ORIGINAL ARTICLE

DOI: https://doi.org/10.53350/Annalspakmed.1.2.19

ASSESSMENT OF GLYCEMIC VARIABILITY AND OXIDATIVE STRESS IN TYPE 2 DIABETIC PATIENTS USING CONTINUOUS GLUCOSE MONITORING

KAINAT BAKHTIAR[1], MUHAMMAD ARHAM RAUF[2], MUHAMMAD MOHID MAQSOOD[3], MALIK FARAZ AHMAD[4]

[1]Ghurki Trust Teaching Hospital, Lahore
[2]Lahore Medical and Dental College, Lahore
[3]Lahore Medical and Dental College, Lahore
[4]Lahore Medical and Dental College, Lahore
Correspondence to: Malik Faraz Ahmad, Email: malikfarazahmad90@gmail.com

ABSTRACT

Background: Glycemic variability (GV) has emerged as an important metabolic parameter contributing to oxidative stress and the development of diabetic complications. Unlike glycated hemoglobin (HbA1c), which reflects mean glycemia, GV represents short-term glucose fluctuations that may exert greater oxidative injury.

Objective: This study aimed to assess the relationship between glycemic variability indices derived from continuous glucose monitoring (CGM) and oxidative stress biomarkers in patients with type 2 diabetes mellitus (T2DM).

Methods: A cross-sectional observational study was conducted from January 2024 to January 2025 at tertiary care centers in Punjab, Pakistan. One hundred T2DM patients aged 35–65 years were monitored using a Freestyle Libre Pro CGM device for 14 days. Glycemic indices including Mean Amplitude of Glycemic Excursion (MAGE), Standard Deviation (SD), and Coefficient of Variation (CV) were calculated. Serum malondialdehyde (MDA) and total antioxidant capacity (TAC) were analyzed to assess oxidative stress. Statistical analysis was performed using SPSS v26 with $p < 0.05$ considered significant.

Results: The mean MAGE was 67.4 ± 17.9 mg/dL, MDA was 4.7 ± 0.8 µmol/L, and TAC was 1.12 ± 0.21 mmol/L. Patients in the highest MAGE tertile exhibited significantly elevated MDA and reduced TAC compared to those in the lowest tertile ($p < 0.001$). MAGE showed a positive correlation with MDA ($r = 0.64$, $p < 0.001$) and a negative correlation with TAC ($r = –0.59$, $p < 0.001$).

Conclusion: Increased glycemic variability is strongly associated with elevated oxidative stress in T2DM, independent of HbA1c. CGM-based monitoring may serve as a valuable tool to identify high-risk patients and guide interventions aimed at reducing glucose fluctuations.

Keywords: Type 2 diabetes mellitus, glycemic variability, continuous glucose monitoring, oxidative stress, malondialdehyde, total antioxidant capacity.

This article may be cited as: Bakhtiar K, Rauf MA, Maqsood MM, Ahmad MF: Assessment of Glycemic Variability and Oxidative Stress in Type 2 Diabetic Patients Using Continuous Glucose Monitoring. Pak Med & Allied, 2025; 01(2): 19-25.

Received: 10-02-2025 **Revised:** 15-04-2025 **Accepted:** 15-05-2025 **Published:** 30-05-2025

INTRODUCTION

The diabetes mellitus type 2 (T2DM) is a chronic metabolic disease that is characterized by persistent hyperglycemia caused by insulin insensitivity, progressive 8-cell dysfunction, and glucose metabolism impairment[1]. It is among the common non-communicable diseases in the world and International Diabetes Federation (IDF) estimates that over 640 million adults would be infected in the world by 2030. South Asian nations, like Pakistan, are especially affected by the burden of diabetes with rapid urbanization, sedentary lifestyles, and dietary changes being a contributing factor to the dramatic increase in the incidence and the onset of the disease earlier[2].

