Blood sugar fasting, post prandial and HbA1c level co-relationship in the management of diabetes mellitus: A Comprehensive Review

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ABSTRACT

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia caused by impairments in insulin secretion leading to severe complications such as retinopathy, nephropathy, neuropathy and cardiovascular diseases. Effective management of DM requires monitoring three key biomarkers like fasting blood glucose (FBG), postprandial blood glucose (PPBG) and glycated hemoglobin (HbA1c). FBG reflects basal glucose levels controlled by hepatic glucose production, while PPBG assesses glucose regulation after meals, serving as a strong indicator of cardiovascular risk. HbA1c, regarded as the gold standard for long-term glycemic monitoring provides an integrated measure of average glucose levels over 2-3 months. The interplay among these markers is critical for understanding glycemic control dynamics and tailoring effective therapeutic strategies. This review explores their interrelationships, emphasizing the contributions of FBG and PPBG to HbA1c levels and their clinical significance in diagnosing and managing diabetes. It also highlights challenges such as individual variability in glucose metabolism and factors affecting measurement accuracy, alongside emerging technologies like continuous glucose monitoring (CGM) that provide real-time insights for personalized care. By addressing these complexities, the study underscores the importance of a multidimensional approach to optimize outcomes and reduce the burden of diabetes-related complications.

Keywords: Diabetes mellitus, FBG, PPBG, HbA1c, glycemic control, glucose monitoring, continuous glucose monitoring (CGM), diabetes management, hyperglycemia, personalized care, biomarkers, diabetes complications.

INTRODUCTION

Diabetes mellitus (DM) is a complex metabolic condition defined by persistent high blood sugar levels (hyperglycemia) caused by impairments in insulin production, insulin action or a combination of both (**American Diabetes Association [ADA], 2020**). Effective management of blood sugar levels is crucial to prevent both immediate and long-term complications, such as retinopathy, nephropathy, neuropathy and cardiovascular diseases. The most common and widely accepted biomarkers for assessing glycemic control in DM are FBG, PPG and HbA1c. These markers provide essential insights into various aspects of glucose regulation, which are critical for optimizing treatment strategies and improving patient outcomes.

FBG is measured after an 8-hour period without food, is an important indicator of basal insulin function and hepatic glucose production (**American Diabetes Association, 2020**). Elevated FBG levels often reflect insulin resistance and inadequate insulin secretion, common features of type 2 diabetes (**Kahn et al., 2014**). On the other hand, PPG assesses the body's ability to regulate glucose following meals. Postprandial hyperglycemia is a significant risk factor for cardiovascular disease and has been shown to be a stronger predictor of complications than FBG in some populations, especially in type 2 diabetes (**Ceriello et al., 2004**). The HbA1c test measures the percentage of hemoglobin that is glycated over a period of 2-3 months, providing a comprehensive reflection of both fasting and postprandial glucose control (**Nathan et al., 2009**). Higher HbA1c levels are associated with an increased risk of microvascular and macrovascular complications in diabetes patients (**Stratton et al., 2000**). The relationship between these markers is critical for diabetes management. Elevated fasting glucose often contributes directly to higher HbA1c, while postprandial glucose surges can also significantly impact HbA1c, even in patients with normal fasting levels (**Zhang et al., 2015**). As such, effective diabetes management strategies aim to address both fasting and postprandial hyperglycemia to prevent long-term complications. Maintaining an optimal HbA1c target of <7% has been shown to reduce the risk of complications significantly, underscoring the importance of a multifaceted approach to blood glucose control (**ADA, 2020**). Therefore, understanding the interrelationship between FBG, PPG and HbA1c is essential for personalized diabetes management with the goal of improving overall outcomes and reducing the burden of diabetes-related complications.

METHODOLOGY:

This review adopts a comprehensive approach to examining the interrelationship between FBG, PPBG and HbA1c in the management of DM. A systematic literature search was conducted using databases such as PubMed, Scopus and Google Scholar to identify relevant studies published between 2000 and 2023. Keywords including "fasting blood glucose," "postprandial blood glucose," "HbA1c," "diabetes management" and "glycemic control" were employed to retrieve studies. Peer-reviewed articles, clinical trials, meta-analyses and review papers that investigated the relationships among these biomarkers and their clinical implications were included.

