Jagua Publication

Healthcare Issues, 5(1):14–22, 2026. DOI: 10.58614/hi513

Healthcare Issues

Journal homepage: https://jpub.org/journal-details.php?journal-id=42

ISSN (E): 2583-7796

Research Article

Evaluation of Prostate-Specific Antigen and some Micronutrients in individuals with Type-II Diabetes Mellitus attending the University of Medical Science Teaching Hospital in Akure, Nigeria

Lawrence Folorunsho Dada [1*], Oluwanifemi Priscilla Shaba[2], Lucky Eromosele Omolumen[1], Kingsley Chinaedozi Osuji [3], Chidubem Augunus Onuoha [3], Rosemary Ebokhasomi Innih[4,5], Chikezie C Nwankwo[3], Samuel Oluboro[3], Nathaniel O Imafidon[6], Andrew Oseghale Eigbedion [7,8] and Kennedy Oberhiri Obohwemu [9]

[1]*Department of Chemical Pathology, Faculty of Medical Laboratory Science, Ambrose Alli University, Ekpoma, Edo State, Nigeria.*
[2]*Department of Medical Laboratory Science, Faculty of Allied Sciences, Elizade University, Ilara-Mokin, Ondo State, Nigeria.*
[3]*Department of Chemical Pathology, Faculty of Clinical Sciences, Ambrose Alli University, Ekpoma, Edo State, Nigeria.*
[4]*Department of Medical Laboratory Science, Edo University Iyamho, Ekpoma, Edo State, Nigeria.* [5] *Department of Histopathology and Cytopathology, Faculty of Medical Laboratory Science, Ambrose Alli University, Ekpoma, Edo State, Nigeria.*
[6]*Chemical Pathology Department, Irrua Specialist Teaching Hospital (ISTH), Irrua, Edo State, Nigeria.*
[7]*Department of Paediatrics, Faculty of Clinical Sciences, Ambrose Alli University, Ekpoma, Edo State, Nigeria.* [8] *Department of Paediatrics, Irrua Specialist Teaching Hospital, Irrua, Edo State, Nigeria.*
[9]*Department of Health & Social Care, Scholars School System, Leeds Trinity University Partnership, Birmingham Campus, United Kingdom and PENKUP Research Institute, Birmingham, United Kingdom.*
[*]*Corresponding author: kaw_dad2002@yahoo.com*

Article Info

Keywords: *Prostate-Specific Antigen, Micronutrients, Type-II Diabetes Mellitus, PSA, zinc, magnesium, and calcium.*

Received: *15.03.2026;*
Accepted: *29.04.2026;*
Published: *07.05.2026*

Abstract

Objective: Type II Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and relative insulin deficiency, frequently accompanied by alterations in micronutrient balance and enzymatic activity. These biochemical disturbances may influence both systemic metabolism and organ-specific markers such as Prostate-Specific Antigen (PSA). Understanding the relationship between T2DM and trace elements like zinc, magnesium, and calcium is vital for evaluating metabolic derangements and potential endocrine implications. This study aimed to assess serum levels of PSA, zinc, magnesium, and calcium among individuals with T2DM attending the University of Medical Sciences Teaching Hospital, Akure, and to explore interrelationships among these biochemical parameters.
Materials and Methods: A cross-sectional study was conducted involving 75 male participants, comprising 60 diagnosed T2DM patients and 15 non-diabetic controls. Blood samples were analyzed for fasting blood sugar (FBS), zinc, magnesium, calcium, and PSA using spectrophotometric and enzyme-linked immunosorbent assay (ELISA) methods. Data were analyzed using SPSS version 29.0, employing descriptive statistics, one-way ANOVA, and Pearson correlation, with a significance threshold of $p < 0.05$.
Results: Results revealed significantly elevated mean fasting blood sugar in diabetic subjects ($p < 0.001$) relative to controls, with progressive increases corresponding to the duration of diabetes. Conversely, serum zinc, magnesium, and calcium levels were significantly lower in T2DM patients compared to controls ($p < 0.001$), indicating persistent trace element depletion associated with disease chronicity. PSA levels, although slightly higher among diabetics, remained within the physiological range and did not differ significantly between groups ($p = 0.408$). Correlation analysis showed a moderate positive relationship between zinc and magnesium ($r = +0.437$, $p = 0.000$) and a moderate negative correlation between magnesium and calcium ($r = –0.345$, $p = 0.007$), suggesting metabolic interdependence among these minerals. **Conclusion:** In conclusion, T2DM is associated with significant reductions in zinc, magnesium, and calcium levels, reflecting disturbances in mineral metabolism and oxidative balance, whereas PSA remains largely unaffected. These findings highlight the importance of monitoring trace element status alongside glycemic indices in diabetic management to mitigate metabolic complications and maintain systemic homeostasis.

