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Comparative effects of oral antidiabetic regimens, exercise and BMI on glycemic control and organ function in type 2 diabetes mellitus patients in Bamenda, Cameroon

Junior Tegha Kum Muankang[1], Andre Gilles Mache[1], Aphrodite Choumessi Tchewonpi[1], Olivia Maih Tim [1], Christian Fusi Suh[2], Faustin Pascal Tsague Manfo[2], Promise Penn Muluh[1], Edouard Nantia Akono[1]*

Abstract

Background: Limited data on the impacts of oral anti-diabetic drugs (OADs) on patient vital functions are available. This study assessed the differential effects of OADs on glycemic control and hepatic and renal function in type 2 diabetes mellitus (T2DM) patients in Bamenda, Cameroon.

Methods: This cross-sectional study was conducted on 125 T2DM patients at Nkwen District Hospital, Bamenda (Cameroon). The patients' socio-demographic characteristics and OADs were collected, while glycated hemoglobin (HbA1c), fasting blood glucose (FBG), liver enzymes, creatinine, and estimated glomerular filtration rate (eGFR) were analyzed. Associations between antidiabetic therapies, socio-demographic variables, and biochemical markers were evaluated using multivariate regression analysis.

Results: Metformin monotherapy demonstrated superior glycemic control (mean HbA1c; 8.20%) and better renal function than glibenclamide or combination therapy. Multivariate regression identified age and body mass index (BMI) as independent predictors of poor glycemic control (OR = 1.068, $p < 0.021$; OR = 1.105, $p = 0.050$), while exercise was a significant positive predictor of renal outcomes across all regimens (OR = 1.369, $p < 0.005$).

Conclusion: Overall, metformin monotherapy displayed superior glycemic control and renoprotective effects while regular exercise was a significant protective factor for renal function across all regimens. These findings emphasize the urgent need for comprehensively adapted diabetes management strategies that integrate pharmacologic optimization into resource-limited settings.

Keywords: Anti-diabetic drugs; biomarkers; body mass index; exercise; glycemic control; hepatic and renal function; type 2 diabetes.

*Correspondence: Tel.: +237 677 89 06 70; E-mail address: akonoed@yahoo.fr ; ORCID: https://orcid.org/0000-0001-7013-2373 (Edouard Nantia Akono)

[1]Department of Biochemistry, Faculty of Science, University of Bamenda, PO Box 39 Bambili, Cameroon; [2]Department of Biochemistry and Molecular Biology, Faculty of Science, University of Buea, PO Box 63 Buea, Cameroon.

Other authors
Email: juniorkum@yahoo.com; ORCID: https://orcid.org/0009-0001-6028-2829 (Junior Tegha Kum Muankang), Email: gillesandremache@yahoo.fr; ORCID: https://orcid.org/0000-0002-9429-952X (Andre Gilles Mache), Email: achoumessi@yahoo.fr; ORCID: https://orcid.org/0000-0002-0962-3242 (Aphrodite Choumessi Tchewonpi), Email: maiholivia@gmail.com; ORCID: https://orcid.org/0000-0001-5659-2859 (Olivia Maih Tim), Email: christianfusisuh@gmail.com; ORCID: https://orcid.org/0009-0000-1445-2823 (Christian Fusi Suh), Email: faustinpascal@yahoo.fr; ORCID: https://orcid.org/0000-0002-7056-7817 (Faustin Pascal Tsague Manfo), Email: pennppromise@yahoo.com; ORCID:. https://orcid.org/0000-0001-5659-2859 (Promise Penn Muluh).

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Background

Type 2 diabetes mellitus (T2DM) is one of the most pressing global health challenges, affecting more than 460 million people worldwide and accounting for over 90% of all diabetes cases [1,2]. Its prevalence is rising most rapidly in low-and middle-income countries (LMICs) where urbanization and lifestyle transitions are driving metabolic risk. Sub-Saharan Africa is projected to face a 129% increase in T2DM incidence by 2045, and in Cameroon, prevalence has already increased from 2.0% in 1999 to 5.5% in 2021 [3,4]. Beyond hyperglycemia, T2DM is characterized by multi-organ involvement, particularly of the liver and kidneys, which are central to glucose metabolism, detoxification, and drug clearance [5]. Chronic hyperglycemia, obesity, and aging accelerate hepatic and renal dysfunction, thereby complicating disease management and contributing to excess morbidity and mortality. Monitoring organ function biomarkers such as liver transaminases, serum creatinine, and estimated glomerular filtration rate (eGFR) is therefore crucial in assessing both disease progression and drug safety.

