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Relationship between time-in-range (TIR) and glycemia risk index (GRI) using continuous glucose monitoring (CGM) in Indian patients with diabetes: in a real-world setting

Abstract

Objective: To assess the correlation between TIR (Time-in-Range) and GRI (Glycemia Risk Index) using real-world CGM (Continuous Glucose Monitoring) data in Indian patients with diabetes.

Methods: This retrospective analysis included CGM data from 50 patients with diabetes. TIR was calculated as the percentage of time glucose levels were within the target range (70–180 mg/dL). GRI scores were calculated using a validated online tool that incorporates the proportion of time patients spent across different glucose categories, including very low, low, high, and very high ranges. A dataset comprising 50 paired values of GRI and TIR was analyzed. Pearson's correlation coefficient (R) was used to evaluate the relationship between GRI and TIR.

Results: A strong, statistically significant inverse correlation was observed between TIR and GRI (The value of R is -0.9416. The P-Value is <.00001). The result is significant at $p < .05$, indicating that higher TIR is associated with reduced Glycemia Risk Index (GRI). Simple linear regression with TIR as the dependent variable and GRI as the independent variable demonstrated a significant inverse association ($\beta = -0.74$, 95% CI −0.82 to −0.67; $p < 0.001$). For every 1-unit increase in TIR, GRI decreases by approximately 1.19 units.

Conclusion: GRI and TIR are inversely correlated, with higher GRI values reflecting poorer glycemic stability and lower TIR percentages.

Abbreviations: TIR, time-in-range; GRI, glycemia risk index; CGM, continuous glucose monitoring

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Introduction

In its *Standards of Care in Diabetes—2026*, the American Diabetes Association (ADA) has introduced important updates related to continuous glucose monitoring (CGM) and overall diabetes management. Notably, the guidance now takes a stronger position on CGM use. Rather than simply suggesting it as an option, the ADA recommends CGM for adults with type 2 diabetes, including those who are not using insulin. The updated recommendations also acknowledge that CGM can be valuable for individuals receiving other glucose-lowering therapies, particularly when real-time glucose data can enhance clinical decision-making and improve glycemic outcomes. This shift reflects growing evidence that CGM offers meaningful benefits across a broader spectrum of patients, regardless of the specific treatment regimen.[1]

Continuous glucose monitoring uses a small sensor placed under the skin to measure glucose levels in the interstitial fluid. These readings closely reflect blood glucose values and allow ongoing assessment of glycaemic patterns.[2]

This CGM technology enables real-time tracking of glucose fluctuations throughout the day and night, offering a clear view of glycaemic patterns. Such insights can support informed treatment adjustments and guide meaningful lifestyle modifications.[3,4]

Time in Range (TIR) is recognized by the American Diabetes Association as an important CGM-derived parameter for evaluating glycaemic control. However, relying solely on TIR has limitations, particularly because it may not sufficiently capture the burden or severity of hypoglycaemia. For this reason, TIR alone is not considered a comprehensive metric for assessing overall glycaemic risk.[1]

The development of the Glycemia Risk Index (GRI) in 2022[5] attempts to address the shortcomings of its predecessor metrics. This novel metric is designed to provide a consolidated assessment of a patient's overall glycemic status, expressing the quality of glucose control as a single, interpretable value.

Glycemia risk index calculation

The glycemia risk index is derived from CGM data and provides a quantitative measure of the overall glycemic risk. It assigns greater weight to hypoglycemic episodes compared to hyperglycemic ones, with particular emphasis on extreme glucose values— specifically, levels below 54 mg/dL and above 250 mg/dL. GRI = 3.0 × [TBR < 54 + (0.8 × TBR 54–70)] + 1.6 × [TAR > 250 + (0.5 × TAR 180–250)].[6,7] The GRI can be calculated for individual patients or cohorts using the online GRI calculator, accessible at www. diabetestechnology.org/gri.[8]

Objective

Objective behind the study to explore the Relationship Between Time-in-Range (TIR) and Glycemia Risk Index (GRI) Using Continuous Glucose Monitoring (CGM) in Indian Patients with Diabetes: In A Real-World Settings.

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Methods

Study design and population

This retrospective, observational study analyzed Continuous Glucose Monitoring (CGM) data obtained from 50 patients with diabetes mellitus. The dataset included adults with type 1 or type 2 diabetes who were using CGM as part of routine clinical care (2 patients with type 1 and rest 48 patient with type 2). Only CGM recordings with adequate data completeness, defined as ≥70% sensor wear time over the assessment period, were included in the final analysis to ensure reliability of glycemic metrics.

All data were anonymized prior to analysis to maintain patient confidentiality. As this was a retrospective analysis of de-identified clinical data, no direct patient intervention was performed.

CGM data collection and processing

CGM data were collected using standardized commercially available CGM i.e., FreeStyle Libre systems approved for clinical use.

Glycemic metrics[1]

Time in range (TIR)

Time in Range (TIR) was defined as the percentage of time during which interstitial glucose values were within the target range of 70–180 mg/dL.

