycemia caused by insulin abnormalities or inadequacies, leading to various health issues due to macrovascular and microvascular alterations. Early diagnosis of diabetes is essential for effective disease management, and innovative non-invasive biomarkers are needed to overcome and address the challenges posed by traditional blood-based tests. Developing non-invasive biomarkers is a critical step for enhancing patient compliance with diabetes screening. The C-peptide hormone, which mirrors endogenous insulin secretion and is excreted in the urine, represents a promising noninvasive candidate. This study aimed to evaluate the correlation between urinary C-peptide levels and conventional glycemic control parameters in newly diagnosed patients with type 2 diabetes mellitus (T2DM) in the Kenyan population. A cross-sectional study was conducted among 54 newly diagnosed patients with type 2 diabetes mellitus attending Kenyatta National Hospital. The urinary C-peptide levels were quantified from first-morning urine specimens using a chemiluminescent immunoassay principle. Glycated hemoglobin levels were determined using a chemiluminescent microparticle immunoassay technology, while fasting blood sugars were determined with the use of a glucometer. Pearson's correlation coefficient was used to assess the relationships between variables. A significantly strong positive correlation was observed between fasting blood sugar and glycated hemoglobin ($r = 0.607$, $p < 0.001$). In contrast, urinary C-peptide concentrations showed comparatively weak, statistically insignificant relationships with fasting blood sugar ($r = 0.132$, $p = 0.342$) and glycated hemoglobin ($r = 0.225$, $p = 0.102$). The weak correlations observed with glycemic control indicators suggest limited utility of urinary C-peptide as a standalone noninvasive diagnostic tool for type 2 diabetes mellitus. Nevertheless, its noninvasive nature and metabolic stability suggest that it has potential for further investigation in more extensive and extended studies, particularly for assessing endogenous insulin secretion.

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Based on these data, we recommend that urine C-peptide serve as a supplemental biomarker rather than an alternative to standard glycemic diagnosis, particularly for evaluating beta-cell activity and insulin secretion dynamics in patients with diabetes. Additionally, we propose an investigation into the potential of the urine C-peptide hormone for monitoring therapy efficacy.

Keywords: Biomarker, C-Peptide, Glycemic control, Noninvasive, Type 2 Diabetes Mellitus.

1.0 Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder of the endocrine system characterized by persistent hyperglycemia (Baynes, 2015). This condition arises either from inadequate insulin production by pancreatic beta cells, an impaired cellular response to insulin, or both (Khin *et al.*, 2023). Despite great development in diabetes diagnosis, diabetes mellitus poses a significant health and economic burden globally (Hossain *et al.*, 2024). This resulting hyperglycemia can lead to progressive damage to various organ systems, particularly the vascular and nervous systems, causing complications such as neuropathy, nephropathy, retinopathy, cardiovascular diseases, and limb amputations (Reddy and Tan, 2020; Mezil and Abed, 2021). According to the International Diabetes Federation (IDF) Diabetes Atlas 11th edition, 2025, there has been a steady global rise in its prevalence, with over 589 million adults (20–79 years) affected, and nearly 50% remaining undiagnosed (Pachauri, 2025; Genitsaridi *et al.*, 2025). It represents a prevalence of 11.1% in 2025, and projections indicate a rise to 12.95% corresponding to 853 million adults by 2050 (Gong *et al.*, 2025; A. Kumar *et al.*, 2024; Azher, 2024). In Kenya, the prevalence is estimated at 3.3%, with over 60% of cases undiagnosed, highlighting a critical need for accessible and non-invasive screening methods (Meme *et al.*, 2015; Denis, 2019). Current diagnostic and monitoring gold standards (HbA_1C and FBS) are invasive, which can be a barrier to routine testing and compliance, particularly in low-resource settings (Sherwani *et al.*, 2016; Parrinello and Selvin, 2014).

