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Age and Sex Modulate Albumin, Glomerular Filtration Rate, and Lipid Profile in Type 2 Diabetic Patients

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ABSTRACT

Background: Metabolic factors associated with type 2 diabetes mellitus (T2DM) remain poorly understood, especially in the context of population-specific influences and varying environmental settings.
Objectives: To investigate the modulation of albumin, lipid profile biomarkers, and glomerular filtration rate (eGFR) in T2DM patients attending the Bamenda Regional Hospital in Cameroon.
Materials and methods: Briefly, 153 patients were interviewed on their socio-demographic and anthropometric information, and their fasting blood glucose (FBG) level, lipid profile, albumin, and eGFR were determined.
Results: The majority (61.4%) of participants were females and almost half (45.7%) of the population was obese. The FBG level was lower in the older age group (70-79 years, 165.62±17.95 mg/dL) than those moderately younger (≤69 years, 241.26±12.96 mg/dL). Also, the eGFR (65.97±4.03 ml/min/1.73m2) and high-density lipoprotein (HDL) level (54.06±2.84 mg/dL) decreased in older patients, particularly in the age 70-79 years. Male participants had higher albumin levels than the females (4.77±0.12 g/dL vs. 4.38±0.11 g/dL). Moreover, albumin was higher in the younger population (39-49 years; 4.99±0.22g/dL) as compared to older individuals (80-89 years; 4.07±0.22 g/dL). Correlation analyses revealed significant associations of FBG, albumin, eGFR, triglycerides, HDL, and low-density lipoprotein with age, gender, and body mass index.
Conclusion: The findings suggested significant variations in albumin, lipid biomarkers, and eGFR among diabetic patients, with age, gender, and cholesterol levels being the key modulators. Older patients seem particularly affected, making them a critical group for targeted management of T2DM.
Keywords: Confounding factors; Glomerular filtration rate; Lipid parameters; Serum albumin; Type 2 diabetes mellitus.

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INTRODUCTION

Diabetes mellitus is one of the major chronic metabolic diseases affecting all individuals with a global prevalence of around 10% representing 537 million people. This figure is expected to significantly increase due to predisposing and potentiating factors and associated risk illnesses [1, 2]. In humans, diabetes is characterized by widespread metabolic changes, including persistently elevated fasting blood glucose (FBG) levels, abnormal plasma insulin, reduced insulin sensitivity to glucose, dyslipidemia, and impaired β-cell function. The disease progresses to metabolic and clinical complications (vascular dysfunctions, ketoacidosis, and metabolic acidosis) which increase the risk of morbidity and mortality [3]. Type 2 diabetes mellitus (T2DM) is the most prevalent form of diabetes, ac-

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counting for more than 90% of all cases [4]. In Cameroon, diabetes is a significant public health concern affecting about 6% of the population. With increasing urbanization and dietary transitions, its prevalence is rising across the country [1, 5].

Altered levels of various parameters including lipid profiles are characteristic of metabolic disturbances in T2DM. Dyslipidemia is commonly presented with high levels of triglycerides (TGs) and low-density lipoprotein (LDL), along with decreased high-density lipoprotein (HDL), and is viewed as a risk factor for cardiovascular diseases [6]. More importantly, targeting dyslipidemia has been considered a crucial component in the management of diabetes and its complications [7]. Furthermore, renal failure is one of the major complications in diabetics, and glomerular filtration rate (eGFR) is a key and most common biomarker used to assess the patient's renal function [2].

Albumin is one of the major proteins synthesized by the liver, and its presence in urine (albuminuria) is an early indicator of kidney damage. The primary physiological functions of albumin include cellular transportation of biomolecules, protection of cells against oxidative stress, and contribution to osmotic pressure [8]. Altered albumin levels have been associated with malnutrition, inflammation, insulin resistance, and metabolic syndrome [8, 9]. However, evaluations of the role of albumin levels in the pathogenesis and complications of T2DM have yielded varied and contradictory conclusions [10, 11]. This study aimed to investigate the modulation of albumin, lipid profile biomarkers, and eGFR in T2DM patients attending the Bamenda Regional Hospital in the North West Region of Cameroon. Additionally, it sought to assess their associations with socio-demographic and anthropometric factors.