How To Cite: L.F. Dada, O.P. Shaba, L.E. Omolumen, K.C. Osuji, C.A. Onuoha, R.E. Innih, C.C. Nwankwo, S.O. Olubori, N.O. Imafidon, A.O. Eigbedion, K.O. Obohwemu. Evaluation of Prostate-Specific Antigen and some Micronutrients in individuals with Type-II Diabetes Mellitus attending the University of Medical Science Teaching Hospital in Akure, Nigeria. *Healthcare Issues*, 5(1):14–22, 2026. https://doi.org/10.58614/hi513

1. Introduction

Type II Diabetes Mellitus (T2DM) is a complex metabolic disorder characterized by insulin resistance and relative insulin deficiency. It is a major global health concern with significant systemic implications, including alterations in biochemical markers and micronutrient metabolism. Chronic hyperglycemia in T2DM affects various physiological processes, including those associated with trace element homeostasis, oxidative stress, and enzymatic functions, which may have downstream effects on organ systems including the prostate. Type II Diabetes Mellitus (T2DM) has been increasingly recognized not just as a disorder of carbohydrate metabolism, but as a systemic condition that affects various biochemical and physiological pathways. Among these, disturbances in trace element status, enzymatic activities, and hormonal markers especially those related to the prostate are of growing concern. Yet, there remains a paucity of local data exploring these interconnections in diabetic populations, particularly in sub-Saharan Africa.

Prostate-Specific Antigen (PSA) is a serine protease produced by the prostate epithelium, commonly used as a biomarker for prostate health. Though predominantly utilized in screening for prostate malignancies, emerging evidence suggests its levels might be influenced by metabolic conditions such as T2DM. Prostate-specific antigen (PSA) is widely recognized as a marker for prostatic conditions, yet emerging research suggests its levels may be altered in metabolic diseases, including T2DM, potentially reflecting subclinical prostatic inflammation or hormonal imbalances. Similarly, zinc a critical micronutrient for insulin metabolism and antioxidant defense has been consistently reported at deficient levels among individuals with diabetes, which may contribute to oxidative stress and enzymatic dysfunction. Acid phosphatase, particularly in its prostatic form, is a zinc-dependent enzyme whose activity may be modulated by changes in zinc status and systemic inflammation. Altered PSA levels in diabetic men may indicate subtle prostatic changes or hormonal disruptions associated with diabetes [1].

Prostate-Specific Antigen (PSA), though primarily used in prostate cancer screening, may also reflect systemic and metabolic disturbances. Zinc has been shown to influence PSA expression and secretion, suggesting a possible biochemical link between micronutrient status and prostatic function in T2DM patients [2]. Furthermore, studies have documented significant associations between PSA and zinc levels in non-cancerous prostatic conditions, implying that changes in PSA might serve as early indicators of metabolic dysregulation [3].

Zinc is an essential trace element that plays a crucial role in insulin synthesis, storage, and secretion. It is also known for its antioxidant properties and modulatory effects on various enzymes. Zinc deficiency has been implicated in the progression of T2DM due to its association with increased oxidative stress and impaired glucose metabolism. Notably, studies have reported significantly reduced serum zinc levels among individuals with T2DM, which may also influence the activity of acid phosphatase enzymes and other metabolic markers relevant to prostate function [4]. Zinc plays a vital role in insulin metabolism and antioxidant defense, and its deficiency has been repeatedly linked to worsening glycemic control and oxidative stress in T2DM patients. A recent systematic evaluation confirmed that zinc supplementation can improve glycemic outcomes, highlighting its central role in diabetes management [5]. However, the relationship between zinc levels and other physiological markers, such as PSA and acid phosphatase, has not been sufficiently explored in diabetic individuals.

Magnesium is another essential mineral that plays a pivotal role in glucose metabolism, insulin signaling, and energy production. It acts as a cofactor in more than 300 enzymatic reactions, many of which are critical for carbohydrate and lipid metabolism. Hypomagnesemia has been consistently reported in individuals with T2DM and is associated with insulin resistance, poor glycemic control, and increased risk of diabetic complications [6]. Magnesium deficiency also contributes to oxidative stress and low-grade inflammation, thereby worsening metabolic outcomes. Evaluating magnesium status in T2DM patients is therefore important for understanding the metabolic imbalances that accompany the disease.

Calcium, a key intracellular messenger, is also closely linked to insulin secretion and action. Proper calcium signaling is required for pancreatic β-cell function and glucose-stimulated insulin release. Dysregulation of calcium homeostasis has been reported in T2DM patients, contributing to impaired insulin secretion, increased insulin resistance, and vascular complications [7]. Furthermore, calcium interacts with other micronutrients such as magnesium and zinc in maintaining metabolic stability, suggesting that alterations in its levels may have broader implications for endocrine and organ health in diabetes.

Given the interdependence between metabolic dysregulation in T2DM, trace element homeostasis, enzymatic activities, and prostate health markers, evaluating PSA, zinc levels, magnesium, and calcium, provides a compelling diagnostic and research interest. Investigating these parameters among diabetic individuals at the University of Medical Science Teaching Hospital, Akure, may offer valuable insights into the metabolic and endocrine alterations characteristic of this population and could help inform targeted interventions and patient monitoring strategies.

In addition to zinc, magnesium and calcium are increasingly recognized as important players in T2DM pathophysiology. Hypomagnesemia is common in diabetic patients and has been associated with poor glycemic control, heightened insulin resistance, and increased risk of complications [6]. Likewise, calcium imbalance may impair pancreatic β-cell function and insulin release, further exacerbating metabolic dysregulation [7]. Yet, few studies in Sub-Saharan Africa have investigated these parameters together in the diabetic population.

Magnesium and Calcium are integral to glucose regulation and insulin function. Magnesium deficiency is common in diabetes and has been associated with increased insulin resistance, poor glycemic control, and higher risk of complications [6]. Calcium, on the other hand, is essential for pancreatic β-cell function and insulin secretion, and its imbalance has been linked to impaired glucose tolerance and vascular complications [7]. Despite their established biological importance, little is known about how magnesium and calcium interact with prostate-related markers in T2DM patients, particularly in African populations.