Timely and accurate diagnosis of diabetes is essential for effective disease management and for mitigating both immediate and long-term complications (Aqela *et al.*, 2024; Felemban, 2025). Currently, diagnostic approaches rely heavily on blood-based tests such as fasting blood sugar (FBS), glycated hemoglobin (HbA_1C), and oral glucose tolerance tests (OGTT). Although reliable, these methods are invasive, which may reduce patient compliance, particularly in routine monitoring (Alqahtani *et al.*, 2013). Consequently, there is growing interest in identifying non-invasive biomarkers that can enhance diabetes diagnosis. The pursuit of non-invasive biomarkers is therefore a priority in diabetology (Catanese *et al.*, 2023). Urinary C-peptide (UCP) has emerged as a promising candidate in this regard (Zhou *et al.*, 2022). The C-peptide hormone is co-secreted with insulin from pancreatic beta-cells in equimolar amounts (Pullicin *et al.*, 2022). Its concentration reflects endogenous insulin production and can be measured non-invasively, offering an attractive alternative for diabetes screening, particularly in resource-limited settings (Higham *et al.*, 2011).

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However, the clinical utility, diagnostic accuracy, and correlation of urinary C-peptide with standard glycemic markers remain unclear. Despite growing interest in urinary C-peptide as a diagnostic tool, significant knowledge gaps remain. There is currently limited data regarding the diagnostic value of urinary C-peptide in diabetes diagnosis. Understanding the relationship between urinary C-peptide and glycemic indicators could provide new insights into its diagnostic potential. Unlike insulin, it has a longer half-life and is excreted renally, making its urinary concentration stable (Maddaloni *et al*., 2022). Urinary C-peptide is an integrated measure of endogenous insulin secretion over time, while serum C-peptide is an established marker of beta-cell function; the urinary assay offers a completely non-invasive alternative. Studies on UCP have shown promise in differentiating diabetes types and assessing insulin secretion (Pullicin *et al*., 2022). However, its direct correlation with conventional glycemic markers like HbA_1C and FBS remains underexplored, especially in African populations. This study aimed to bridge these gaps by evaluating the correlation between UCP and glycemic controls (HbA_1C and FBS) in a cohort of newly diagnosed type 2 diabetic patients at Kenyatta National Hospital, Kenya. This study investigated the role of urinary C-peptide as a potential non-invasive biomarker for the diagnosis of diabetes mellitus by determining the correlation between urinary C-peptide levels and established glycemic markers (fasting blood sugar and HbA_1C. If urinary C-peptide proves to be a potential noninvasive biomarker of glycemic control, it could improve early detection and facilitate frequent monitoring, especially in underserved or resource-limited healthcare settings. Ultimately, this may enhance patient compliance, support timely interventions, and improve diabetes outcomes.

2.0 Materials and methods

2.1 Study design and participants

This cross-sectional study was conducted at Kenyatta National Hospital in Kenya to evaluate urinary C-peptide as a potential non-invasive biomarker for the diagnosis of type 2 diabetes mellitus (T2DM). The study and data collection were conducted at Kenyatta National Hospital (KNH), Kenya's largest public referral and teaching hospital, which is located in the Upper Hill neighborhood of Nairobi city. The hospital offers an excellent clinical atmosphere for medical education, diagnostics, and biomedical research. A structured face-to-face interview was conducted using a questionnaire containing closed-ended questions. This study featured 54 Kenyan nationals aged 18 to 65 years who had been newly diagnosed with type 2 diabetes mellitus and submitted informed consent. Newly diagnosed participants were defined as individuals who had received a clinical diagnosis of type 2 diabetes mellitus within the previous three months, based on the World Health Organization (WHO) diagnostic criteria (R. Kumar *et al.*, 2016) (fasting plasma glucose ≥7.0 mmol/L, 2-hour plasma glucose ≥11.1 mmol/L, or HbA_1C ≥6.5%). This narrow diagnostic window was chosen to ensure participants were enrolled before significant metabolic adaptation or pharmacologic intervention could influence endogenous insulin secretion or urinary C-peptide excretion. The study employed fasting blood sugar and HbA_1C as the standard diagnostic methods. Participants who matched the inclusion criteria were grouped into eight age groups with

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a five-year interval class (21-25 to 61-65 years); however, those with other life-threatening conditions, anuric, younger than 18, older than 65, or who declined to grant consent were excluded.