Data were extracted to assess the contributions of FBG and PPBG to HbA1c levels and to evaluate the clinical utility and limitations of each marker. Additionally, studies on the application of advanced technologies like continuous glucose monitoring (CGM) and flash glucose monitoring (FGM) were included to understand their impact on modern diabetes management. Comparative analyses of studies across diverse populations including type 1 and type 2 diabetes, gestational diabetes and high-risk groups, were conducted to account for variations in glycemic dynamics.

DIABETES MELLITUS AND ITS GLOBAL PREVALENCE

Diabetes mellitus is a chronic metabolic condition marked by the body's inability to regulate blood glucose levels effectively, leading to consistently elevated concentrations of blood sugar. This disorder may result from insufficient insulin production by the pancreas, characteristic of type 1 diabetes, or from the body's resistance to insulin, as observed in type 2 diabetes (**Ozougwu, 2013; Seino et al., 2010**). As a significant global health issue, diabetes is poised to become even more prevalent in the coming years, necessitating urgent public health interventions.

The worldwide prevalence of diabetes is rising at an alarming rate. According to projections by the WHO, the number of adults with diabetes is expected to nearly double from 177 million in 2000 to 370 million by 2030 (**Ozougwu, 2013**). Moreover, experts predict a staggering 64% increase in diabetes incidence by 2025, potentially affecting 53.1 million individuals. Recent statistics further highlight this trend, with global diabetes prevalence recorded at 9.3% in 2019, a figure anticipated to climb to 10.2% by 2030 and 10.9% by 2045 (**Saeedi et al., 2019**). Both type 1 and type 2 diabetes are becoming increasingly common, with the International Diabetes Federation estimating that approximately 500 million individuals are currently living with diabetes, a number projected to surge to 783.2 million within the next two decades (**Oyagbemi et al., 2014; Ozougwu, 2013; Ansari et al., 2022**).

The increased prevalence of diabetes is not limited to any specific region or country. In fact, the burden of this condition is felt across the globe with the International Diabetes Federation reporting that the largest number of individuals with diabetes reside in the Western Pacific region, followed by Europe, Southeast Asia and the Middle East and North Africa (**Wang et al., 2022; Lin et al., 2020; Saeedi et al., 2019**).

The rising prevalence of diabetes is a complex issue, driven by a variety of factors including changes in lifestyle, diet and physical activity patterns, as well as genetic and environmental influences. Addressing the global diabetes epidemic will require a multifaceted approach with a focus on prevention, early detection and effective management strategies.

THE SIGNIFICANCE OF BLOOD GLUCOSE MONITORING IN DIABETES MANAGEMENT

Diabetes, a chronic condition characterized by the body's inability to regulate blood sugar levels effectively has become a global health concern, affecting millions of individuals worldwide. Proper management of diabetes is crucial, as uncontrolled blood glucose levels can lead to a host of complications, ranging from cardiovascular disease to nerve damage and vision loss (**Vrany et al., 2023**). One of the cornerstones of effective diabetes management is the practice of regular blood glucose monitoring. Decades of research have consistently demonstrated the importance of maintaining healthy blood glucose levels in preventing or delaying the onset of diabetes-related complications, particularly in high-risk and marginalized populations (**Vrany et al., 2023**).

Continuous glucose monitoring has emerged as a cutting-edge technology that provides real-time data on an individual's blood sugar levels, allowing for more precise and personalized diabetes management (**Gilbert et al., 2021**). Continuous glucose monitoring provides a complete picture of blood sugar patterns, helping individuals with diabetes make more informed decisions about their treatment and daily habits, which can lead to improved glycemic control and better quality of life (**Gilbert et al., 2021**). However, the benefits of glucose monitoring can vary depending on the individual and their specific needs. For some, regular self-monitoring of blood glucose, combined with education and support can offer valuable insights into how lifestyle choices and medication management impact their blood sugar levels (**Davies et al., 2018**).

In the case of type 2 diabetes, the advantages of continuous glucose monitoring have been more modest, as the condition is often characterized by a more gradual deterioration of beta cell function and a less pronounced need for tight glycemic control. Nonetheless, the implementation of patient-centered care, which acknowledges the multifaceted nature of diabetes and respects individual preferences and barriers, is essential for effective diabetes management. Incorporating continuous glucose monitoring and other novel technologies into a comprehensive, personalized approach to care can lead to improved outcomes, particularly for individuals from marginalized racial and ethnic groups, who have historically experienced disproportionate rates of diabetes-related complications (**Vrany et al., 2023**).