The potential for these markers to reflect both metabolic control and subclinical organ dysfunction, their concurrent evaluation in T2DM patients could provide critical insights into disease progression and complication risk. Despite the potential clinical relevance of these markers, few studies have concurrently assessed PSA, zinc levels, magnesium, and calcium in the context of T2DM in Sub-Saharan Africa. The lack of localized data limits the ability of healthcare providers to identify subclinical complications or metabolic trends that may inform patient management strategies. Therefore, this study seeks to fill a critical knowledge gap by evaluating these biochemical parameters among individuals with T2DM attending the University of Medical Science Teaching Hospital in Akure, thereby contributing to the broader understanding of diabetes-associated biochemical alterations in a Nigerian. This study is justified not only by the scientific gaps in the literature but also by the urgent need for region-specific data that can inform clinical practice in settings like the University of Medical Science Teaching Hospital, Akure.

2. Materials and Methods

2.1. Study Area

This study was undertaken at Akure South Local Government Area in the University of Medical Sciences Teaching Hospital, Akure Ondo State Nigeria.

2.2. Study Population

The current estimated population of Akure South Local Government Area is put at 803,062 inhabitants (Ministry Economic Planning and Budget Akure, 2025). Hence this study was drawn from A total of 75 adult subjects ($\geq$ 18 years) attending the medical outpatient clinic of the University of Medical Science Teaching Hospital, Akure.

2.3. Study Design

This study adopted an observational comparative cross-sectional design, aimed at evaluating and comparing the serum PSA, Zinc, Magnesium and Calcium levels among male individuals diagnosed with Type II Diabetes Mellitus (T2DM) and non-diabetic male controls. This design is appropriate because it enables simultaneous measurement and comparison of the biochemical parameters of interest at a single point in time, without any intervention or manipulation

2.4. Consent and Ethical Consideration

Subjects who participated in this study were fully briefed in the research protocols, after which they were required to sign a written consent form. Ethical approval was duly obtained from the Ethical Review Committee of the University of Medical Sciences Teaching Hospital Akure.

2.5. Inclusion Criteria

This study consisted of male individuals aged between 30 to 70 years. Participants must either had a confirmed clinical diagnosis of Type II Diabetes Mellitus, in the case of the diabetic group, or no history or current diagnosis of diabetes for those in the control group. Only participants who provided informed consent and demonstrate willingness to participate in the study were included.

2.6. Exclusion Criteria

To ensure the validity and reliability of the data, certain individuals were excluded from the study. These included any male individuals with a prior diagnosis of prostate cancer, benign prostatic hyperplasia (BPH), or any other known prostatic disorder, as these conditions could independently affect PSA levels. Additionally, individuals currently undergoing treatment with zinc supplements, antioxidants, hormonal therapies, or medications known to interfere with the biochemical markers under investigation were excluded. Patients with chronic kidney disease, liver dysfunction, or any inflammatory or infectious condition that may influence serum zinc or enzyme levels were also not be eligible. Lastly, any participant who has undergone recent urological procedures or prostate manipulation within four weeks prior to sample collection were excluded to avoid false elevations in PSA and enzyme readings

2.7. Sample Size Determination

Population of study will be determined using the formula

$$s = \frac{a^2bc}{d^2}$$ sample size greater than 10,000 [8].

S=sample size greater than 10,000.
Where S= the desired sample size (when population is greater than 10,000)
a= is a constant given as 1.96 which corresponds to the 95% Confidence level.
b= expected prevalence of 60.0%= 0.60 [9].
c = [1 - b] = [1 – 0.05] = 0.95
d = margin of error = 5% = 0.05 [9].

$$s = \frac{1.96^2 \times 0.05 \times 0.95}{0.05^2}$$

S = 72.9, approx. 73
Therefore 75 participants were enrolled for the study.

3. Research Procedure

3.1. Sample Collection

A total of 6 ml of fasting venous blood was aseptically collected from the antecubital vein of each subject using a sterile disposable needle and syringe. The collected blood was dispensed into two containers: 2 ml into a plain vacutainer tube for serum analysis of Prostate-Specific

Antigen (PSA), 2ml into fluoride oxalate and the remaining 2 ml into a lithium heparinized tube for serum Zinc, Calcium and Magnesium estimation. The sample in the lithium heparinized container was gently mixed to prevent clotting and then centrifuged at 3000 revolutions per minute (rpm) for 10 minutes to separate plasma. Similarly, the blood in the plain container was allowed to clot at room temperature and then centrifuged under the same conditions. The resulting serum and plasma were carefully transferred into appropriately labelled sterile plain containers and stored at –20°C until biochemical analysis.

3.2. Analytical Methods

Measurement of Serum Zinc, Magnesium, Calcium and Glucose, was assayed using Spectrophotometric method. Measurement of Prostate-Specific Antigen (PSA) was done using Enzyme-Linked Immunosorbent Assay (ELISA) method, utilizing a commercial PSA ELISA kit based on the sandwich principle.