2.2 Sample size determination

The sample size was calculated using Cochran's formula for a finite population, considering a 3.3% diabetes prevalence in Kenya, a 95% confidence level (Z = 1.96), and a 5% margin of error (Kotrlik & Higgins, 2001). Where:

$$n = \frac{Z^2 p(1-p)}{E^2}$$

Where

n = Sample size required

Z^2 = 95% Confidence level (standard value of 1.96)

p = Diabetes prevalence in Kenya 3.3% (Denis, 2019).

E = Desired margin of error (0.05)

$$= \frac{(1.96)^2 \times 0.033 \times (1-0.033)}{0.05^2} = 49.04$$

The final sample size incorporated 10% of n (49) due to confounders and attrition factors. Therefore, the sample size will be 49+5 = 54. While the sample size was calculated based on disease prevalence, it is acknowledged that correlation studies are more sensitive to the magnitude of expected effect sizes. Therefore, the sample size of 54 might have been underpowered to detect weak but clinically relevant correlations between urinary C-peptide and the glycemic markers.

2.3 Sample collection and laboratory analysis

Data was collected using a structured face-to-face interview questionnaire that included closed-ended questions. Participants were also guaranteed that the responses would remain confidential. The researcher reviewed the statements on the written authorization form and acquired signed consent from the individuals. The researcher made it clear that participants had the right to withdraw from the study at any point if they felt uncomfortable. Fasting whole blood (1–2 mL) was collected by venipuncture, and fasting blood sugar was measured using an Accu-Check Instant glucometer before being put into EDTA tubes for HbA_1C analysis. Blood is drawn into a testing strip through capillary action, and when it comes into contact with immobilized glucose oxidase, it reacts with glucose to form gluconic acid. This acid then reacts with potassium ferricyanide to form ferrocyanide, which generates a current proportional to plasma glucose concentration

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(Buzanovskii, 2015). A first-morning void urine samples (5-10 mL) were collected into a sterile container for UCP analysis. The UCP levels were determined using the Alinity i System analyzer, which employs chemiluminescent microparticle immunoassay technology to quantitatively measure urinary C-peptide levels (Dasgupta, 2019). The analyzer calculates C-peptide concentrations based on calibration curves and quantifies results using relative light units (Polacco *et al*., 2018). The process is fully automated and ensures accurate, reliable C-peptide levels determination, and results are produced in print-out form. It is important to note that urinary C-peptide concentrations were not corrected for urinary creatinine, which is a limitation as it does not account for variations in urine concentration. The HbA_1C analysis involved the whole blood analysis using the Mindray BS-430 analyzer. The analyzer is primarily automated, relying on high-performance liquid chromatography technology to reduce manual handling. Using the preprogrammed HbA_1C test procedure, the analyzer automatically dilutes and prepares the sample (Li *et al*., 2023). It incorporates internal chemicals into the sample to lyse red blood cells and release hemoglobin, then quantifies HbA_1C by binding glycated hemoglobin to specific antibodies. The chemiluminescent signal generated during the reaction is proportional to the HbA_1C concentration and calculated as a percentage of total hemoglobin (Mandal & Manasreh, 2018).

2.4 Quality assurance

All laboratory analyses were performed in accordance with the standard operating procedures of the accredited clinical chemistry laboratory at Kenyatta National Hospital. Internal Quality Control (IQC) was performed daily for all analytes, and results were accepted only if they fell within pre-defined limits. The laboratory also participates in External Quality Assurance (EQA) schemes under the Randox International Quality Assessment Scheme (RIQAS). Calibration was performed on the machine/equipment before the analysis commenced to ensure a rigorous quality framework, reliability, and credibility of the reported results.

2.5 Data management and statistical analysis

The urine C-peptide levels and glycemic control data were recorded in an Excel spreadsheet and then exported to Minitab version 17 for statistical analysis. The data collected were analyzed descriptively, focusing on means ± standard deviations (SD), minimum, and maximum. The descriptive statistical analysis explored different age groups and genders. The association between urine C-peptide levels and glycemic controls (FBS and HbA_1C) was compared using Pearson correlation coefficient (r) analysis. A p-value of ≤ 0.05 was considered statistically significant.