Oral antidiabetic drugs (OADs) remain the cornerstone of pharmacological therapy for T2DM, with metformin and sulfonylureas such as glibenclamide mostly prescribed in LMICs [6,7]. While metformin is globally recognized for its insulin sensitizing and reno-protective properties, sulfonylureas are associated with increased risk of hypoglycemia and potential hepatic or renal toxicity [8,9]. However, most evidence comes from high-income countries, and comparative data on the effects of OAD regimens on hepatic and renal biomarkers in African populations remain sparse [9]. This knowledge gap is particularly critical in resource-limited settings. In addition to pharmacological therapy, demographic and lifestyle factors such as age, body mass index (BMI), and physical activity are important modifiers of glycemic control and organ outcomes [10,11]. Yet, their interaction with drug response is often neglected in African settings. Understanding how these factors influence treatment effectiveness is essential for guiding context-specific diabetes care. Therefore, this study aimed to evaluate the comparative effects of commonly prescribed OAD regimens on glycemic control, hepatic function and renal function among T2DM patients in Cameroon. We further examined how demographic and lifestyle factors modulate these outcomes. By addressing these gaps, this work seeks to provide evidence that can inform individualized and resource-appropriate diabetes management strategies in sub-Saharan Africa.

Methods

This cross-sectional, hospital-based study was conducted between February and September 2024 at the Diabetic Center of Nkwen District Hospital, Bamenda, Northwest Region, Cameroon. The hospital serves a diverse patient population within an urban and semi-urban catchment area. The target population comprises patients aged ≥ 21 years with a confirmed diagnosis of T2DM for at least one year. Patients with type 1 diabetes, secondary diabetes, pregnancy or critical illness were excluded. Using Yamane`s formula [12], for sample size estimation ($n = N/(1 + Ne^2)$), where N is the total population (181 registered diabetic patients) and e is the margin of error (0.05), the calculated sample size (n) was125 participants. The study received ethical clearance from the institutional Review Board of the University of Bamenda (Ref: 2024/0619H/UBa/IRB) and administrative authorization from the Regional Delegation of Public Health (Ref: 34/ATT/NWR/RDPH/BRIGAD). Written informed consent was obtained from all participants.

Participants underwent face-to-face interviews during their clinical visits. Information collected included age, gender, educational level, duration of diabetes, anti-diabetic medications prescribed, and self-reported physical activity. Anthropometric measurements (height, weight) were performed to calculate body mass index (BMI, kg/m^2). Venous blood samples were collected after an overnight fast of at least 12 hours. Samples were collected into ethylenediaminetetraacetic acid (EDTA) tubes, centrifuged at 3000 rpm for 10 minutes, and plasma was aliquoted for biochemical analyses.

Fasting Blood Glucose (FBG) was measured using a glucometer (On-Call-Plus, *ACON* Laboratories, Inc., 5850, San Diego, USA). Glycated hemoglobin A1c (HbA1c) was determined via a commercial immunoturbidimetric assay kit (ref. VMPO06, AF1040 hemoglobin A1c, Chengdu VACURE Biotechnology, China), following manufacturer's instruction. Absorbance was measured at 540 nm using a bioanalyzer (LansioBio L520201075, Lansion Biotechnology, China). Liver biomarkers alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities were determined using commercially available assay kits (Ref: 92027 and Ref: LP805, respectively; BIOLABO SAS Les Hautes Rives 02160, Maizy, France), adhering to the manufacturer's protocols. Briefly, 800 µL of reagent R1 were mixed with 200 µL of reagent R2 and 100 µL of sample, then thoroughly vortexed, incubated for 30 seconds at ambient temperature, and the absorbance measured at 340 nm using a biochemical analyzer (EMP – 168 Biochemical Analyzer, ChenduEmpsun Medical, China). The kidney biomarker, serum creatinine was assessed using Jaffe kinetic method [13], with a commercially available kit (Abbott Laboratories, USA). Briefly, 100 µL of serum sample was combined with 1 mL of working reagent, homogenized, and absorbance was measured at 505 nm using a biochemical analyzer (EMP–168 Biochemical Analyzer, ChenduEmpsun Medical, China). Estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease (MDRD) equation, incorporating serum creatinine (SCr), age, gender, and self–reported ethnicity.