MATERIALS AND METHODS

This was a cross-sectional study from January to July 2022 intended to apprehend the changes in biomarkers (albumin, lipid profile, eGFR) in T2DM patients attending the Regional Hospital of Bamenda, which is one of the referral hospitals of the NWR of Cameroon. The sample size was determined using the Yamane formula, $n = N\ (1 + Ne^2)$, where n, N, and e represent the corrected sample, the population size (250 T2DM patients visiting the hospital diabetic unit), and the margin of error (0.05), respectively [2]. A total of 153 participants from both sexes with a confirmed diagnosis of T2DM for at least 6 months and aged ≥21 years old were enrolled.

The participants understood the purpose of the study, agreed to participate and freely signed the consent form. Pregnant women, patients suffering from secondary diabetes, with comorbidities, or under medications that could independently affect the investigated biomarkers were excluded. The study received approval from the Ethics Committee Review Board of the University of Bamenda (Reference number: 2011/0790H/UBa/IRB), and the administrative authorities (Reference number: 121/ATT/NWR/RDPH/BRIGAD).

A structured questionnaire was used to collect the patient demographic information (gender, age, and education) and anthropometric parameters. The body mass index (BMI) was determined by dividing a participant's weight in kg by the height in m^2. The participants were classified into 4 categories according to their BMI: underweight (< 18.5 Kg/m^2), normal-weighted (18.5–24.9 Kg/m^2), over-weight (> 24.9–< 30 Kg/m^2), and obese (≥ 30 Kg/m^2).

The FBG level of each participant was assessed in the morning after at least 12 hours of fasting using a glucometer. Thereafter venous blood sample was collected in Vacutainer tubes with or without anticoagulant and plasma or serum obtained was used for biochemical analyses.

Creatinine (Cr) was estimated by colorimetric method using a commercially available kit as pre-viously reported [2]. The eGFR was calculated using the Modification of Diet in Renal Disease Study equation as described elsewhere [2, 12], and as follows:

Females: $Cr \leq 0.7$ mg/dl, $eGFR = 144 \times (Cr/0.7)^{-0.329} \times (0.993)^{age} \times 1.018 \times 1.159$

$Cr > 0.7$ mg/dl, $eGFR = 144 \times (Cr/0.7)^{-0.209} \times (0.993)^{age} \times 1.018 \times 1.159$

Males: $Cr \leq 0.7$ mg/dl, $eGFR = 144 \times (Cr/0.7)^{-0.209} \times (0.993)^{age} \times 1.159$

$Cr > 0.7$ mg/dl, $eGFR = 144 \times (Cr/0.7)^{-0.209} \times (0.993)^{age} \times 1.159$

The stage of chronic kidney disease (CKD) was defined based on the eGFR values as classified by KDIGO [13]. The serum albumin levels and lipid profile biomarkers, namely the total cholesterol (TChol), HDL cholesterol, LDL cholesterol, and TGs, were determined using kits as described elsewhere [2, 14].

Descriptive statistics were performed on the questionnaire data, and the results were presented as frequencies and percentages. For biochemical parameters, any difference between groups of patients was assessed using ANOVA coupled with the Tukey Honest test. The odds ratios were performed at a 95% confidence interval using logistic regression to investigate the effect of quantitative data and reported confounders and their influence on a particular factor. The Stata MP software (version 14.0) was used for data analyses. A P-value < 0.05 was considered a statistically significant difference.

RESULTS

The demographic and anthropometric parameters (Table 1) showed that the participants were predominantly females (61.4%), and 92.2% of them have achieved at least primary education. The largest age group (33.3%) was those aged 60–69 years. Nearly half (45.7%) of the population was obese.

As shown in Table 2, males and females had comparable FBG levels, while patients in the age group of 60–69 years had higher FBG levels (241.26±12.96 mg/dL, P-value <0.05) as compared to the age group 70–79 years (165.62±17.95 mg/dL). The males had higher albumin levels (4.77±0.12 g/dL, P-value <0.05) when compared to females (4.38±0.11 g/dL), and this biomarker was higher in the younger population (39-49 years; 4.99±0.22 g/dL, P-value <0.05) while lower in older people (80–89 years; 4.07±0.22 g/dL, P-value <0.05) as compared to other age groups. The eGFR showed a significant decrease in older patients, particularly in the age range of 70–79 years (65.97±4.03 ml/min/1.73m^2, P-value <0.05) as compared to the other age groups, while the serum creatinine (SCr) displayed the opposite trend, and this is consistent with the relationship between both parameters. Globally, all patients had eGFR within 60-89 mL/min/1.73 m^2 and then fell within stage 2 CKD.