3.3. Principles of Methods

Principle of Serum Zinc, Calcium and Magnesium, Glucose and PSA

- **For Serum Zinc:** Zinc forms with 2-(5-Bromo-2-pyridylazo)-5-(N-propyl-Nsulfopropylamino)-phenol a red chelate complex. The increase of absorbance can be measured and is proportional to the concentration of total zinc in the sample [10].
- **For Calcium:** At a neutral pH the Ca^{2+} form with Arsenazo III a complex, the color intensity of which is directly proportional to the concentration of calcium in the sample [11].
- **For Magnesium:** Magnesium ions form a colored chelate complex when reacting with Phosphonazo III, the intensity of the color is proportional to the magnesium concentration. Calcium ions are masked by EGTA [12].
- **For Glucose:** Glucose is determined after enzymatic oxidation in the presence of glucose oxidase. The hydrogen peroxide formed reacts, under catalysis of peroxidase, with phenol and 4-aminophenazone to form a red-violet quinonimine dye as indicator [13].

Principle Of Prostate-Specific Antigen (PSA) (Enzyme-Linked Immunosorbent Assay (ELISA) method)

The ELISA method is based on the principle of antigen-antibody binding specificity. In the sandwich ELISA format used for PSA detection, the microplate wells are coated with a capture antibody specific to PSA. The sample is added and PSA binds to the capture antibody. A secondary enzyme-linked antibody is added which binds to the PSA. Upon addition of a chromogenic substrate, the enzyme catalyzes a color reaction. The intensity of the color formed is directly proportional to the PSA concentration and is measured spectrophotometrically [14].

3.4. Sample Analysis

For Serum Zinc Estimation

- **Reagent Preparation, Storage and Stability:** Spectrum Zinc reagents are supplied ready-to-use and stable until expiration date stated on label when stored refrigerated at 2 - 8°C. Once opened, the reagent and standard are stable for 3 months at the specified temperature if contamination is avoided.
- **Procedure:** According to manufacturer's instructions [10].

For Magnesium Estimation

- **Reagent Preparation, Storage and Stability:** The reagents are supplied ready to use. Magnesium reagent is stable up to the expiry date stated on the vial label when stored at 2 - 8°C. once opened, the reagent and standard are stable for 3 months at the specified temperature if contamination is avoided.
- **Procedure:** According to manufacturer's instructions [12].

For Calcium Estimation

- **Reagent Preparation, Storage and Stability:** The reagents are supplied ready to use. Calcium reagent is stable up to the expiry date stated on the vial label when stored at 2 - 8°C. Once opened, the reagent and standard are stable for 3 months at the specified temperature if contamination is avoided.
- **Procedure:** According to manufacturer's instructions [11].

For Glucose Estimation

Principle
Glucose is determined after enzymatic oxidation in the presence of glucose oxidase. The hydrogen peroxide formed reacts, under catalysis of peroxidase, with phenol and 4-aminophenazone to form a red - violet quinoneimine dye as indicator.
Storage and Stability
All the components of the kit are stable until the expiration date on the label when stored tightly closed at 2 - 8°C, protected from light and contaminations prevented during their use. Do not use reagents over the expiration date.

According to manufacturer's instructions [13].

For Prostate-Specific Antigen (PSA)

Reagent Preparation:

1. Wash Buffer Dilute contents of wash concentrate to 1000 ml with distilled or deionized water in a suitable storage container. Store diluted buffer at 2-30°C for up to 60 days.
2. Working Substrate Solution – Stable for one year Pour the contents of the amber vial labeled Solution 'A' into the clear vial labeled Solution 'B'. Place the yellow cap on the clear vial for easy identification. Mix and label accordingly. Store at 2 - 8°C.
(Note 1: Do not use the working substrate if it looks blue. Note 2: Do not use reagents that are contaminated or have bacteria growth)

Procedure: According to manufacturer's instructions [12].

3.5. Statistical Analysis

A statistical package for social sciences (SPSS) 29.0 versions was used for the analysis of the data appropriately. One-way analysis of variance (ANOVA), the student's t-test and Pearson's correlation was used to test the association between variables. Data was then presented using mean ± standard deviation (mean ± SD) for all quantitative values. The level of significance was taken at a 95% confidence interval and $P < 0.05$ was considered significant.

4. Results

4.1. Characteristics of Participants in the Study

Table 1: Sociodemographic and Clinical Characteristics of Participants

Variable	Category	Frequency (n=75)	Percentage (%)
Group	T2DM (Test)	60	80
	Control	15	20
Age Group (years)	<40	12	17.1
	41-50	11	15.7
	51-60	21	30
	61-70	13	18.6
	71-80	14	20
	>81	4	5.7
	Mean ±S.D	59.4 ± 13.2	
DM Diagnosis Duration	1-5 years	24	40
	6-10 years	17	28.3
	>10 years	19	31.6
Marital Status	Married	48	64
	Single	18	24
	Widowed	9	12
Education Level	Illiterate	9	12
	Secondary	4	5.3
	Tertiary	62	82.7
Occupation	Civil Servant	27	36
	Retired	23	30.7
	Student	6	8
	Farmers	10	13.3
	Others	9	12
Religion	Christianity	66	88
	Islam	9	12
Common Medications	Metformin	40	66.7
	Sulfonylureas	12	20
	Thiazolidinediones	8	13.3
Family History of DM	Yes	18	30
	No	42	70
Prostate Condition	Yes	4	6.7
	No	56	93.3
Alcohol Intake	Yes	8	13.3
	No	52	86.7