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

Chronic kidney disease (CKD) stages were defined according to KDIGO guidelines [14]. Data were entered into Microsoft Excel and analyzed using XLSTAT version 16.0 (Addinsoft, New York, USA). Continuous variables were summarized as mean ± standard deviation (SD) or median (interquartile range), and categorical variables as frequencies and percentages. Graphs were generated using Sigma plot. Comparison between groups were performed using ANOVA and Tukey`s Honest Significant Difference (HSD) test for multiple group comparisons. Binary logistic regression was performed to assess associations between independent variables (age, BMI, physical activity, gender) and Glycemia, hepatic and Renal outcomes. All tests were two-tailed, and significance was considered at $p < 0.05$.

Results

Demographic characteristics

A total of 125 patients with T2DM were enrolled, of whom 64% were female. The majority (51.2%) were aged between 45 - 64 years. Obesity was prevalent, with 34.4% classified as obese (BMI > 30kg/m^2). Most participants (92%) reported engaging in regular physical exercise. Regarding pharmacological treatment, 68% were on metformin monotherapy, 3.2% on glibenclamide monotherapy, with 28.8% on metformin plus glibenclamide combination therapy (Table 1).

Biochemical outcomes of Antidiabetic treatment

Patients receiving metformin monotherapy exhibited significantly lower HbA1c (8.20 ±0.51%) (Figure 1), and fasting blood glucose (120.32 ± 9.56 mg/dL) compared to those on glibenclamide or combination therapy ($p < 0.05$) (Table 2, Supple 1). Obese participants demonstrated significantly higher AST activity (38.28 ± 2.29 U/L) compared to those with normal BMI (29.68 ±2.74 U/L; $p < 0.05$). ALT levels did not differ significantly across groups. Physical exercise was associated with improved glycemic markers, although the difference did not reach statistical significance (Suppl 1).

Renal function assessment showed that female patients had a lower mean eGFR (87.80 ± 9.57 mL/min/1.73m^2), corresponding to stage 2 CKD predominance among females. Metformin monotherapy significantly preserved renal function compared to glibenclamide (85.29 ± 15.05 mL/min/1.73m^2 vs. 100.0 ± 5.53 mL/min/1.73m 2, $p<0.05$) (Table 1, Figure 2). Exercise was significantly associated with higher eGFR compared to inactivity ($p < 0.05$) (Suppl 2). Bar graph compares HbA1c levels among patients treated with metformin monotherapy, glibenclamide monotherapy, and metformin plus glibenclamide combination therapy. Error bars represent standard deviations. The red dashed line indicates the target threshold of 7% recommended for glycaemic control (Figure 1).

Box – plot illustrating eGFR distribution across patients on metformin, glibenclamide, and combination therapies. The dashed line denotes the average normal eGFR (90 mL/min/1.73m^2). Patients on metformin exhibited higher mediane eGFR values, suggesting better renal preservation therapies are shown in Figure 2.

Predictive performance of Age, BMI and Exercise on glycemic outcome and Organ function

Age and BMI were independent predictors of poor glycemic control (higher HbA1c) across all treatment groups. Age was significantly associated with HbA1c in patients receiving metformin (OR ± 1.068, p ± 0.021), glibenclamide (OR = 1.067, $p < 0.006$), or metformin/glibenclamide combination therapy (OR = 1.067, $p < 0.006$). BMI also exhibited a significant association with HbA1c for metformin and glibenclamide and a marginal significance for the combination therapy (OR = 1.105, $p > 0.050$; OR = 1.105, $p < 0.005$; OR = 1.105, $p > 0.051$, respectively) (Figure 3).

The eGFR outcome was significantly influenced by age (OR = 1.116, $p <0.0001$; OR = 1.111, $p < 0.0001$; OR = 1.114, $p < 0.0001$) and exercise (OR = 1.369, $p < 0.005$; OR = 1.352, $p < 0.006$; OR = 1.387, $p < 0.003$) across all three regimens (metformin, glibenclamide and metformin/glibenclamide combination therapy), when), when respectively used. The liver function biomarker AST activity was primarily influenced by BMI (OR = 1.098, $p < 0.022$; OR = 1.096, $p < 0.024$; OR = 1.101, $p < 0.019$) across all treatments used (Table 3).