The TChol, TG, and LDL levels did not significantly vary across the gender and age of the participants. The age group 39-49 years demonstrated significantly higher HDL levels (66.89±3.35 mg/dL, P-value <0.05) as compared to the age group 70-79 years (54.06±2.84mg/dL) (Table 3).

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Table 1. Demographic and anthropometric parameters of the population*.

Gender	Frequency(%)		
Male	59 (38.6)		
Female	94 (61.4)		
Total	153 (100)		
Education	Frequency(%)		
No education	12 (7.8)		
Primary level	83 (54.3)		
Secondary level	38 (24.8)		
University level	20 (13.1)		
Total	153 (100)		
Age (years)	Male n(%)	Female n(%)	Total n(%)
39–49	11(18.6)	7(7.4)	18(11.8)
50–59	12(20.3)	29(30.9)	41(26.8)
60–69	15(25.4)	36(38.3)	51(33.3)
70–79	12(20.3)	13(13.8)	25(16.3)
80–89	9(15.4)	9(9.6)	18(11.8)
Total	59 (100)	94 (100)	153 (100)
BMI (kg/m^2)	Male n(%)	Female n(%)	Total(%)
Normal(18.5–24.9)	15(25.4)	18(19.2)	33(21.6)
Overweight(25–29.9)	23(39.0)	27(28.7)	50(32.7)
Obese (≥30)	21(35.6)	49(52.1)	70(45.7)
Total	59 (100)	94 (100)	153 (100)

* BMI: Body mass index.

The FBG (OR=0.971, P-value = 0.02) and albumin (OR=0.898, P-value = 0.001) were significantly associated with the patient's age. Moreover, albumin was significantly associated with Tchol (OR=0.989, P-value = 0.019). The eGFR (OR=0.897, P-value =0.001) and HDL (OR=0.969, P-value = 0.012) were associated with patient's age. Both HDL (OR=0.508, P-value =0.021) and LDL (OR=2.355, P-value = 0.049) were influenced by gender while TG levels were influenced by the BMI (OR=1.105, P-value = 0.001) of the patients (Table 4).

DISCUSSION

Understanding the importance of intrinsic factors that influence the current state of T2DM in patients is essential for better managing the disease, particularly in the local context. The study cohort was largely composed of females and this is consistent with previous reports [2, 5, 15]. The primary contributing factor to T2DM is obesity, and the cornerstone of diabetes control and management is weight reduction [16]. Nearly half of the study population was obese, with females comprising the majority, and this is consistent with the other studies [17, 18]. More importantly, the prevalence of obesity among diabetes in the present study is consistent with 44% prevalence in the literature and is within the range of 3.7 to 93.3% obtained from a systematic and meta-analysis review study across Africa [15].

The FBG is a key and easy-to-assess biomarker to define the diabetic status of a patient. Its level > 126 mg/dL among the present participants confirms their diabetic status. As age advances, it is expected that the patient' FBG will tend to increase, as observed in this study. However, older populations, especially the age range between 70–79 years old, seem to display lower FBG than the younger ones, and this is in disagreement with the study of Wu et al. [19]. These findings could be attributed to factors such as strict medical and lifestyle follow-up and individual genetic variability. Furthermore, a study has indicated a decrease in FBG in the oldest age group, possibly attributable to a healthy survivor bias [20, 21]. On the other hand, carbohydrate metabolism in older patients is susceptible to impairment through the counter-regulatory system with a reduced response of glucagon and growth hormone to hypoglycemia, and this can, in turn lead to lower FBG in certain patients [22].

All patient age groups were classified as having a stage 2 CKD based on their eGFR (60–89 mL/min/1.73 m^2), with the 70–79 years' age group showing significantly lower eGFR as compared to the other groups. This finding aligns with the significant correlation between eGFR and patient age. The eGFR value is usually used to characterize the integrity of the kidney; i.e., its ability to eliminate metabolic waste or toxic substances from the organism. A decreased eGFR is a high-risk factor for CKD, which can progress to kidney failure [12]. Despite the observed stage 2 CKD status, with eGFR values >60 mL/min/1.73 m^2, the patients exhibited only mild kidney damage.