Table 1 summarizes the sociodemographic and clinical characteristics of the 75 male participants enrolled in this study, comprising 60 (80.0%) individuals with Type II Diabetes Mellitus (T2DM) and 15 (20.0%) non-diabetic controls. The participants' ages ranged from below 40 to above 70 years, with the mean age of 59.4 ± 13.2 years, indicating that the population was predominantly middle-aged to elderly. The 51–60years age groups constituted 30.0%, representing the most common age bracket. Duration for which T2DM had been diagnosed for the disease showed that most of the test subjects (40.0%) were just recently diagnosed of the disease within the duration

of 1-5 years. Marital distribution showed that 64.0% were married, while 24.0% were single and 12.0% widowed. Educationally, a vast majority (82.7%) attained tertiary education, followed by participants (12.0) with no formal education. Occupationally, civil servants (36.0%) and retirees (30.7%) made up the majority, while traders, students, and others accounted for the remaining share. Religiously, Christianity (88.0%) was predominant, with only 12.0% identifying as Muslims. Among the diabetic group, all were on some form medication, with Metformin (66.7%) being the most common drug. A positive family history of diabetes was reported in 30.0% of participants. Only 6.7% had a documented prostate condition, and 13.3% reported alcohol use.

Overall, the study population represents a well-educated, middle-aged male cohort, predominantly Christian, with most diabetic participants adhering to hypoglycaemic therapy.

Table 2 presents the mean and standard deviation of fasting blood sugar (FBS), zinc, magnesium, calcium, and prostate-specific antigen (PSA) levels among participants. FBS was markedly elevated across all diabetic subgroups relative to controls, showing a progressive increase with the duration of diabetes, indicative of declining glycemic control over time. Serum zinc, magnesium, and calcium concentrations were significantly reduced in T2DM individuals compared with non-diabetic controls, and values tended to decline further with increasing duration of disease. These findings suggest persistent oxidative stress and impaired mineral metabolism in chronic diabetes. PSA levels were within the physiological reference range in all groups but showed a gradual rise among long-term diabetics, implying possible subclinical prostatic changes associated with metabolic alterations. Overall, the data indicate that prolonged diabetes is associated with hyperglycemia, trace-element depletion, and mild elevations in PSA, reflecting systemic metabolic and endocrine effects of the disease.

Table 2: Descriptive Statistics of Biochemical Parameters among Study Groups According to Disease Duration

Parameter	GROUP 1 (Control) (n = 15)	GROUP 2 (T2DM 1-5) yrs (n = 24)	GROUP 3 (T2DM 6-10) yrs (n = 17)	GROUP 4 (T2DM >10) yrs (n = 19)	Remark
FBS (mg/dL)	85.67 ± 12.18	202.7 ± 69.16	168.08 ± 52.59	221.88 ± 90.34	Elevated in diabetics and increases with duration
Zinc (µmol/L)	172.6 ± 13.67	74.78 ± 32.19	87.82 ± 44.17	68.66 ± 7.76	Significantly reduced in diabetics ($p<0.05$)
Magnesium (mg/dL)	1.66 ± 0.30	0.74 ± 0.52	0.89 ± 0.43	0.45 ± 0.33	Significantly reduced in all diabetics group ($p<0.05$)
Calcium (mg/dL)	8.38 ± 0.73	6.85 ± 0.77	6.64 ± 0.44	7.35 ± 1.38	Lower in diabetics compared ($p<0.05$)
PSA (ng/mL)	2.45 ± 1.40	7.21 ± 12.35	5.81 ± 5.19	4.36 ± 5.37	Within normal physiological range

Table 3 shows the one-way ANOVA comparison of mean biochemical parameters across the four study groups. A statistically significant difference ($p < 0.05$) was observed in all parameters analyzed. FBS, Zinc, Magnesium, and Calcium levels showed highly significant differences ($p < 0.001$), while PSA demonstrated a non-significant variation ($p = 0.408$). Zinc, Magnesium, and Calcium concentrations were significantly lower among diabetic groups, showing a clear downward trend with disease chronicity. PSA levels did not differ much between the diabetic and control groups. These results confirm that Type II diabetes mellitus significantly alters trace element balance and glycemic markers, but does not have a significant effect on prostatic health.

Table 3: One-Way ANOVA of Biochemical Parameters among Study Groups

Parameter	Sum of Squares (Between)	Df	Mean Square	F-value	p-value	Remark
FBS (mg/dL)	181,424.00	3	60474.68	16.31	0	Significant
Zinc (µmol/L)	111,975.90	3	37325.29	40.31	0	Significant
Magnesium (mg/dL)	11.07	3	3.69	17.7	0	Significant
Calcium (mg/dL)	34.98	3	11.66	20.12	0	Significant
PSA (ng/mL)	267.14	3	89.05	0.98	0.408	Not Significant

Table 4 shows the Pearson's correlation coefficients between selected biochemical parameters among individuals with Type II Diabetes Mellitus (T2DM). A moderate negative correlation ($r = –0.345$, $p = 0.007$) was observed between serum magnesium and calcium levels, indicating as magnesium levels increase, calcium tends to decrease. Since the p-value is <0.05, this relationship is statistically significant among the diabetic population. A weak negative correlation ($r = +0.027$, $p = 0.840$) was found between PSA and zinc levels, suggesting that PSA and zinc levels move in the same direction but very weakly. The high p-value shows it is not statistically significant. Zinc also showed a moderate positive correlation with magnesium ($r = +0.437$, $p = 0.000$) indicating that higher magnesium levels are associated with higher zinc levels. The relationship is highly significant, while FBS demonstrated weak negative correlations with zinc ($r = –0.132$, $p=0.314$) suggesting that higher fasting blood sugar (FBS) may slightly correspond to lower zinc, but the relationship is not statistically significant. FBS also has a weak negative correlation with PSA ($r = –0.218$, $p = 0.095$) meaning as blood sugar increases, PSA may slightly decrease. However, since $p > 0.05$, this is not statistically significant.