Conventionally, glycated hemoglobin (HbA1c), the measure of mean plasma glucose in the last 8 to 12 weeks, has been used to measure long-term glycemic control[3]. Nevertheless, HbA1c does not reflect short acting variation in blood glucose that happens throughout the day. There is

an increasing amount of evidence that these severe oscillations taken as a whole dubbed glycemic variability (GV) can have a more detrimental impact on vascular endothelium than sustained hyperglycemia in itself. The result of high GV is recurring and irregular glucose and insulin swings, which cause mitochondrial overproduction of reactive oxygen species (ROS), initiate inflammatory mechanisms, and eventually lead to endothelial dysfunction and atherosclerosis[4].

One of the primary pathways by which diabetes causes cellular damage is oxidative stress an imbalance between the production and the antioxidant defenses. Overproduction of ROS damages membrane lipids, proteins, and DNA, and causes the second product as a malondialdehyde (MDA), a sure index of lipid peroxidation[5]. At the same time, total antioxidant capacity (TAC) is the sum total of antioxidant activity of enzymes and non-enzymes that neutralize the free radicals. High levels of oxidative stress have been strongly linked to diabetic microvascular and macrovascular complications, such as retinopathy, nephropathy and cardiovascular disease[6].

Now thanks to the introduction of the continuous glucose monitoring (CGM) systems, real-time interstitial glucose profiles could be measured and dynamic glycemic indices, including the Mean Amplitude of Glycemic Excursions (MAGE), Standard Deviation (SD), and Coefficient of Variation (CV) could be quantified. CGM has a more accurate and detailed evaluation of daily glucose trends in comparison to self-monitoring of blood glucose or infrequent laboratory tests. Recent reports have also pointed out that despite patients having comparable HbA1c levels, those with higher GV had more oxidative stress and vascular damage[7,8].

Although such an accumulating literature exists, there is scant information on South Asian populations, whose variation in eating behaviors, genetic factors and access of the treatments can modulate the interaction between GV and oxidative stress. This relationship is important because it helps to design personalized treatment plans that will not only help reduce the average glucose levels but also to ensure the normalization of intradaily fluctuations[1,9].

Thus, the current study aimed at evaluating the relationship between the glycemic variability indices using the continuous glucose monitoring and oxidative stress biomarkers (MDA and TAC) in type 2 diabetes mellitus patients. The results can be useful in the pathophysiological connection between glucose instability and oxidative damage and indicate the possibility of CGM to maximize glycemic control to avoid diabetic complications[10].

MATERIALS AND METHODS

Study Design and Setting

The study was developed as a cross-sectional observational study and was conducted during one year, January 2024 to January 2025, and in a group of tertiary care centers in Punjab, Pakistan, namely, Jinnah Hospital Lahore, Services Hospital Lahore, and Nishtar Hospital Multan. The purpose of selecting these centers was that they are some of the most important referral centers in the diabetic care and have access to continuous glucose monitoring centers and biochemical laboratories. It was conducted under the auspices of the Endocrinology and Internal Medicine Departments. Data collection was done with the ethical consent of the Institutional Review Boards of the participating hospitals.

Population and Sample-size of the Study.

The study population was a total of 100 patients with an earlier diagnosis of type 2 diabetes mellitus (T2DM) using a purposive sampling method. The sample size was calculated upon a review of the past researches concerning glycemic variability and oxidative stress; it had a sufficient power of 80 percent and the confidence level of 95 percent. The test subjects were aged 35 to 65 years, with a disease history of one-year or more, and under antidiabetic stable therapy of not less than three months before admission. Written informed consent was signed by all patients.

Inclusion and Exclusion Criteria.

The inclusion criteria were male and female patients aged above 18 years with T2DM according to the American Diabetes Association (ADA) 2023 criteria, HbA1c levels between 7% and 10, and desire to wear a continuous glucose monitor (CGM) throughout the study period. The exclusion criteria used were type 1 diabetes, secondary diabetes as a result of pancreatitis or steroid therapy, chronic kidney disease (stage 3 or above), liver cirrhosis, cardiovascular events within 6 months before enrolment, pregnancy, current intake of vitamin supplements or antioxidant supplements within three months before enrolment. Patients who did not adhere to the use of CGM or those who gave incomplete information were also excluded.