ELUCIDATION OF THE THREE PRIMARY MEASUREMENTS:

1. Fasting blood sugar (FBS)

FBS plays a vital role in managing diabetes as it provides a clear measure of blood glucose levels when no recent food intake influences the reading. Keeping FBS within healthy limits is crucial for preventing or delaying diabetes-related complications including cardiovascular disease, nerve damage and vision loss. Regularly monitoring FBS enables individuals with diabetes to make better-informed decisions about their treatment and daily habits contributing to improved blood sugar control and enhanced quality of life (**Cappon et al., 2017; Davies et al., 2018; Gilbert et al., 2021; Yu et al., 2021**).

FBS is a measure of the body's ability to regulate blood glucose levels in the absence of recent food intake. In the fasting state, glucose levels are primarily controlled by the liver, which releases glucose to maintain stable blood sugar levels (**Giugliano et al., 2008**). Several factors can influence the results of FBS tests. Diurnal variation has been observed with a higher prevalence of diabetes in patients examined in the morning compared to the afternoon. Additionally, factors such as food intake during the fasting period, hypocaloric diets and delays in processing the blood sample can all impact the accuracy of the results (**Sacks, 2011**). Glucose homeostasis is a tightly regulated process in healthy individuals, maintained by a delicate balance between insulin and counterregulatory hormones. However, in patients with diabetes, this balance is disrupted, leading to dysregulation of glucose levels After an overnight fast, healthy individuals can utilize the glycogen stores in the liver to maintain glucose levels for approximately 12 hours (**Alarouj et al., 2010**). Understanding the factors that influence FBS levels is crucial for accurate interpretation of diagnostic tests and effective management of glucose homeostasis in both healthy individuals and those with diabetes (**Alarouj et al., 2010; Barker et al., 2011**).

2. Postprandial blood sugar (PPBS)

In addition to FBS, PPBS (the level of blood glucose after a meal) is also an important consideration in diabetes management. High blood sugar levels after meals known as postprandial hyperglycemia have been associated with a higher risk of heart problems and other complications related to diabetes (**Knowler et al., 2002**). While many experts agree that postprandial glucose levels offer a more accurate and early indication of diabetes symptoms compared to fasting glucose levels, it has not yet been definitively proven that controlling postprandial hyperglycemia can prevent these complications (**Zimmerman, 2001**).

While the literature provides valuable insights into the importance of monitoring postprandial glucose, there is still uncertainty about the causal relationship between postmeal glucose and complications of diabetes (**Guideline for Management of Postmeal Glucose in Diabetes, 2013**). Diabetes is diagnosed when FBS levels are consistently ≥7 mmol/L or when blood sugar levels measured two hours after a meal reach ≥11.1 mmol/L highlighting the importance of both fasting and PPBS in clinical evaluations (**Giugliano et al., 2008**). Recognizing the impact of high PPBS (postprandial hyperglycemia), researchers have investigated various strategies to manage this condition. These include using pre-packaged meals, medications like α-glucosidase inhibitors and acarbose and fast-acting insulin therapies. While many agree that postprandial glucose levels provide an earlier and more reliable marker for identifying diabetes symptoms compared to FBS, there is still no conclusive proof that controlling postprandial hyperglycemia alone can prevent diabetes-related complications.

3. Glycated hemoglobin (HbA1c)

Blood glucose levels provide a snapshot of a person's current glycemic status, but these levels can be influenced by various factors such as food intake, physical activity, stress and medication use, which may lead to significant fluctuations throughout the day. In contrast, HbA1c or glycated hemoglobin offers a broader perspective by reflecting the average blood glucose levels over the previous 8–12 weeks. This long-term marker is less affected by daily variations, making it a reliable measure of overall glycemic control. HbA1c has become an indispensable tool in diabetes management, not only for tracking long-term blood sugar trends but also for predicting the risk of complications like cardiovascular disease and neuropathy (**Sacks, 2012; Weykamp, 2013**). It is widely regarded as the gold standard for evaluating glycemic control in patients with diabetes. However, research has shown that even with similar average blood glucose profiles, individuals can exhibit significant differences in HbA1c levels. These variations suggest that factors beyond glucose levels, such as individual biological differences and environmental influences also impact HbA1c results (**Xin et al., 2023**). Despite these complexities, HbA1c remains a critical marker in routine diabetes care, enabling clinicians to assess long-term glycemic control and tailor management strategies to reduce the risk of diabetes-related complications.