Table 4: Pearson's Correlation Analysis among Selected Biochemical Parameters in T2DM Subjects

Parameters Correlated	Correlation Coefficient (r)	p-value	Remark
Magnesium vs Calcium	–0.345	0.007	Moderate negative correlation (significant)
PSA vs Zinc	+0.027	0.840	Weak positive correlation (not significant)
Zinc vs Magnesium	+0.437	0.000	Moderate positive correlation (significant)
FBS vs Zinc	–0.132	0.314	Weak negative correlation (not significant)
FBS vs PSA	–0.218	0.095	Weak negative correlation (not significant)

5. Discussion

This study investigated the serum levels of zinc, magnesium, calcium, and prostate-specific antigen (PSA) among individuals with Type II Diabetes Mellitus (T2DM) compared with non-diabetic controls attending the University of Medical Science Teaching Hospital, Akure. Findings from this study revealed significant alterations in trace element concentrations among diabetic participants, particularly reductions in zinc, magnesium, and calcium, while PSA levels remained largely within normal physiological ranges. These observations are consistent with previously documented biochemical patterns in diabetes-related metabolic dysregulation and mineral imbalance.

The mean serum zinc concentration among T2DM participants was markedly reduced compared with non-diabetic controls, with the lowest values observed among subjects with a disease duration exceeding ten years. This decline supports the findings of [4, 15], who both reported significant zinc depletion in diabetic populations. The reduced zinc status in diabetes may reflect increased urinary zinc excretion, oxidative stress, and impaired intestinal absorption as described by [16, 17]. Zinc plays an integral role in insulin synthesis and secretion, and its deficiency can aggravate β-cell dysfunction and insulin resistance [18]. The negative but non-significant correlation between fasting blood sugar (FBS) and zinc observed in this study ($r = –0.132$, $p = 0.314$) further suggests that chronic hyperglycemia may contribute to progressive zinc depletion, consistent with the work of [19] who emphasized the bidirectional association between altered zinc homeostasis and glucose intolerance.

Magnesium and Calcium concentrations were significantly lower among diabetic individuals relative to controls, showing a progressive decline with increasing duration of illness. This aligns with the reports of [2, 6], who found that hypomagnesemia is a common biochemical feature of T2DM and correlates with poor glycemic control. Magnesium is a vital cofactor for enzymes involved in glucose metabolism and insulin receptor signalling; therefore, its deficiency impairs both insulin secretion and action. Similarly, reduced serum calcium observed in this study corresponds with findings by [7, 20], who reported lower calcium levels in Nigerian diabetic populations. The observed moderate negative correlation between magnesium and calcium ($r = –0.345$, $p = 0.007$) supports the interdependent nature of these minerals in maintaining cellular ionic balance, as discussed by [21]. These relationships highlight that persistent hypomagnesemia may alter calcium transport and homeostasis, thereby compounding metabolic disturbances in diabetes.

The significant positive correlation between zinc and magnesium ($r = +0.437$, $p = 0.000$) also agrees with [22], who noted that zinc and magnesium function synergistically in antioxidant defense and enzymatic regulation. Collectively, these findings show the importance of assessing multiple trace elements concurrently, as deficiencies rarely occur in isolation in chronic metabolic disorders.

In this study, PSA levels remained within the normal reference range across all groups, and the difference between diabetic and control subjects was not statistically significant ($p = 0.408$). This observation corroborates reports by [23], which concluded that men with diabetes tend to exhibit slightly lower or comparable PSA levels compared to non-diabetic men. The lack of significant PSA elevation suggests that T2DM may not independently increase prostatic activity or cancer risk. Crawley et al. (2021) [24] also noted that while T2DM can influence prostate cancer outcomes, its direct impact on PSA concentration is minimal.

Furthermore, the weak and non-significant positive correlation between PSA and zinc ($r = +0.027$, $p = 0.840$) aligns with the work of [3, 25], who observed inconsistent associations between zinc status and PSA levels in non-malignant conditions. This implies that mild variations in zinc do not necessarily translate to changes in PSA synthesis or secretion. Nonetheless, [26, 27] emphasized that chronic zinc imbalance may still have long-term implications for prostate health, warranting continuous monitoring in diabetic males.

Fasting blood sugar values were markedly elevated in all diabetic subgroups compared to controls, increasing progressively with disease duration. This trend reflects deteriorating glycemic control with longer diabetes history, consistent with the observations of [17, 28], who highlighted that β-cell dysfunction and insulin resistance intensify over time. The weak inverse correlations between FBS and both zinc ($r = –0.132$) and PSA ($r = –0.218$) indicate that hyperglycaemia may slightly suppress these parameters, though the relationships were not statistically significant. These findings collectively support the notion that poor metabolic control in T2DM is accompanied by micronutrient depletion and subtle endocrine alterations.

The statistically significant one-way ANOVA results for zinc, magnesium, and calcium ($p < 0.001$) confirm that diabetes exerts a strong effect on mineral metabolism. These findings are in agreement with [8], who documented similar trace element derangements in diabetic patients in Owo, Nigeria. Conversely, the non-significant PSA variation supports conclusions by [1] that PSA changes in diabetics are generally minimal in the absence of overt prostatic disease. The overall pattern of mineral depletion and stable PSA values observed in this study thus aligns closely with existing biochemical and clinical evidence across Nigerian and global studies.