Figure 3 shows a forest plot of odds ratio (ORs) with 95% confidence interval for predictors of poor glycemic control and reduced renal function. Variables analyzed include age, body mass index (BMI) and physical activity status. The vertical line represents the null effect (OR = 1.0) (Figure 3).

Discussion

This study evaluated the differential effects of oral antidiabetic therapies on glycemic control, hepatic and renal biomarkers in T2DM patients from an urban Cameroonian population. Our findings underscore the superiority of metformin monotherapy in achieving optimal glycemic and renal outcomes compared to glibenclamide or combination therapy, while also highlighting the modifying influence of demographic and lifestyle factors. Metformin monotherapy was associated with significantly lower HbA1c and fasting blood glucose levels, consistent with its established role as the first-line pharmacologic agent for T2DM [15]. Recent meta-analysis further support that metformin improves insulin sensitivity and may exert protective effects on renal function beyond glycemic control [16]. Younger patients (age 25-44) exhibited significantly lower HbA1c levels, potentially due to shorter diabetes duration, better treatment responsiveness, or higher physical activity levels [17]. Older patients (age 45 – 84 years) had higher HbA1c levels, suggesting a need for further investigation into contributing factors like medication adherence, age-related physiological changes, or other factors. Age-related physiological changes, including reductions in reno-hepatic function, can affect drug pharmacokinetics and pharmacodynamics, necessitating careful dose adjustments in older adults [18]. This may explain the variation in HbA1c levels across age groups, despite similar medication regimens.

Renal function, as assessed by eGFR, was better preserved in patients treated with metformin alone. This aligns with emerging evidence that metformin uses correlates with slower CKD progression in T2DM patients, even among those with mild to moderate renal impairment [19]. Mechanistically, metformin may reduce oxidative stress and inflammatory responses implicated in diabetic nephropathy.

Demographic factors such as age and BMI exerted substantial influence on clinical outcomes. Higher BMI was significantly associated with elevated HbA1c and AST levels, consistent with global reports linking obesity with metabolic dysfunction and hepatic steatosis [20]. Obesity insulin resistance, and chronic low-grade inflammation together worsen both glycemic control and organ damage risk in T2DM.

Physical activity emerged as a positive modifier of renal function, with participants reporting regular exercise showing higher eGFR. This aligns with recent guidelines sensitivity and reducing complications in diabetes [21-23]. Even minimal weekly physical activity appears protective, supporting targeted lifestyle interventions. Our findings are particularly relevant given the alarming global trends; the world-wide prevalence of diabetes has quadrupled over the last four decades, now affecting over 800 million adults [24]. Sub-Saharan Africa is projected to see the fastest proportional rise, making context-specific management strategies urgent [25,26].

Though the study provided relevant and informative data on differential effects of antidiabetic regimens on glycemic control

and vital metabolic organs, there are some limitations worth mentioning. The cross-sectional design limits causal interpretation of the observed associations between predictors and outcomes. The relatively moderate number of patients on glibenclamide reduced statistical power for subgroup comparison. Physical activity was self-reported, introducing possible bias recall. Additionally, the single center setting in Bamenda limits generalizability to wider Cameroonian or sub-Saharan African populations.

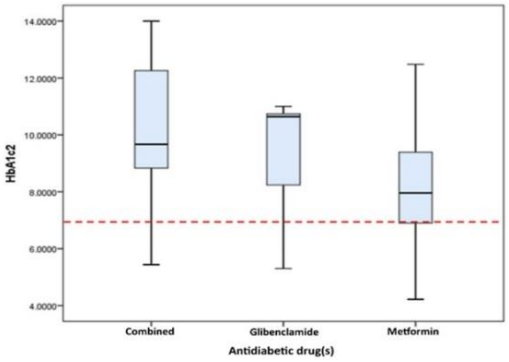

Figure 1. HbA1c levels by antidiabetic regimen.