The older participants showed reduced blood albumin levels, consistent with a significant correlation between lower albumin levels and participant age. Albumin constitutes more than half of plasma proteins, and low albumin levels in older individuals have been observed in various studies [23, 24]. Interestingly, in diabetic conditions, high blood glucose levels can exacerbate pancreatic beta cell dysfunction, leading to the depletion of insulin secretory reserve and negatively affecting hepatic albumin synthesis [25]. Reduced serum albumin levels have been associated with malnutrition, a condition that has been well documented in advanced age [8]. Older adults are more prone to malnutrition due to factors such as changes in metabolism, reduced dietary intake, and impaired nutrient absorption. On the other hand, lower serum albumin levels in female participants compared to male patients were consistently noted in a previous study [26].

Albumin plays an essential role in lipid metabolism and transport, including lipoproteins. HDL levels were lower in older patients compared to younger ones. The primary function of HDL is to mediate reverse cholesterol transport, scavenging cholesterol from peripheral cells, and returning it to the liver for further metabolism [27]. Therefore, reduced HDL levels can directly affect the transport of molecules, including cholesterol. Moreover, the influence of albumin on cholesterol was shown with a significant association with total cholesterol. HDL in protecting vascular complications has demonstrated anti-inflammatory, anti-oxidative, anti-thrombotic, and anti-diabetic properties [28]. The reduced HDL observed at a certain age may increase vulnerability and predispose the individuals to various diseases. Interestingly, the significant implication of age as a confounder was further illustrated in correlation analysis with HDL. The levels of LDL were generally higher than the normal reference value (<100 mg/dL) in both male and female patients. This corroborates with decreased HDL levels observed only in female participants (>60 mg/dL). Therefore, the significant association of these lipoproteins with the gender suggests that both males and females are at risk for cardiovascular diseases, although the likelihood is higher in women.

While the sample size from a single hospital may intro-

Table 2. The study population included fasting blood glucose, albumin, serum creatinine, and glomerular filtration rate*.

	FBG (70-125 mg/dL)	Alb Adults (3.5-5.5 g/dL)	SCr (0.5-1.2 mg/dL)	eGFR (mL/min/1.73 m^2)	CKD
Sex					
Male	198.78±11.75^{a}	4.77±0.12^{a}	1.085±0.05^{a}	75.23±2.33^{a}	Stage 2
Female	199.81±10.38^{a}	4.38±0.11^{b}	0.893±0.04^{b}	72.79±2.64^{a}	Stage 2
Total	206.73±7.62	4.55±0.77	0.94±0.03	75.03±1.76	Stage 2
Age range (years)					
39–49	234.95±21.23^{ab}	4.99±0.22^{a}	0.780±0.08^{c}	89.28±4.77^{a}	Stage 2
50–59	197.98±14.38^{ab}	4.73±0.15^{ab}	0.799±0.06^{c}	81.24±3.23^{a}	Stage 2
60–69	241.26±12.96^{a}	4.55±0.13^{ab}	0.933±0.05^{bc}	74.12±2.91^{ab}	Stage 2
70–79	165.62±17.95^{b}	4.53±0.18^{ab}	1.240±0.07^{a}	65.97±4.03^{b}	Stage 2
80–89	198.78±11.75^{ab}	4.07±0.22^{b}	1.196±0.08^{ab}	75.23±2.33^{ab}	Stage 2
Total	206.73±7.62	4.55±0.77	0.94±0.03	75.03±1.76	Stage 2

* Alb: Albumin, SCr: Serum creatinine, CKD: Chronic kidney disease, eGFR = Glomerular filtration rate, FBG= Fasting blood glucose. The values represent the mean ± Standard Deviation of different parameters and those with different superscripts in a given column are significantly different at P-value <0.05.

Table 3. Lipid profile levels stratified by age and gender*.