INTERRELATIONSHIP BETWEEN FBS, PPBS and HbA1c:

Diabetes mellitus, a long-term metabolic condition marked by consistently high blood sugar levels (hyperglycemia) has emerged as a significant global health challenge affecting approximately 463 million people worldwide as of 2019. The significance of blood glucose monitoring in the management of diabetes cannot be overstated, as it plays a crucial role in the early detection, treatment and prevention of complications (**Hu & Lin, 2018; Zhou et al., 2023**). Fasting blood glucose and postprandial blood glucose are commonly used as diagnostic tools for diabetes, providing a snapshot of an individual's glycemic status at a given time (**Erbach et al., 2016**). Glycated hemoglobin (HbA1c), on the other hand, reflects the average blood glucose level over a 2-3 month period and is widely regarded as the "gold standard" for monitoring long-term glycemic control (**Yan et al., 2019; Lapolla et al., 2011**).

The relationship between FBS, PPBS and HbA1c is pivotal in understanding glycemic control dynamics in diabetes management. FBS and PPBS serve as real-time indicators of glucose levels, reflecting basal and post-meal glucose fluctuations, while HbA1c provides an integrated picture of average blood glucose over approximately three months. The comparative analysis of studies on the interrelationship between FBS, PPBS and HbA1c highlights diverse findings that reflect the complexity of glycemic control in different populations and conditions. **Patel and Anuradha (2023)** identified a robust correlation (r > 0.9) between HbA1c, FBS and PPBS in Type 2 diabetes, underscoring the utility of these markers in tandem for comprehensive glycemic assessments. Their findings emphasize that both FBS, as a marker of fasting glucose stability and PPBS as an indicator of post-meal spikes, contribute significantly to the long-term glycemic average represented by HbA1c. This is consistent with other studies but provides a particularly high degree of correlation, suggesting effective glucose regulation strategies.

In contrast, **Kariyawasan et al. (2021)** focused on the practical application of HbA1c-derived Estimated Average Glucose (eAG), bridging short-term glucose measurements like FBS and PPBS with long-term glycemic evaluations. The introduction of eAG provides a simplified approach for patient education and clinical decision-making, making glycemic trends more accessible and actionable. This study aligns with **Patel and Anuradha's** findings but adds a layer of utility for contexts where direct HbA1c testing might be less accessible or more difficult to interpret. The dynamics between HbA1c, FBS and PPBS shift when comparing other studies like **Vani and Renuka (2020)** and **Ahmed et al. (2013)**. **Vani and Renuka** found a stronger correlation of HbA1c with PPBS (r = 0.79) compared to FBS (r = 0.77), highlighting the significant influence of postprandial glucose spikes on long-term glycemic averages in Type 2 diabetes. In contrast, **Ahmed et al.** demonstrated that in gestational diabetes, HbA1c correlated better with FBS (r = 0.87) than PPBS (r = 0.51), reflecting the physiological adaptation during pregnancy where fasting glucose plays a dominant role. These findings highlight how the relative contribution of FBS and PPBS to HbA1c varies depending on the underlying condition with PPBS playing a more critical role in Type 2 diabetes and FBS taking precedence in gestational diabetes. Further expanding the perspective, **Sunthari (2018)** explored the impact of micronutrient deficiencies, identifying an inverse relationship between serum zinc levels and HbA1c. This unique approach adds a biological dimension to the discussion, suggesting that deficiencies in essential nutrients like zinc could exacerbate hyperglycemia or affect glycemic markers. **Rajan et al. (2020)** complemented this systemic view by linking oxidative stress markers, such as malondialdehyde (MDA) with elevated HbA1c, FBS and PPBS, indicating that prolonged hyperglycemia contributes to broader systemic dysfunction, including inflammation and oxidative stress.