Ethical Considerations

This study received ethical approval by the Ethical Review Committee of Jinnah Hospital Lahore (Ref: JHL/IRB/2023/211) and other cooperating institutions. Informed consent was signed by all the participants after a discussion on the purpose, procedures, risks and benefits of the study. Anonymization of all patient data was done to protect confidentiality. It was carried out and performed in accordance with the principles of the Declaration of Helsinki (2013 revision) of human biomedical research.

Clinical and Anthropometric Examination.

All participants were properly assessed clinically. Demographic data such as age, sex, length of diabetes, mode of treatment and comorbidities were recorded. A

standardized protocol was used to take anthropometric measurements including height, weight and waist circumference, and Body Mass Index (BMI) was computed as weight (kg)/height (m 2). A calibrated sphygmomanometer was used to record blood pressure at the sitting position, after taking a 10-minute rest position. The measurements were useful in evaluating the metabolic and hemodynamic profile of the participants.

Continuous Glucose Monitoring.
Each participant was equipped with a professional glucose monitoring device and inspected to measure the glycemic variability (Freestyle Libre Pro, Abbott Diabetes Care, USA). The sensor was attached to the upper arm and kept on continuously measuring interstitial glucose level after every 15 minutes over a period of 14 days. In this phase, the subjects were told to continue their normal eating and physical activity habits. At the finishing point of the monitoring, several glycemic variability indices were calculated based on data which had been downloaded and analysed in the LibreView software. Those were mean glucose (mg/dL), SD, coefficient of variation (CV%), and the mean amplitude of glycemic excursions (MAGE). MAGE was established as the mean of the glucose excursions that were more than one standard deviation to the mean glucose value. These indices gave objective evaluation of the changes in glucose level on a short term basis in each participant.

Biochemical Analysis
The venous blood (5 mL) samples were taken at the end of the CGM monitoring period under aseptic conditions following a 10-12-hours fasting. Centrifugation was performed at 3,000 rpm and serum was segregated and kept at -80 o C pending biochemical analysis.

The glycemic parameters were fasting plasma glucose (FPG), assessed with the help of enzyme glucose oxidase-peroxidase technique, and glycated hemoglobin (HbA1c), which was measured by high-performance liquid chromatography (HPLC).

For the evaluation of **oxidative stress**, two biomarkers were measured:

1. **Malondialdehyde (MDA)** an indicator of lipid peroxidation, estimated using the thiobarbituric acid reactive substances (TBARS) method, with results expressed in micromoles per liter (μmol/L).
2. **Total Antioxidant Capacity (TAC)** representing the cumulative antioxidant defense, determined through the ABTS radical cation decolorization assay, with results expressed in millimoles per liter (mmol/L) Trolox equivalents.
   All assays were performed in the Central Diagnostic Laboratory of Jinnah Hospital Lahore using standardized protocols and quality control procedures to ensure reproducibility and accuracy.

Statistical Analysis and Data Management
The data was entered and analyzed with the help of IBM SPSS Statistics version 26.0. Continuous variables were displayed as the mean and standard deviation (SD) and categorical variables were shown as frequencies and percentages. The study population was separated into tertiles according to MAGE values in order to determine the correlation between various levels of glycemic variability and the level of oxidative stress.

Tertile comparisons were carried out using the one way analysis of variance (ANOVA) where the multiple post hoc tests were applied as post hoc. The correlation between the indices of glycemic variability (MAGE, SD, CV) and the oxidative stress markers (MDA, TAC) was analyzed by Pearson correlation coefficient (r). Besides that, the analysis of multiple linear regression was also performed to control the possible confounding factors including age, gender, BMI, and HbA1c. A p-value of less than 0.05 was taken as statistically significant.