Glycemia risk index (GRI)[6]

The Glycemia Risk Index (GRI) was calculated for each participant using a validated online calculator (www. diabetestechnology.org/gri).[8] GRI integrates information from multiple glycemic domains, including:

I. Very Low glucose (<54 mg/dL)

II. Low glucose (54–69 mg/dL)

III. High glucose (181–250 mg/dL)

IV. Very High glucose (>250 mg/dL)

The GRI score reflects both hypoglycemic and hyperglycemic risk exposure, providing a composite measure of glycemic variability and risk burden. Higher GRI values indicate greater overall glycemic risk. For each participant, paired values of TIR and GRI were derived from the same CGM dataset to ensure direct comparability.[6]

Statistical analysis

A dataset comprising 50 paired observations of TIR and GRI was constructed for statistical evaluation. Pearson's correlation coefficient (R) was used to evaluate the relationship between GRI and TIR.

A strong, statistically significant inverse correlation was observed between TIR and GRI (The value of R is -0.9416. The P-Value is <.00001). The result is significant at p <.05, indicating that higher TIR is associated with reduced Glycemia Risk Index (GRI). (Refer Figure 1)

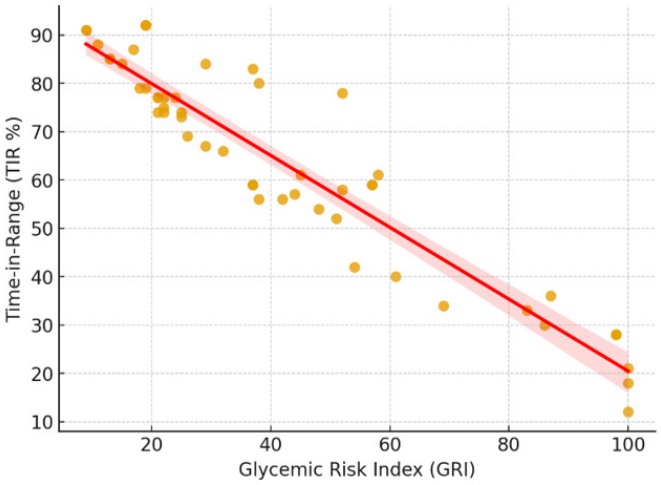

Figure 1 Correlation between GRI and TIR.

Simple linear regression with TIR as the dependent variable and GRI as the independent variable demonstrated a significant inverse association ($\beta = -0.74$, 95% CI −0.82 to −0.67; $p < 0.001$). The model accounted for 88.7% of the variance in TIR ($R^2 = 0.887$). For every 1-unit increase in TIR, GRI decreases by approximately 1.19 units.

Discussion

In modern diabetes management, TIR has emerged as a meaningful clinical outcome because it reflects the proportion of time a patient maintains glucose within a target range. Higher TIR is linked with better short-term metabolic stability and lower long-term microvascular and cardiovascular risk. GRI, on the other hand, captures glycemic instability by integrating magnitude and frequency of excursions. Elevated GRI indicates more variability, more time in hyperglycemia or hypoglycemia, and greater overall glucose dysregulation.

The strong inverse association observed in this dataset between GRI and TIR is consistent with these physiological expectations. As GRI increases, glycemic fluctuations broaden and the proportion of time within therapeutic range declines. The regression model showed that GRI explained a large proportion of the variance in TIR, suggesting that instability metrics are tightly coupled with clinically relevant glucose outcomes. The correlation coefficient also supported a robust linear inverse relationship, further reinforcing the biological plausibility of these findings.

A research team from South Korea led by Kim evaluated the relationship between GRI and TIR by reviewing 524 continuous glucose monitoring traces, each covering 90 days, from 194 adults with type 1 diabetes and 2 diabetes treated with insulin. Their analysis showed a very strong inverse correlation between GRI and TIR ($R = -0.974$). In addition, GRI demonstrated a significant positive correlation with glycemic variability, as reflected by the coefficient of variation (CV) ($R = 0.683$).[9]

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Conclusion

This observation aligns with published evidence that metrics of variability, rather than mean glucose alone, are important determinants of glycemic quality and diabetes complications. The result also supports the growing shift toward multimodal CGM interpretation frameworks that incorporate both variability indices and clinically actionable endpoints. Clinically, such a relationship has implications for treatment assessment and therapy optimization. This also suggests a role for GRI as a marker to monitor therapeutic response over time and to stratify patients at higher risk for suboptimal control.

Clinical recommendation

Given its comprehensive nature and clinical relevance, GRI should be routinely used by all physicians, diabetologists, and endocrinologists involved in diabetes care. It enables better identification of patients at risk, supports personalized treatment adjustments, and complements existing metrics like TIR and HbA1c.

Limitations: Small sample size

Disclaimer: AI support was taken specially for language editing, without compromising trust. While efforts have been made to ensure clarity, accuracy, and relevance, the content should be independently reviewed and verified, particularly for clinical, scientific, or regulatory use.

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None.

Conflict of interest

The author declares that there is no conflict of interest.

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