Occupational influences on glycemic variability were highlighted by **Sharma et al. (2023)**, who emphasized the challenges faced by diabetic shift workers. Their study advocated integrating Self-Monitoring of Blood Glucose (SMBG) with HbA1c monitoring to address the glycemic variability induced by irregular schedules. This study stands out in its focus on behavioral and occupational factors, showcasing how lifestyle dynamics can complicate glycemic control and necessitate tailored monitoring strategies. **Renuka et al. (2020)** reinforced the reliability of HbA1c as a glycemic marker, aligning with **Vani and Renuka (2020)** in observing a marginally stronger correlation with PPBS than FBS. This consistency emphasizes the role of postprandial glucose in influencing HbA1c, especially in non-gestational diabetic populations.

These studies collectively underscore the multifaceted interplay between FBS, PPBS and HbA1c. While HbA1c provides an overarching view of long-term glycemic control, the contributions of FBS and PPBS vary depending on the population, physiological condition and lifestyle factors. Tools like eAG enhance practical applications, while considerations of oxidative stress, micronutrient status and behavioral influences provide a deeper understanding of systemic and environmental impacts on glycemic markers. This comparative analysis highlights the importance of personalized and context-specific approaches to diabetes management, leveraging the strengths of these interrelated markers to optimize outcomes.

CLINICAL RELEVANCE OF THE INTERRELATIONSHIP:

The interrelationship between FBS, PPBS and HbA1c plays a pivotal role in diagnosing and managing diabetes. Diagnostic criteria from the **American Diabetes Association** **(ADA)** heavily utilize these markers to assess glycemic status comprehensively. FBS with a diagnostic threshold of ≥126 mg/dL (7.0 mmol/L) after an 8-hour fast is one of the most reliable tools for screening and reflects basal glucose levels (**Patel & Anuradha, 2023**). PPBS measured two hours after a meal, is diagnostic at ≥200 mg/dL (11.1 mmol/L) and captures glucose spikes after meals, often indicating early glucose intolerance when FBS remains normal. Glycated hemoglobin (HbA1c) with a diagnostic threshold of ≥6.5%, represents average blood glucose over 2–3 months and provides a comprehensive marker of long-term glycemic control (**Kariyawasan et al., 2021**). Together, these markers enhance diagnostic precision allowing for early identification and classification of diabetes and prediabetes.

For effective diabetes management, optimal ranges for these markers have been defined to prevent complications and ensure glycemic control. The ADA recommends maintaining FBS between 80–130 mg/dL (4.4–7.2 mmol/L) to manage baseline glucose levels and reduce risks such as nephropathy and retinopathy (**Vani & Renuka, 2020**). PPBS levels should remain below 180 mg/dL (10 mmol/L) two hours after meals, as postprandial glucose spikes are strongly linked to cardiovascular events and endothelial dysfunction (**Ahmed et al., 2013**). HbA1c, widely regarded as the gold standard for long-term monitoring, should ideally be <7.0% for most adults with diabetes. However, individualized targets are critical: younger, healthier individuals may aim for stricter control (<6.5%), while older patients or those with comorbidities may target <8.0% to minimize hypoglycemia risks (**Renuka et al., 2020**).

These optimal ranges are essential for guiding therapeutic decisions and achieving effective glycemic control. For instance, while FBS provides insights into baseline glucose levels, PPBS is crucial for detecting post-meal glucose excursions, which contribute significantly to HbA1c variability. HbA1c, in turn, integrates these daily variations into a long-term average, reflecting overall glycemic trends (**Sunthari, 2018**). Effective monitoring of these markers ensures a comprehensive approach to diabetes management, reducing risks of microvascular and macrovascular complications. Studies also highlight the importance of behavioral and systemic factors; for example, integrating self-monitoring of blood glucose (SMBG) with HbA1c monitoring has been particularly effective in managing diabetic shift workers, where glycemic variability is more pronounced (**Sharma et al., 2023**).

The interplay between FBS, PPBS and HbA1c provides a multidimensional approach to diagnosing and managing diabetes. While FBS and PPBS offer immediate insights into fasting and postprandial glucose levels, HbA1c serves as an integrated marker of long-term glycemic control. These measures complement each other, enabling precise diagnostic and management strategies tailored to individual patient needs.

Regular monitoring and achieving optimal ranges for these markers remain central to preventing complications and improving long-term outcomes for individuals with diabetes.