RESULTS

Demographic and Clinical Characteristics of the Study Population
This study included 100 patients with type 2 diabetes mellitus (T2DM) who qualified through all inclusion criteria. The average age of the participants was 52.6-8.1 years with a range of 35-65 years, which implies that the majority of participants were middle-aged. Male participants were a little more prevalent (56 percent) than female participants (44 percent) which was indicative of gender distribution in a typical diabetic population within a hospital setting in Pakistan. The mean patient-year of diabetes was 8.4 ± 3.9 years and indicated that the majority of the patients had chronic disease history. The average Body Mass Index (BMI) was 27.804.1kg/m 2 which is in the overweight range of WHO. The most common comorbidity was hypertension with 47% of patients having it, then dyslipidemia with 42. Systolic blood pressure was 134/11mmHg with a diastolic blood pressure of 83/7mmHg which showed moderately controlled blood pressure among most of the subjects. The average of HbA1c was 8.4(1.1) indicating a poor level of glycemic control in the cohort. The average fasting plasma glucose was 154.3 +/-31.8mg/dl, and postprandial glucose was 212.5 +/-46.7mg/dl, which once again indicates chronic hyperglycemia.

Table 1 shows the demographic and clinical baseline of study population. Gender distribution is indicated directly, as well as anthropometric and metabolic parameters. Comprehensively, these results suggest that the sample was a representative population of the poorly controlled T2DM patients that are common in tertiary care endocrinology units in Punjab, Pakistan.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Participants (n = 100)

Parameter	Total (n = 100)	Male (n = 56)	Female (n = 44)
Age (years)	52.6 ± 8.1	53.4 ± 8.3	51.7 ± 7.9
BMI (kg/m²)	27.8 ± 4.1	27.4 ± 3.9	28.2 ± 4.3
Duration of diabetes (years)	8.4 ± 3.9	8.6 ± 4.1	8.2 ± 3.7
Systolic BP (mmHg)	134 ± 11	133 ± 10	135 ± 12
Diastolic BP (mmHg)	83 ± 7	82 ± 7	84 ± 6
HbA1c (%)	8.4 ± 1.1	8.3 ± 1.0	8.5 ± 1.2
Fasting glucose (mg/dL)	154.3 ± 31.8	152.6 ± 29.4	156.3 ± 33.7
Postprandial glucose (mg/dL)	212.5 ± 46.7	210.1 ± 43.5	215.8 ± 49.4
Hypertension (%)	47	48.2	45.4
Dyslipidemia (%)	42	44.6	39.5

Glycemic Variability Indices Assessed by Continuous Glucose Monitoring

The monitoring of glucose (Continuous glucose monitoring or CGM) offered to each participant real-time interstitial glucose profile during a 14 days continuous period. Mean interstitial glucose of all participants was found to be 171.5 ± 34.6 mg/dL and standard deviation (SD) of glucose was 43.8 ± 9.7 mg/dL which indicated moderate glycemic dispersion. The coefficient of variation (CV%), which is SD/mean glucose x 100, mean value is 25.7 ± 5.9 per cent, which indicates that there are high variations between days in the glycemia. The critical value of short-term glycemic instability was revealed to be the Mean Amplitude of Glycemic Excursion (MAGE) 67.4 ± 17.9 mg/dL in the cohort as a whole.

In terms of gender stratification, males had a slightly better MAGE (68.9 ± 18.3mg/dL) than females (65.4 ± 17.1mg/dl) with the difference having no statistical significance ($p > 0.05$). The subjects were further divided into three tertiles of MAGE Low (<55 mg/dL), Moderate (55-75 mg/dL) and High (>75 mg/dL) to delve into the impact of increasing the glycemic variability on the oxidative stress parameters. Table 2 indicates that the HbA1c, fasting glucose, and post prandial glucose levels of participants in the high tertile of MAGE were significantly large and thus indicated that unstable glycemia also contributed to high levels of chronic hyperglycemia.