3.0 Results

3.1 Descriptive statistics for the study cohort.

The demographic and metabolic characteristics of the 54 newly diagnosed type 2 diabetes patients are summarized in Table 1 below. The cohort had a mean (±SD) urinary C-peptide level of 20.98 ±

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15.42 ng/mL, indicating a wide variation in endogenous insulin secretion at diagnosis. This substantial standard deviation (±15.42), which is over 70% of the mean value, highlights profound inter-individual heterogeneity in endogenous insulin secretion among newly diagnosed patients. This finding is physiologically critical, and it visually demonstrates that at diagnosis, individuals exist on a wide spectrum from those with very low insulin output (potentially indicating rapid β-cell exhaustion or a more insulin-deficient phenotype) to those with high output (suggesting significant compensatory hyperinsulinemia in the face of insulin resistance). This variability is a primary reason why a simple linear correlation with glycemic markers might be weak, as it underpins the pathophysiological diversity of early T2DM. The mean fasting blood sugar was 7.84 ± 1.89 mmol/L, and the mean glycated hemoglobin was 8.55 ± 2.49 %, confirming a state of hyperglycemia in the study population. The range (5.60 to 16.10 mmol/L) indicates that while all participants were clinically diagnosed, some presented with severe hyperglycemia, while others were near the diagnostic threshold. This spread is typical of a clinical population and validates that the study captured patients across a severity gradient. The mean HbA_1C was 8.55 ± 2.49%, significantly above the diagnostic cutoff of 6.5%. This confirms that hyperglycemia was not an acute finding but had persisted for approximately 2-3 months before diagnosis. The wide range (5.60 to 16.40%) is striking. The lower end near 5.6% suggests a few participants may have been diagnosed based on acute glucose values, while the extreme upper values point to individuals with prolonged, dangerously uncontrolled diabetes. This high level of uncontrolled disease at diagnosis underscores the critical public health need for earlier screening methods in this setting. The substantial standard deviations and broad ranges for all parameters, particularly urinary C-peptide, highlight significant metabolic heterogeneity among participants at diagnosis.

Table 1: Descriptive characteristics of the study cohort (n=54).

Parameter	Mean ± SD	Range
Urinary C-peptide (ng/mL)	20.98 ± 15.42	1.25- 58.10
Fasting Blood Sugar (mmol/L)	7.84 ± 1.89	5.60- 16.10
Glycated Hemoglobin, HbA_1C (%)	8.55 ± 2.49	5.60- 16.40

Key: Results are expressed as Mean ± Standard Deviation (SD).

3.2 Correlation analysis between UCP and glycemic controls (FBS and HbA_1C).

A Pearson correlation analysis was conducted to examine the associations among urinary C-peptide, fasting blood sugar, and glycated hemoglobin levels, as detailed in Table 2. A strong and statistically significant positive correlation was observed between fasting blood sugar and glycated hemoglobin levels ($r = 0.607$, $p < 0.001$), confirming their reliability as interdependent measures of glycemic control. As FBS rises, so does HbA_1C, validating both as consistent, interdependent markers of hyperglycemia in this study population. However, there was a weak and non-significant correlation between urine C-peptide levels and fasting blood sugar levels ($r = 0.132$, $p = 0.342$), as well as a statistically insignificant weak correlation ($r = 0.225$, $p = 0.102$) between urine C-peptide

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levels and glycated hemoglobin levels. This suggests that in this cohort, the level of endogenous insulin secretion (as measured by UCP) does not have a clear or consistent linear relationship with fasting glucose and glycated hemoglobin levels at a single point in time.

Table 2: Pearson correlation and p-value analysis.

Variable Pair	Correlation Coefficient (r)	p-Value
FBS versus HbA_1C	0.607	0.001
UCP versus FBS	0.132	0.342
UCP versus HbA_1C	0.225	0.102

Key: p-value of ≤ 0.05 indicates a statistically significant correlation.

The observed association between glycated hemoglobin (HbA_1C) and fasting blood sugar (FBS) levels is visualized in Figure 1 below. It clearly shows a strong, positive, linear relationship between FBS and HbA_1C, confirming a statistically significant correlation (r = 0.607, p = 0.001). Each point represents an individual participant's paired HbA_1C (%) and FBS (mmol/L) measurement. The red trendline indicates a positive linear relationship, suggesting that higher HbA_1C values are associated with increased fasting blood glucose levels. This pattern supports the known pathophysiological link between chronic glycemic exposure (HbA_1C) and short-term glucose status (FBS). Despite some variability and a few outliers, the general upward trend demonstrates a strong positive correlation between the two variables.