In clinical applications, these findings highlight the necessity of routine monitoring of trace elements in diabetic care, as their deficiencies may worsen oxidative stress, insulin resistance, and secondary complications. Supplementation with zinc and magnesium, as supported by [5], could offer adjunctive benefits in metabolic control. Furthermore, despite normal PSA levels, periodic prostate assessment remains advisable in male diabetics given the subtle endocrine interconnections described by [26, 29].

6. Conclusion

This study assessed serum levels of prostate-specific antigen (PSA), zinc, magnesium, and calcium among Type II Diabetes Mellitus (T2DM) individuals attending the University of Medical Science Teaching Hospital, Akure, and compared them with non-diabetic controls. The findings demonstrated that chronic hyperglycemia in T2DM is associated with marked reductions in essential trace elements particularly Zinc,

Magnesium, and Calcium while PSA levels remained within normal physiological limits across all participant groups. The significant decline in Zinc, Magnesium, and Calcium concentrations with increasing disease duration underscores the progressive metabolic and oxidative derangements that accompany poorly controlled diabetes. These biochemical imbalances may contribute to worsening insulin resistance, impaired β-cell function, and increased risk of secondary complications.

The absence of significant differences in PSA levels between diabetic and control subjects suggests that T2DM does not independently exert a substantial effect on prostatic secretory function or PSA synthesis. However, the slight upward trend observed in long-term diabetics may reflect early metabolic or inflammatory influences on the prostate, which warrant continued surveillance.

Overall, the results of this study confirm that T2DM alters mineral homeostasis but has minimal direct influence on PSA levels. These findings support the need for integrated metabolic management strategies that include micronutrient monitoring alongside conventional glycaemic control measures in diabetic care.

Regular biochemical assessment of zinc, magnesium, and calcium should be incorporated into the routine management of Type II Diabetes Mellitus patients. Early identification and correction of deficiencies may help improve metabolic stability and prevent complications associated with long-term mineral imbalance. Dietary counseling emphasizing foods rich in zinc and magnesium (e.g., seafood, legumes, nuts, and whole grains) should be encouraged. In patients with documented deficiencies, clinically supervised supplementation should be considered to enhance insulin sensitivity and antioxidant defense. Although PSA levels were not significantly affected in this study, periodic prostate evaluation is advised for male diabetic patients above 50 years of age. This is to ensure early detection of subclinical prostatic alterations that may arise from chronic metabolic stress.

Article Information

Acknowledgements: The authors would like to acknowledge the management of the University of Medical Sciences Teaching Hospital Akure, Ondo State Nigeria for creating the enabling environment for this study. Thanks to all the Laboratory and technical staff of St Kenny Diagnostic and Research Centre, Ekpoma, Edo State, Nigeria for their excellent assistance and for providing medical writing support/editorial support in accordance with Good Publication Practice (GPP3) guidelines.

Authors' Contribution: Lawrence Folorunsho DADA - Conceptualization, Supervision; Oluwanifemi Priscilla SHABA - Methodology, Writing – original draft; Rosemary Ebokhasomi INNIH - Methodology; Andrew Oseghale EIGBEDION and Samuel OLUBORO - Data curation; OBOHWEMU Oberhiri Kennedy and Nathaniel O IMAFIDON - Formal analysis;

Funding: This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Disclosure of Conflict of Interest: The authors declare no conflicts of interest. The authors alone are responsible for the content and the writing of the paper.

Ethical Approval: The study was approved by the Ethical approval was duly obtained from the Ethical Review Committee of the University of Medical Sciences Teaching Hospital Akure (Approval No. ERC-2025-137).
Statement of informed consent: Informed consent was obtained from all individual participants included in the study.

Availability of Data and Materials: The authors declare consent for all available data present in this study.

Reporting Guidelines Statement: STROBE (observational studies).

Disclaimer (Artificial Intelligence): The author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.), and text-to-image generators have been used during writing or editing of manuscripts.

References

[1] W. E. Olooto, A. A. Oyelekan, O. O. Adewole, A. O. Fajobi, A. A. Adedo, and O. Olasimbo. Serum gonadotropins, cortisol, PSA, and micronutrient levels among men with prostate carcinoma. *African Journal of Urology*, 27(1):1–8, 2021.

[2] I. M. Bello and A. Mohammed. Impact of Magnesium Deficiency on Pancreatic β -Cell Function in Type 2 Diabetic Nigerians. 11(2): 87–92, 2022.

[3] G. M. Radhi, N. N. Aziz Hilal, and Ohammed M. A. Relationship between PSA and Serum Zinc in BPH-Afflicted Iraqi Men. *South Asian Research Journal of Pharmaceutical Sciences*, 5(04):158–167, 2023.

[4] D. Pushparani. Low serum zinc and increased acid phosphatase activity in type 2 diabetes mellitus with periodontitis subjects. *Biochemistry Pharmacology: Open Access*, 04(02), 2022.

[5] K. Ghaedi, D. Ghasempour, M. Jowshan, M. Zheng, S. Ghobadi, and A. Jafari. Effect of zinc supplementation in the management of type 2 diabetes: A grading of recommendations assessment, development, and evaluation-assessed, dose-response meta-analysis of randomized controlled trials. *Critical Reviews in Food Science and Nutrition*, pages 15–17, May 2023.