Table 2. Glycemic Variability Parameters Derived from Continuous Glucose Monitoring (CGM)

Glycemic Parameter	Low MAGE (<55 mg/dL)	Moderate MAGE (55–75 mg/dL)	High MAGE (>75 mg/dL)	p-value
Mean glucose (mg/dL)	158.4 ± 28.2	170.7 ± 31.5	187.6 ± 37.9	<0.001
SD (mg/dL)	36.2 ± 8.1	42.5 ± 9.3	49.3 ± 10.4	<0.001
CV (%)	22.5 ± 4.7	25.9 ± 5.4	28.3 ± 6.1	<0.001
HbA1c (%)	7.9 ± 0.9	8.4 ± 1.0	8.9 ± 1.2	0.002
Fasting glucose (mg/dL)	142.8 ± 29.3	154.6 ± 30.8	166.7 ± 32.4	0.001
Postprandial glucose (mg/dL)	198.1 ± 42.7	213.9 ± 45.5	225.7 ± 47.8	0.004

Table 2 provides a vivid demonstration of the statistically significant and graded increase in mean glucose and changes in variability indices with tertiles of MAGE ($p < 0.001$) with higher short-term changes observed to be associated with higher overall glycemia. These results support the emerging idea that glycemic variability can be used as an independent pathological feature in the management of diabetes on top of mean HbA1c.

Correlation of Glycemic variability and oxidative stress biomarkers.

The oxidative stress was assessed through the determination of serum malondialdehyde (MDA) which is a product of lipid peroxidation and total antioxidant capacity (TAC) that is the cumulative antioxidant defense condition. The average serum MDA level in the whole population was 4.7 + 0.8 mu mol/L and the average TAC was 1.12 + 0.21 mmol/L. Upon the analysis based on the tertiles of MAGE, the consistent pattern appeared as the higher the MAGE, the more the MDA levels grew, and the reverse was also true. Table 3 shows that the mean MDA of the patients in the highest tertile of the MAGE ranged 5.3056 µmol/L with a standard deviation of 0.60 compared to 3.9056 µmol/L with a standard deviation of 0.50 in the lowest tertile ($p < 0.001$), which indicates an increase in lipid peroxidation in patients with the highest glucose instability. Likewise, TAC reduced in the low MAGE group (1.31-0.15 mmol/L) at the high MAGE group (0.93-0.11 mmol/L) ($p < 0.001$).

Correlation analysis revealed positive relationship between MAGE and MDA ($r = 0.64$, $p < 0.001$) and an inverse relationship between MAGE and TAC ($r = -0.59$, $p < 0.001$) which means that a proportional increase in glycemic variability was followed by an increase in oxidative damage and antioxidant reserves depletion. These relationships were also observed to be notable despite the multivariate regression analysis by the consideration of possible confounders including age, BMI, and HbA1c. There was no statistically significant

difference in the sample of oxidative stress markers of males and females, which had been controlled by MAGE, and the hypothesis of the relationship between glucose variability and oxidative stress relied on gender was found not significant.

Table 3. Comparison of Oxidative Stress Biomarkers Across MAGE Tertiles

Parameter	Low MAGE (<55 mg/dL)	Moderate MAGE (55–75 mg/dL)	High MAGE (>75 mg/dL)	p-value
MDA (µmol/L)	3.9 ± 0.5	4.7 ± 0.6	5.3 ± 0.6	<0.001
TAC (mmol/L)	1.31 ± 0.15	1.11 ± 0.13	0.93 ± 0.11	<0.001

Table 3 depicts a definite negative trend between the levels of glycemic variability and the oxidative stress and anti-oxidant capacity. These patterns support the supposition that glucose oscillations are powerful inducing factors of oxidative stress, even with patients having almost similar average glycemic management.