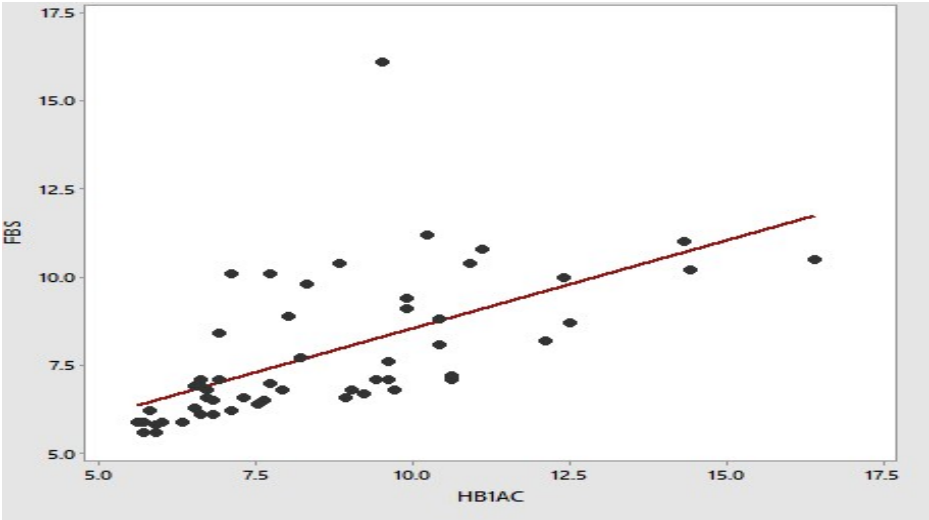

Figure 1: A scatter plot for FBS levels versus HbA_1C levels.

Key: x-axis represents HbA_1C levels in %
y-axis represents FBS levels in mmol/L
— represents the line of best fit
● represent a data point

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The correlation between urinary C-peptide and fasting blood sugar levels among study participants is visualized in Figure 2 below. Each point represents a paired observation where data points appear widely scattered around the regression line. The scatter plot indicates a very weak nonlinear relationship, suggesting that urinary C-peptide levels do not reliably predict fasting blood glucose among the study participants. However, the association is not statistically significant (r = 0.132, p = 0.342). The wide dispersion of data points and presence of outliers may reflect variability in individual insulin response or beta-cell function that may not be captured by urinary C-peptide alone. The lack of relationship indicates that urinary C-peptide and fasting blood glucose represent distinct aspects of glucose metabolism.

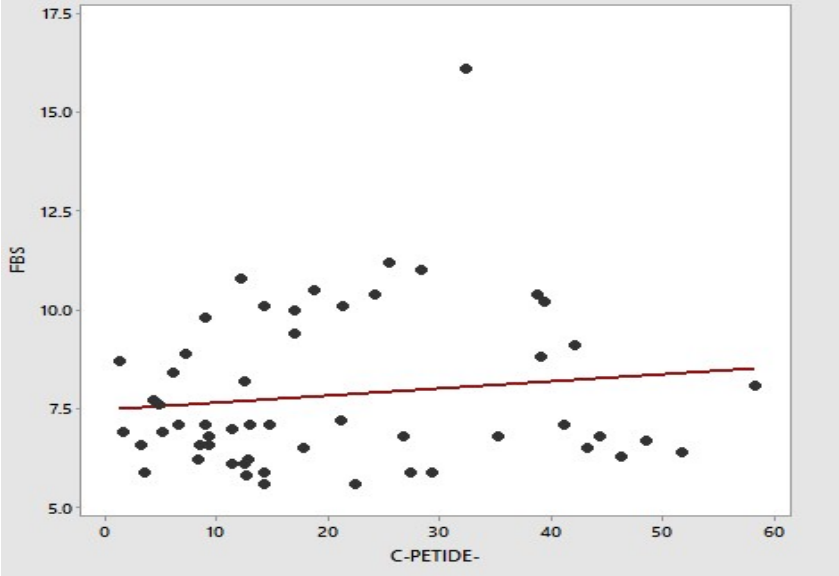

Figure 2: A Scatter plot for UCP levels versus FBS levels.