[6] T. A. Azeez and O. O. Sonuga. Hypomagnesemia as a Cardiometabolic Risk Marker in Type 2 Diabetes Mellitus : Implications for Sub - Saharan Africa. *29–32*, 2021.

[7] O. O. Odusan, O. B. Familoni, A. O. Odewabi, A. O. Idowu, and A. S. Adekolade. Patterns and Correlates of Serum Magnesium Levels in Subsets of Type 2 Diabetes Mellitus Patients in Nigeria. *439–442*, 2021.

[8] F. O. Ajao, T. G.-G. Olusegun, B. O. Oyeromi, and E. I. Obeagu. Evaluation of Some Serum Minerals in Type 2 Diabetic Patients Attending Federal Medical Centre Owo. 2024.

[9] M. A. Olamoyegun, K. Alare, S. A. Afolabi, and N. Aderinto. A systematic review and meta - analysis of the prevalence and risk factors of type 2 diabetes mellitus in Nigeria. *Clinical Diabetes and Endocrinology*, pages 1–13, 2024.

[10] D. Spectrum Zinc. Spectrum Zinc. 2025.

[11] A. Agape Calcium. Agape Diagnostic Kit Calcium. 7151:200–201, 2025.

[12] P. Spectrum Magnesium. MAGNESIUM Phosphonazo. pages 0–1, 2025.

[13] Randox. Glucose (Gluc-Pap). pages 1–4, 2025.

[14] E. Psa Accubind. Total Prostate Specific Antigen (PSA) Test System Product Code : 2125-300. m, 1–2. 2025.

[15] M. F. Javaid, S. Rasheed, A. Siddiqui, B. Habib, and E. R. Chaudhry. Zinc De ciency in Type II Diabetes Mellitus. *86–89*, 2024.

[16] M. I. Costa, A. B. Sarmento-Ribeiro, and A. C. Gonçalves. Zinc : From biological functions to therapeutic potential. *1–26*, 2023.

[17] I. M. Chung, G. Rajakumar, U. Subramanian, B. Venkidasamy, V. G. Khanna, and M. Thiruvengadam. Insights on the current status and advancement of diabetes mellitus type 2 and to avert complications: An overview. *Biotechnology and Applied Biochemistry*, 67(6): 920–928, 2020. URL https://doi.org/10.1002/bab.1853.

[18] L. I. Stiles, K. Ferrao, and K. J. Mehta. Role of zinc in health and disease. *Clinical and Experimental Medicine*, 24(1):1–19, 2024.

[19] A. Chu, M. Foster, and S. Samman. Zinc status and risk of cardiovascular diseases and type 2 diabetes mellitus—A systematic review of prospective cohort studies. *Nutrients*, 8(11):1–19, 2022.

[20] A. Z. Ogunleye and M. F. Asaolu. Evaluation of Macro Minerals in Patients with Type II Diabetes Mellitus in Southern Nigeria. 2013: 1–9, 2020.

[21] K. Paul. Seminal Oxidative Stress Markers, Calcium, Magnesium and Semen Profile of Infertile Diabetic and Nondiabetic Nigerian Men. pages 159–164, 2020.

[22] R. Patil, T. Sontakke, A. Biradar, and D. Nalage. Zinc : an essential trace element for human health and beyond. 5(3):1–7, 2023.

[23] M. C. Bernal-Soriano, B. Lumbreras, I. Hernández-Aguado, M. Pastor-Valero, M. López-Garrigos, and L. A. Parker. Untangling the association between prostate-specific antigen and diabetes: A systematic review and meta-analysis. *Clinical Chemistry and Laboratory Medicine*, 59(1):11–26, 2021. URL https://doi.org/10.1515/cclm-2020-0145.

[24] D. Crawley, F. Chamberlain, H. Garmo, S. Rudman, B. Zethelius, L. Holmberg, J. Adolfsson, P. Stattin, P. Carroll, and M. Van Hemelrijck. A systematic review of the literature exploring the interplay between prostate cancer and type two diabetes mellitus. *Ecancermedicalscience*, 12:1–27, 2021.

[25] N. Mohammed, A. A. Saeed, and M. A. Mahdi. Association of Plasma Zinc and Prostate-Specific Antigen in Patients with Prostatic Cancer in Khartoum. *Matrix Science Medica*, 6(1):23–26, 2022.

[26] P. K. To, M. H. Do, J. Cho, and C. Jung. Growth Modulatory Role of Zinc in Prostate Cancer and Application to Cancer Therapeutics. 2020.

[27] M. K. Andersen, S. Krossa, T. S. Høiem, R. Buchholz, B. S. R. Claes, B. Ballu, S. R. Ellis, E. Richardsen, H. Bertilsson, R. M. A. Heeren, T. F. Bathen, U. Karst, G. F. Giskeødegård, and M. Tessem. Simultaneous Detection of Zinc and Its Pathway Metabolites Using MALDI MS Imaging of Prostate Tissue. 2020.

[28] C. G. Östenson. The pathophysiology of type 2 diabetes mellitus: An overview. *Acta Physiologica Scandinavica*, 171(3):241–247, 2021.

[29] X. Chen, C. Chen, B. Hu, W. Wang, and F. Zhang. Exposure to Heavy Metal Elements May Significantly Increase Serum Prostate-Specific Antigen Levels With Overdosed Dietary Zinc. pages 1–27, 2023.