Overall, this paper has shown that diabetic patients with T2DM had significant short-term glycemic variability as measured by continuous glucose monitoring and these variations were highly correlated with elevated oxidative stress and reduced antioxidant defense. Analysis of the gender proportion showed no significant difference in the variability or the oxidative parameters based on sex, but the males were more likely to have higher glucose excursions. The fact that MDA was significantly and steadily increased in a step-wise manner and TAC decreased in parallelogram with each MAGE tertile indicates that oxidative stress is closely associated with glycemic instability and not simply mean glucose concentration. Taken together, these findings help to emphasize the value of including CGM-based variability indices in a clinical practice to define a high-risk population as well as to inform individualized interventions that can help to stabilize glucose levels and reduce the impact of oxidative damage in patients with type 2 diabetes mellitus.

DISCUSSION

The current cross-sectional analysis compared the glycemic variability (GV) measured by the use of continuous glucose monitoring (CGM) with the oxidative stress products among patients with type 2 diabetes mellitus (T2DM) in tertiary care units in Punjab, Pakistan[9]. The results showed that increased glucose fluctuations, in terms of high Mean Amplitude of Glycemic Excursion (MAGE), Standarddeviation (SD) and Coefficient of Variation (CV), were significantly linked with high malondialdehyde (MDA) and low totalantioxidant capacity (TAC) levels. These findings highlight the fact that glycemic instability is a major factor leading to oxidative stress regardless of the level of mean glycemic control or the level of HbA1c2,[11].

The correlation between GV and oxidative stress that we have observed in this study leads to the accumulating evidence that transient changes in the glucose levels can induce more significant metabolic disturbances than prolonged hyperglycemia in isolation[12]. Previous experimental studies by Monnier et al. (2018) established that intermittent glucose spikes trigger overproduction of reactive oxygen species (ROS) by the stimulation of mitochondrial oxidative processes which cause more endothelial damage than constant high glucose concentrations. The present paper is an extrapolation of the findings to South Asian population and shows that the same mechanism could be involved to explain the rapid onset of diabetic vascular complications in South Asian area[8-10].

Biochemically, there is a mechanical and metabolic stress of endothelial cells on the glucose variation that results in sudden variations in oxidative status. Those swings trigger the NADPH oxidase system that results in the overproduction of ROS and lipid peroxidation[11]. This oxidative lipid degradation is indicated by high levels of MDA in the current study and a low level of TAC indicates depletion of the antioxidant defenses because of continuous oxidative stress. Such bilateral change increases the production of oxidants and reduces the level of the antioxidant reserve forms a vicious cycle increasing the endothelial dysfunction and insulin resistance. This kind of oxidative mal-regulation has now been identified as the key factor leading to the occurrence of microvascular complications, including retinopathy, nephropathy and neuropathy[12,13].

The findings can also be compared to the work of Ceriello et al. (2020) and Giacco and Brownlee (2018), who proved that transient bursts of oxidative stress induced by postprandial and glycemic waveforms disrupt the bioavailability of nitric oxide, vascular tone, and atherogenesis[14]. On the same note, Wang et al. (2016) established that elevated MAGE values are associated with endothelial dysfunction and elevated carotid intima-media thickness which is an early sign of atherosclerotic change. This mechanistic association is supported by our data (MAGE and MDA demonstrate strong correlation r, $p < 0.001$ and inverse correlation r, $p < 0.001$), which supports the idea of targeting GV reduction as a therapeutic outcome[15].

It is also remarkable that whereas HbA1c is the traditional measure of the long-term glycosylation control, it gives merely an average measurement of blood sugar

and masks short-term variations that can be the cause of tissue damage[16]. HbA1c, in the current study had no significant association with oxidative stress parameter, controlling for MAGE indicating the idea that GV is a separate pathology. In this observation, the authors note that the study by Kilpatrick et al. (2017) supported this fact, stating that two patients whose HbA1c levels are similar may have dramatically different complications risks based on their daily glucose variability[17].