Key: x-axis represents UCP levels in ng/mL
y-axis represents FBS levels in mmol/L.
— represents the line of best fit
● represents a data point

The relationship between urinary C-peptide (UCP) levels and glycated hemoglobin (HbA_1C) among study participants is depicted in Figure 3 below. The scatter plot shows a weak nonlinear correlation between UCP and HbA_1C, reflected by the gentle upward slope of the trend line. However, this association was not statistically significant (r = 0.225, p = 0.102**)**. The wide dispersion of data points indicates substantial inter-individual variability in urinary C-peptide excretion across different HbA_1C levels. This indicates that higher urinary C-peptide levels are not associated with

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marginally higher HbA_1C values. The weak relationship suggests that while both markers are related to glucose metabolism, they capture distinct physiological processes. However, the lack of a strong or significant association underscores that urinary C-peptide should be interpreted as an independent measure of β-cell function, rather than a direct indicator of glycemic status.

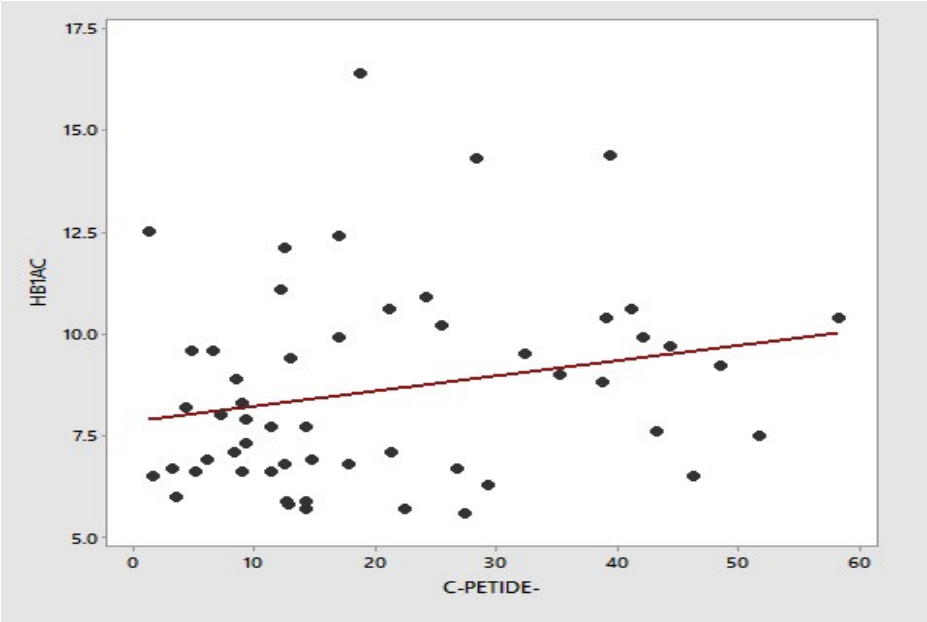

Figure 3: A scatter plot for UCP levels versus HbA_1C levels.

Key: x-axis represents UCP levels in ng/mL
y-axis represents HbA_1C levels in %
— represents the line of best fit
● represents a data point

4.0 Discussions

This study found a significant positive relationship between fasting blood sugar (FBS) and HbA_1C, indicating that both affirm the internal reliability and effectively reflect glycemic state. The strong link highlights the ongoing presence of hyperglycemia among the participants. The results align perfectly with the literature that considers FBS and HbA_1C as complementary indicators for diagnosing and monitoring diabetes mellitus (Begum *et al.*, 2018). Additionally, the results confirm that although FBS and HbA_1C are closely related and remain the standard markers for assessing glycemic control, urinary C-peptide plays a distinct yet complementary role. Its value lies in determining residual β-cell function, which offers insights into the pathophysiology and classification of diabetes rather than immediate glucose levels. This aligns with the conclusions of (Bonnefond & Semple, 2022) and (Fritsche *et al.*, 2022), who highlighted the diagnostic usefulness of C-peptide in distinguishing between insulin-deficient and insulin-resistant forms of diabetes.