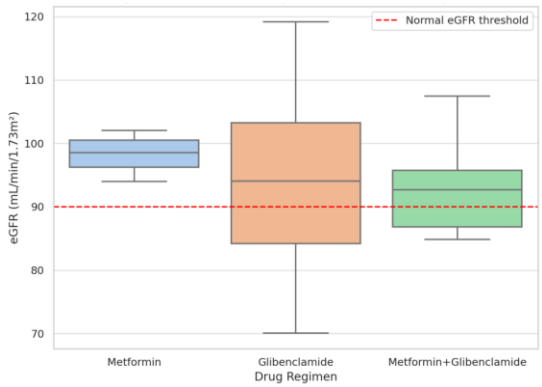

Figure 2. eGFR distribution by antidiabetic treatment regimen.

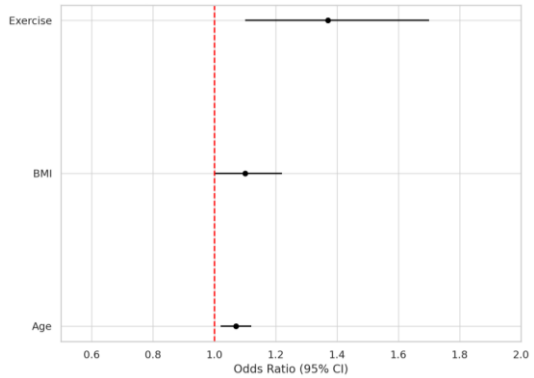

Figure 3. Predictors of poor outcomes in T2DM patients.

Table 1. Socio-demographic characteristics of participants.

Distribution of participants			
Variables	Male	Female	Total
Frequency	45 (36.0)	80 (64.0)	125 (100.0)
Age of respondents with diabetes type 2 (T2DM)			
	Male (frequency, %)	Female (frequency, %)	Total (frequency, %)
25 – 44	6 (4.8)	10 (8.0)	16 (12.8)
45 – 64	22 (17.6)	42 (33.6)	64 (51.2)
65 – 84	15 (12.0)	26(22.4)	43 (34.4)
85 – 104	1 (0.8)	1 (0.8)	2 (1.6)
Total	45 (36.0)	80 (64.0)	125 (100.0)
Educational level of respondents			
	Male (frequency, %)	Female (frequency, %)	Total (frequency, %)
No education	1 (2.2)	11 (13.8)	12 (9.6)
Primary	21 (46.7)	40 (50)	61 (48.8)
Secondary	5 (11.1)	12 (15)	17 (13.6)
High school	3 (6.7)	13 (16.2)	16 (12.8)
University	15 (33.3)	4 (5)	19 (15.2)
Total	45 (100)	80 (100)	125 (100.0)
Exercise status of participants			
variable	Male (frequency, %)	Female (frequency, %)	Total (frequency, %)
Exercise	44 (97.8)	71 (88.7)	115 (92)
No exercise	1 (2.2)	9 (11.3)	10 (8)
Total	45 (100)	80 (100)	125 (100)
Weight distribution of participants			
BMI (kg/m^2)	Male (frequency, %)	Female (frequency, %)	Total (frequency, %)
Normal (18 – 24.9)	15 (33.4)	15 (18.8)	30 (24.0)
Overweight (25-29.9)	21 (46.6)	31 (38.8)	52 (41.6)
Obese>30	9 (20)	34 (42.4)	43 (34.4)
Total	45 (100.0)	80 (100.0)	125 (100.0)
Population distribution as function of antidiabetic drugs and gender			
Antidiabetic drug	Male (frequency, %)	Female (frequency, %)	Total (frequency, %)
Metformin	31 (68.8)	54 (67.5)	85 (68.0)
Glibenclamide	(0) 0.0	4 (5.0)	4 (3.2)
Metformin & glibenclamide	14 (31.2)	22 (27.5)	36 (28.8)
Total	45 (100)	80 (100)	125 (100.0)

Values represent absolute frequency (relative frequency in %) for various socio-demographic variables and antidiabetic drug distribution in the population. T2DM = Type 2 diabetes mellitus.

Table 2. Biochemical Outcomes by Antidiabetic Regimen.