The clinical implication of these results is that continuous monitoring of glucose gives a more detailed and physiologically valid image of glucose management rather than the traditional fasting or postprandial tests[18]. The parameters derived using the CGM reflect the dynamic aspects of the glucose excursions in real time, and clinicians can develop interventions that exclusively correct variations. New pharmacotherapeutic agents, including glucagon-like peptide-1 (GLP-1) receptor agonists and sodium-glucose co-transporter 2 (SGLT2) inhibitors, have demonstrated the capability to reduce glycemic fluctuations and lessen oxidative stress. Moreover, organized lifestyles change interventions, which focus on the composition of meals, regularity of carbohydrates and stress management, were proven to minimize the glucose fluctuations and oxidative load[19].

Regarding the regional and general health context, this work represents an excellent contribution to the understanding of the biochemical composition of Pakistani T2DM patients, which frequently do not have signs of such problems at an earlier stage, demonstrate increased insulin resistance, and cannot afford to use sophisticated monitoring parameters. CGM implementation into these populations will help in closing a significant diagnostic gap, as it is able to detect detrimental glycemic variability which otherwise might remain undetected when assessing HbA1c alone. The diagnosis of patients with high GV may then facilitate preventive measures to postpone the development of complications and positively influence the clinical outcome and decrease the healthcare expenses in the end[17,20].

Regardless of these significant results, some limitations should be admitted. The cross-sectional design does not allow creating a direct causal relationship between GV and oxidative stress, longitudinal studies would shed more light on the chronological order of events. The sample size, although sufficient enough to be used in correlation analysis, might be insufficient in terms of exploring subgroups based on gender, age, or treatment regimen[13,17]. Further, oxidative stress was assessed with two well-established but fairly general indicators MDA and TAC that though reflective of the overall oxidative balance, fail to reflect the complexity of the cellular antioxidant systems. Future research to include more biomarkers including superoxide dismutase (SOD) glutathione peroxidase and catalase, and inflammatory cytokines, may further explain the mechanistically mediated relationship between glucose instability, oxidative stress and inflammation[16].

However, the advantages of this study are in its real time measurement of glycemic variability by making use of professional CGM technology, and the use of representative South Asian diabetic cohort and the strict control of biochemical analysis of oxidative parameters. Together, these aspects contribute to the strength of the observed relationships and provide a feasible clinical implication to patient treatment and policy development[19].

To summarize, the current results are a part of the increasing evidence of the importance of the variability of glucose control not only of the mean glucose level in the pathophysiology of complications of diabetes. This study informs about the need to consider GV monitoring as part of regular nursing interventions in the management of diabetes in Pakistan and other low- to middle-income countries by stating the strong correlation between CGM-derived GV indices and oxidative stress biomarkers[12,16].

CONCLUSION

This paper establishes that glycemic variability, assessed using continuous glucose monitoring, has a strong relationship with elevated levels of oxidative stress and low antioxidant capacity in patients with type 2 diabetes mellitus. These associations remain unchanged even in the presence of average glycemic control using an HbA1c, and thus the short-term changes in glucose carry an extra metabolic cost underpinning vascular damage and chronic complications. The steady increase in the malondialdehyde and the subsequent reduction in total antioxidant capacity in the higher tertiles of MAGE support the fact that the oxidative imbalance is closely associated with unstable glucose dynamics. This highlights the possible advantage of therapies and lifestyle changes that would reduce the glycemic fluctuations, but not necessarily reduce HbA1c. Clinically, the integration of CGM-based assessment in the diabetes care can enable detection of high-risk patients in early stages and the application of more specific therapeutic interventions to enhance the metabolic stability. To determine whether the long-term suppression of the glycemic variability will be applicable to the reduction of the oxidative stress and decrease the prevalence of diabetic micro- and macrovascular complications in the South Asian population, future prospective studies are justified. Overall, the results of the present research confirm that stable glycemia is no less critical than controlled glycemia, and the control of glucose variability must be a key element among global interventions in the diabetes management in the contemporary endocrinology.

Conflict of Interest: None

Grants/Funding: None

Disclaimer: None

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