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The research question was informed by the pathophysiology of T2DM. We sought to evaluate the relationship between urinary C-peptide (reflecting insulin secretion) and established markers of hyperglycemia in newly diagnosed patients, a stage where individuals may be at different points on the spectrum from compensatory hyperinsulinemia to incipient β-cell exhaustion. The weak correlation observed likely reflects this inherent physiological heterogeneity at diagnosis.

In contrast, urinary C-peptide exhibited weak, non-significant correlations with the established glycemic markers (FBS and HbA_1C) in a newly diagnosed Kenyan cohort with type 2 diabetes mellitus (T2DM). This lack of a clear linear relationship among newly diagnosed participants may reflect the biphasic nature of insulin secretion in type 2 diabetes (Del Prato *et al.*, 2017). Early in the disease, many patients experience compensatory hyperinsulinemia due to insulin resistance, resulting in elevated C-peptide levels despite hyperglycemia. Conversely, others may already be progressing toward β-cell exhaustion, characterized by declining C-peptide despite poor glycemic control. This physiological heterogeneity complicates attempts to identify a simple linear relationship between urinary C-peptide and glycemic indices, as reported in similar studies exploring early T2DM pathophysiology. The scatter plots depicting UCP versus FBS and UCP versus HbA_1C showed a wide dispersion of data points with minimal clustering along the regression lines, further emphasizing the weak linear association. These findings are similar to those reported by (Huang *et al.*, 2022) and (Zhou *et al.*, 2022), who observed that urinary C-peptide levels do not always parallel glycemic parameters in individuals with type 2 diabetes. Another critical factor confounding this relationship is renal function. A key limitation of our study is that we did not assess renal status. Diabetic nephropathy, even at a subclinical stage, can impair glomerular filtration and tubular secretion, thereby reducing the renal clearance of C-peptide. This could lead to artificially elevated UCP levels independent of insulin secretion, further obscuring any true correlation with glycemic control. This central finding suggests that UCP has limited utility as a potential non-invasive standalone diagnostic tool for diabetes mellitus or for assessing short- and long-term glycemic control. Although UCP levels may increase slightly with worsening glycemia, the relationship is not sufficiently strong to be predictive of glucose concentrations or HbA_1C levels. The weak associations observed are consistent with reports by (Leighton *et al.*, 2017; Uzunlulu *et al.*, 2019), who found that urinary C-peptide primarily reflects endogenous insulin secretion and β-cell reserve rather than current blood glucose levels. Similarly, (Brunskill, 2017) noted that urinary C-peptide excretion can be influenced by renal clearance, hydration status, and disease duration, factors which may explain the variability observed among participants in this study. Consequently, an individual can exhibit high UCP levels while experiencing hyperglycemia, a state characterized by ineffective insulin action rather than insufficient insulin production. (Jones & Hattersley, 2013) aptly noted that the main clinical utility of C-peptide measurement is to assess endogenous insulin secretion as a measure of beta-cell function. It is not a direct marker of glycaemia, a distinction that is crucial for interpreting our results. Therefore, our results support the perspective that UCP is a more relevant indicator of underlying beta-cell function than of direct glycemic status. This finding is consistent with studies conducted in other populations. A study by

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(Zhou *et al*., 2022) highlighted the complex relationship between UCP and renal function, demonstrating that urinary C-peptide excretion is influenced by glomerular filtration rate. This introduces another significant variable that may confound the interpretation of UCP levels independently of glycemic control, particularly in a population where undiagnosed renal impairment may be present. The non-invasive nature of UCP collection remains its most compelling advantage, especially in resource-limited settings like Kenya, where barriers to repeated phlebotomy can hinder monitoring. However, based on our findings, its application appears limited for diagnostic purposes. Instead, its potential value may lie in other clinical niches. (Jamiołkowska-Sztabkowska *et al*., 2021) demonstrated that UCP can reliably differentiate between type 1 and type 2 diabetes, a critical diagnostic challenge. Research by (Baidal *et al*., 2023) suggested that UCP has prognostic value, predicting glycemic response to certain therapies based on residual beta-cell function.