	TChol(<200 mg/dL)	HDL(60 mg/dL)	TG(100-150 mg/dL)	LDL(<100 mg/dL)
Sex				
Male	206.24±6.18^{a}	62.49±1.86^{a}	115.89±11.52^{a}	178.58±7.44^{a}
Female	221.24±5.46^{a}	57.88±1.64^{a}	169.05±10.17^{a}	160.18±8.43^{a}
Total	216.84±3.89	59.19±1.18	149.54±7.32	171.50±5.22
Age range (years)				
39–49	199.62±11.16^{a}	66.89±3.35^{a}	143.93±20.79^{a}	157.39±15.22^{a}
50–59	223.93±7.56^{a}	60.74±2.77^{ab}	151.32±14.08^{a}	160.62±10.31^{a}
60–69	209.89±6.81^{a}	58.91±2.05^{ab}	141.49±17.59^{a}	172.40±9.31^{a}
70–79	227.80±9.44^{a}	54.06±2.84^{b}	139.79±17.59^{a}	184.22±12.88^{a}
80–89	207.67±11.12^{a}	60.33±3.34^{ab}	135.82±20.73^{a}	172.27±15.17^{a}
Total	216.84±3.89	59.19±1.18	149.54±7.32	171.50±5.22

* TChol: Total cholesterol, TG: Triglycerides. The values represent the mean ±Standard deviation of different parameters and those with different superscripts in a given column are significantly different at P-value <0.05.

Table 4. Bivariate analyses examining the relationship between biochemical parameters, age, and gender*

Dependent variable	Covariate	Crude odds Ratio	P-value	95%Confidence Interval
FBG	Age	0.971	0.020	0.947 – 0.995
Alb	Age	0.898	0.001	0.869 – 0.927
Alb	TChol	0.989	0.019	0.980 – 0.998
eGFR	Age	0.897	0.001	0.869 – 0.927
HDL	Age	0.969	0.012	0.945 – 0.993
HDL	Gender	0.508	0.021	0.286 – 0.903
TG	BMI	1.105	0.001	1.040 – 1.173
LDL	Gender	2.355	0.049	1.005 – 5.519

* Alb: Albumin; eGFR: Glomerular filtration rate, FBG= Fasting blood glucose, TChol: Total cholesterol, TG: Triglycerides, BMI: Body mass index.

duce selection bias, it also allows for an in-depth analysis of a well-defined local population, providing valuable insights into the regional healthcare context. The cross-sectional design, although limited in its ability of establish causality or temporal relationships, offers a snapshot of the current health status of T2DM patients, which can inform immediate clinical decisions. Although potential confounding variables such as diet and physical activity were not accounted for, the study's inclusion of socio-demographic and anthropometric data enriches the understanding of the patient population. Measurement errors and self-reported data could introduce bias; however, the comprehensive assessment of multiple biomarkers

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strengthens the study's ability to capture a holistic view of the patient's health. Lastly, the focus on specific age groups and the predominance of female participants may limit generalizability, but it also highlights the unique characteristics and needs of these subgroups within the T2DM population.

CONCLUSION

This study provides valuable insights into the modulation of albumin, lipid profile biomarkers, and eGFR in T2DM patients attending the Bamenda Regional Hospital in Cameroon. The findings highlight significant variations in FBG, eGFR, and HDL levels across different age groups, with older patients generally showing lower values. Additionally, gender differences were noted, with male patients exhibiting higher albumin levels than females. The study also underscores the impact of age, gender, and BMI on these biomarkers, emphasizing the need for personalized management strategies for T2DM patients. The study offers a comprehensive snapshot of the metabolic and renal health status of T2DM patients in this region, contributing to the broader understanding of disease management in similar populations.

ETHICAL DECLARATIONS

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Ethics Approval and Consent to Participate

The study received approval from the Ethics Committee Review Board of the University of Bamenda (Reference number: 2011/0790H/UBa/IRB) and the administrative authorities (Reference number: 121/ATT/NWR/RDPH/BRIGAD). The participants freely took part in the study and any patient who did not sign the consent form was excluded.

Consent for Publication

Not applicable (no individual personal data included).

Availability of Data and Material

Data generated during this study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that there is no conflict of interest.

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Authors' Contributions

CTA contributed to designing and following up on the experiments, preparation, and revision of the manuscript; SFUB followed up the study and revised the manuscript; YT participated in designing and carrying out the study; MJKT contributed to data analysis and manuscript revision; MTFP participated in preparation and revision of the manuscript; NAE contributed to designing and following-up the study, preparation, and revision of the manuscript. All authors read and approved the final version of the manuscript.

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