Biomarker	Metformin (n = 85)	Glibenclamide (n = 5)	Combined group (n = 35)	p – value
HbA1c (%)	8.20 ± 0.51[a]	10.14 ± 1.40[b]	9.67 ± 0.67[b]	<0.05
FBG (mg/dL)	120.32± 9.57[a]	153.07± 26.07[b]	136.50± 12.41[ab]	<0.05
ALT (U/L)	25.12± 3.14[a]	25.98± 8.55[a]	20.00± 4.07[a]	NS
AST (U/L)	31.22 ±2.99[a]	36.84± 8.16[b]	30.27± 3.88[a]	<0.05
eGFR (mL/min/1.73m^2)	100.0 ± 5.53[b]	85.29± 15.05[a]	94.89 ± 7.17[a]	<0.05

N=125, Normal ranges for HbA1c (glycated hemoglobin), FBG (fasting blood glucose), ALT (alanine transaminase) and AST (aspartate transaminase), eGFR (estimated glomerular filtration rate) are <7%, between 70 – 125 mg/dL, <55 U/L,<45U/L, and ≥ 90 mL/min/1.72m2, respectively. Values with different superscripts across the same row are statistically different at p<0.05 (Tukey (HSD) test). NS = not significant.

Table 3. Multivariate analysis of the effect of diabetic drugs on liver, renal, and glycemic biomarkers.

Drug	Biomarker	Variable	Odd-ratio	p value	Conf. Int. 95%
Metformin	HbA1c	Age	1.068	0.021	1.021 – 1.117
		BMI	1.105	0.050	1.000 – 1.221
	AST	BMI	1.098	0.022	1.014 – 1.190
		Exercise	1.239	0.041	1.009 – 1.522
	eGFR	Age	1.116	<0.0001	1.062 – 1.172
		Exercise	1.369	0.005	1.100 – 1.704
Glibenclamide	HbA1c	Age	1.067	0.006	1.019 – 1.116
		BMI	1.105	0.049	1.001 – 1.221
	AST	BMI	1.096	0.024	1.012 – 1.188
	eGFR	Age	1.111	<0.0001	1.059 – 1.166
		Exercise	1.352	0.006	1.092 – 1.674
Metformin & glibenclamide	HbA1c	Age	1.068	0.004	1.021 – 1.117
		BMI	1.105	0.051	1.000 – 1.221
	AST	Gender	0.986	0.001	0.377 – 2.581
		BMI	1.101	0.019	1.016 – 1.192
		Exercise	1.241	0.039	1.011 – 1.524
	eGFR	Age	1.114	<0.0001	1.061 – 1.171
		Exercise	1.387	0.003	1.115 – 1.724

Multivariate logistic regression Odd Ratio (OR), Conf. int 95% ± confidence interval of 95% significance level calculated at $p < 0.05$.

Conclusion

Metformin monotherapy demonstrated superior glycemic control and renoprotective effects compared to glibenclamide or combination therapies among T2DM patients in Cameroon. Age, BMI and lifestyle factors notably modified treatment outcomes. Older age, higher BMI independently predicted poor glycemic and hepatic outcomes, while regular exercise was a significant protective factor for renal function across all regimens. These findings emphasize the urgent need for comprehensive, culturally adapted diabetes management strategies that integrate pharmacologic optimization with weight management and physical activity promotion.

Additional file

Suppl 1: Blood glucose and liver biomarkers by antidiabetic treatments, age, gender, and BMI*;* Suppl 2: Kidney biomarkers by gender, age, BMI, exercise, and antidiabetics.PDF (Available at: https://www.investchempharma.com/wp-content/uploads/2018/01/www.investchempharma.com-supplementary-data-tegha-et-al.pdf)

Abbreviations

ALT: Alanine Transaminase
AST: Aspartate Transaminase
BMI: Body Mass Index
CKD: Chronic Kidney Disease
eGFR: Estimated Glomerular Filtration Rate
FBG: Fasting Blood Glucose
HbA1c: Glycated Hemoglobin
HSD: Honest Significance Difference
KDIGO: Kidney Disease Improving Global Outcomes
OADs: Oral Antidiabetic Drugs
SCr: Serum Creatinine
T2DM: Type 2 Diabetes Mellitus

Authors' Contribution

MJTK participated in designing and carrying out of the experiments, data analysis and drafting of the manuscript; MAG and CTA took part in designing and follow up of the experiments and revision of the manuscript; TOM and MPP contributed to carrying out the study and data analysis; CFS took part in sample analysis and manuscript preparation, MTFP and NAE contributed to designing and following-up the study, preparation, and revision of the manuscript.

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Conflict of interest

The authors declare no conflict of interest

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