The observed weak correlations between UCP and the glycemic markers (FBS and HbA_1C) may also be explained by the physiological differences in what these biomarkers represent. Fasting blood sugar reflects immediate glucose homeostasis, while HbA_1C indicates long-term glycemic exposure over the preceding two to three months. Conversely, C-peptide is a marker of insulin secretion, released in equimolar amounts with endogenous insulin during proinsulin cleavage. Therefore, while elevated glucose levels often coincide with reduced insulin secretion in advanced diabetes, in early or compensatory stages of insulin resistance, C-peptide may remain relatively high despite poor glycemic control. This physiological variability explains the inconsistent linear association between UCP and glycemic indices seen in this study. In conclusion, urinary C-peptide could serve as a valuable adjunct biomarker in clinical practice, especially in low-resource settings such as Kenyatta National Hospital, where non-invasive and affordable diagnostic options are essential.

5.0 Conclusion

The study revealed that urinary C-peptide levels do not significantly correlate with standard glycemic markers in newly diagnosed type 2 diabetes patients. Therefore, it cannot be recommended as an independent noninvasive diagnostic biomarker for type 2 diabetes. Its potential clinical value may reside in assessing beta-cell functional capacity rather than diagnosing hyperglycemia. Although urinary C-peptide showed limited correlation with conventional glycemic markers, its non-invasive nature and stability make it a valuable adjunct marker for evaluating β-cell function. Clinically, UCP assessment could be particularly useful in differentiating type 2 diabetes from latent autoimmune diabetes in adults (LADA), evaluating residual insulin secretion in insulin-treated patients, or monitoring β-cell function decline over time. Its integration into clinical workflows could enhance personalized diabetes management in resource-limited settings where non-invasive testing is advantageous. Future studies with larger, more diverse cohorts are essential for a more profound understanding of the clinical applications of UCP in evaluating insulin resistance.

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5.1 Recommendations

Urinary C-peptide, while valuable as a non-invasive indicator of pancreatic beta-cell activity, should not be viewed as a replacement for gold-standard glycemic metrics such as fasting blood glucose (FBS) and glycated hemoglobin (HbA_1C) in the diagnosis of diabetes. These standard tests remain the cornerstone of clinical assessment due to their proven accuracy and reliability. We specifically recommend that future studies measure urinary C-peptide alongside urinary creatinine to report the urine C-peptide-to-creatinine ratio (UCPCR), which corrects for renal dilution and provides a more robust measure of C-peptide excretion. However, future correlative studies should measure urinary C-peptide alongside serum C-peptide, insulin, creatinine, and glomerular filtrate rate (GFR) to correct for kidney function, hydration, and improve the interpretation of urinary C-peptide levels.

5.2 Strengths and Limitations

A key strength of this study is its focus on an understudied African population. It may be the first to evaluate the association between urinary C-peptide levels and the standard glycemic controls among type 2 diabetes patients. We underscore the timely diabetes diagnosis to prevent diabetic complications associated with chronic hyperglycemia. However, primary limitations include a relatively small sample size and a cross-sectional design, which preclude inferences regarding causality or the longitudinal utility of UCP. Additionally, a methodological limitation was experienced due to the lack of urinary creatinine measurement. Consequently, UCP levels were not expressed as a urine C-peptide-to-creatinine ratio (UCPCR), which is the recommended standard to correct for urine concentration and hydration status. This omission may have introduced variability and weakened the observed correlations with glycemic markers. Since C-peptide is primarily cleared by the kidneys, undetected renal impairment or early diabetic nephropathy could have affected urinary C-peptide concentrations by reducing clearance and artificially inflating measured levels. This may partially explain the variability and weak correlations observed between urinary C-peptide and glycemic markers. not assessed, which could influence UCP levels.

6.0 Acknowledgements

I want to thank the administration and employees of Kenyatta National Hospital for allowing me to use the facilities for this study. I express my deepest appreciation to the Clinical Chemistry Laboratory staff for their cooperation and technical support throughout the sample collection and analysis process.

6.1 Ethical Considerations

A certificate of ethics review approval by the KNH-UoN Ethical Review Committee (Ref No: P471/06/2024) and a license by NACOSTI (Ref No: 839966) were issued. The study procedures

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were explained to all participants prior to enrolment, and written informed consent was obtained. Participants were assured of confidentiality and the right to withdraw from the study at any time without prejudice.

6.2 Conflict of interest:

The authors declare no conflict of interest.

6.3 Funding

None.

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