LIMITATIONS AND CHALLENGES IN INTERPRETING THE INTERRELATIONSHIP:

1. Factors affecting measurement accuracy

The interpretation of FBS, PPBS and HbA1c is often influenced by factors that compromise measurement accuracy, posing challenges in clinical decision-making. HbA1c, while widely regarded as the gold standard for long-term glycemic control, is particularly susceptible to inaccuracies in certain conditions. Hemoglobinopathies, anemia, or alterations in red blood cell turnover can significantly distort HbA1c levels. For example, in patients with iron-deficiency anemia, HbA1c levels may be falsely elevated due to prolonged red blood cell survival, leading to an overestimation of glycemic control (**Ahmed et al., 2013**). Conversely, conditions like hemolytic anemia or chronic kidney disease can reduce red blood cell lifespan, causing falsely low HbA1c readings and underestimating glycemic burden. FBS and PPBS measurements are also subject to variability due to improper fasting or timing errors during sample collection. For instance, a misreported fasting period or delayed testing post-meal can lead to inaccurate readings, complicating the interpretation of glucose patterns (**Patel & Anuradha, 2023**). Additionally, glucose-lowering medications such as insulin or SGLT2 inhibitors can differentially affect FBS and PPBS, potentially skewing correlations with HbA1c.

2. Individual variations in glucose metabolism

Another major challenge is the variability in glucose metabolism among individuals, which can affect the interrelationship between FBS, PPBS and HbA1c. These variations may stem from genetic, physiological and behavioral factors. For example, postprandial glucose levels are highly influenced by dietary patterns, meal composition and insulin sensitivity. In some individuals, postprandial spikes significantly contribute to HbA1c variability, while in others, fasting glucose plays a more dominant role (**Vani & Renuka, 2020**). Conditions such as gestational diabetes further illustrate this complexity; as Ahmed et al. (2013) demonstrated, HbA1c correlates better with FBS ($r = 0.87$) than PPBS ($r = 0.51$), reflecting the physiological adaptations during pregnancy that alter glucose dynamics. Lifestyle factors like physical activity, stress and adherence to medication regimens further contribute to this variability. For example, **Sharma et al. (2023)** showed that shift workers with irregular schedules exhibit more pronounced glycemic variability, complicating the relationship between HbA1c, FBS and PPBS.

EMERGING TECHNOLOGIES IN GLUCOSE MONITORING AND THEIR IMPACT ON UNDERSTANDING THE INTERRELATIONSHIP

The advent of emerging technologies in glucose monitoring has significantly enhanced our ability to understand the interrelationship between FBS, PPBS and HbA1c. Continuous Glucose Monitoring (CGM) systems are at the forefront of these advancements, providing real-time, dynamic data on glucose trends throughout the day. Unlike static measures like FBS, PPBS, or HbA1c, CGM captures interstitial glucose levels at frequent intervals, offering insights into glucose variability, patterns of hyperglycemia or hypoglycemia and the effects of meals, medications and physical activity. This granularity allows for a more comprehensive assessment of how fasting and postprandial glucose fluctuations contribute to long-term glycemic control reflected in HbA1c (**Sharma et al., 2023**).

Another emerging tool is Flash Glucose Monitoring (FGM), which provides glucose readings on demand through a small sensor worn on the skin. While less detailed than CGM, FGM is more accessible and offers a practical alternative for patients who need frequent but not continuous glucose data. These systems are particularly impactful in managing individuals with high glucose variability, such as diabetic shift workers or those with irregular eating patterns. By tracking postprandial glucose excursions and overnight trends, FGM and CGM help elucidate the contributions of FBS and PPBS to HbA1c variability, enabling more targeted interventions (**Kariyawasan et al., 2021**).

CONCLUSION

Diabetes mellitus is a complex and prevalent global health challenge that requires meticulous glycemic control to prevent acute and chronic complications. FBG, PPBG and HbA1c are critical biomarkers that collectively provide a comprehensive understanding of glucose regulation and long-term glycemic trends. Their interrelationship underscores the need for a multifaceted approach in diabetes management, addressing both fasting and postprandial hyperglycemia to achieve optimal HbA1c targets. Emerging technologies such as continuous glucose monitoring (CGM) offer innovative solutions to monitor glycemic variability in real-time, enabling more personalized and effective interventions. Despite advancements, challenges like individual variability in glucose metabolism and limitations in biomarker interpretation necessitate ongoing research and tailored approaches. By integrating advanced monitoring tools, patient-centered care and a deeper understanding of the interconnections between FBG, PPBG and HbA1c, healthcare providers can significantly improve diabetes outcomes and reduce the burden of this chronic disease.

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