Original

Real-time Continuous Glucose Monitoring Outperforms Blood Glucose Meters in Predicting Diabetes Risk Among Children with Acanthosis Nigricans: A Nine-Month Observational Study

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Abstract

Background: The rising prevalence of diabetes mellitus in children necessitates precise glucose monitoring for early detection and intervention. Blood Glucose Meters (BGM) and Continuous Glucose Monitoring (CGM) are widely used, yet their effectiveness in predicting diabetes onset in at-risk paediatric populations remains debated. This study aimed to compare BGM and CGM in predicting diabetes risk among children with Acanthosis Nigricans (AN) and elevated FINDRISC scores.

Methods: A quasi-experimental study was conducted at the Health Polytechnic of the Ministry of Health Sorong over nine months (January–September 2024), involving 76 children aged 10–18 years. Participants were assigned to either the BGM group (measurements every three days) or the CGM group (continuous monitoring every 15 minutes). Key parameters included Time in Range (TIR), mean glucose levels, hypoglycaemia and hyperglycaemia episodes, and adherence rates.

Results: CGM demonstrated superior performance, with a significantly higher TIR (78.9% vs. 63.4%, $p<0.001$), lower mean glucose levels (145.3 vs. 162.7 mg/dL, $p=0.003$), and fewer hypoglycaemia (1.1 vs. 2.8, $p=0.015$) and hyperglycaemia episodes (2.6 vs. 4.5, $p=0.002$). CGM users also exhibited higher adherence (88.7% vs. 71.3%, $p<0.001$) and greater accuracy, as indicated by a lower Mean Absolute Relative Difference (MARD) (7.2% vs. 10.8%, $p=0.004$).

Conclusions: CGM outperforms BGM in predicting diabetes onset in at-risk children, offering improved glycaemic control and adherence. These findings support CGM as the preferred glucose monitoring method for paediatric populations at risk of diabetes.

Keywords: Blood Glucose Self-Monitoring; Child; Diabetes Mellitus; Early Diagnosis; Glucose Monitoring, Continuous

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Introduction

Diabetes mellitus, particularly type 2 diabetes, has emerged as a significant public health concern among children and adolescents worldwide, driven by increasing rates of obesity and sedentary lifestyles.[1–8] Early detection and management of glucose dysregulation in paediatric populations are crucial to mitigating the progression of prediabetes to overt diabetes. Current strategies emphasise the need for accurate and timely monitoring of blood glucose levels to prevent long-term complications associated with hyperglycaemia, including cardiovascular disease, neuropathy, and retinopathy[9–11]. However, there remains considerable debate regarding the optimal method for monitoring glucose levels in children at risk of diabetes, with Blood Glucose Meters (BGM) and Continuous Glucose Monitoring (CGM) systems representing two widely utilised approaches.

Despite technological advancements, significant challenges persist in predicting diabetes onset in paediatric populations. Traditional BGMs, which involve intermittent capillary blood sampling, provide limited snapshots of glucose levels and may fail to capture glycaemic variability effectively[12,13]. In contrast, CGM systems continuously track interstitial glucose levels, offering a comprehensive view of glycaemic patterns over time[14]. The dynamic nature of glucose fluctuations in children, particularly those with varying metabolic rates and eating habits, necessitates a monitoring approach that can capture real-time changes and provide actionable data for early intervention. However, questions remain regarding the comparative efficacy, cost-effectiveness, and user compliance of CGM and BGM, particularly in resource-limited settings.

One of the critical challenges in paediatric diabetes management is identifying the most effective method for monitoring glucose levels to predict diabetes onset. While BGMs are more widely available and cost-effective, they often fail to detect transient episodes of hyperglycaemia or hypoglycaemia due to their intermittent nature. This limitation can result in suboptimal clinical decisions, particularly in paediatric patients where glucose levels may fluctuate rapidly. Conversely, although more technologically advanced, CGM systems present their own set of challenges, including higher costs, sensor inaccuracies, and the necessity for continuous wear, which may affect patient adherence.[15–18] These challenges necessitate a critical evaluation of both methods to determine which is better suited for predicting the onset of diabetes in children.

Existing literature has primarily focused on the effectiveness of CGM in managing established diabetes rather than its predictive utility in at-risk paediatric populations[19,20,21(p20)]. There is a notable gap in research that directly compares the predictive accuracy of BGM and CGM in children with early signs of metabolic dysregulation. Addressing this gap is essential because early intervention can prevent the irreversible progression of prediabetes to diabetes. Additionally, previous studies have been limited by small sample sizes, lack of longitudinal data, and variability in patient adherence, making it difficult to generalise their findings. Understanding the comparative benefits of these monitoring systems could lead to improved clinical guidelines and targeted preventive strategies.

The primary aim of this study was to compare the predictive efficacy of Blood Glucose Meters (BGM) and Continuous Glucose Monitoring (CGM) systems in identifying early signs of diabetes mellitus in children aged 10-18 years who present with clinical markers, such as acanthosis nigricans and a positive Finnish Diabetes Risk Score (FINDRISC). We hypothesised that CGM will provide superior predictive value over BGM due to its ability to continuously capture glucose variability and detect episodes of dysglycaemia that are missed by intermittent monitoring. The study focuses on evaluating the accuracy, user compliance, and practical applicability of these two methods over a nine-month period in a single-centre observational design.

From a theoretical perspective, this research contributes to the understanding of glucose monitoring technologies in paediatric populations by elucidating the strengths and limitations of the BGM and CGM systems. In practical terms, the findings aim to inform clinicians and policymakers on optimal strategies for the early detection of diabetes in children, potentially influencing screening protocols and healthcare policies. The study's innovative approach of utilising both BGM and CGM data longitudinally to assess predictive outcomes addresses a critical gap in current diabetes prevention strategies.

This research employed a prospective observational design conducted at *the Health Polytechnic of the Ministry of Health Sorong*, Indonesia, from January to September

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2024. Seventy-six paediatric participants, aged 10-18 years, were recruited based on specific inclusion criteria, such as the presence of acanthosis nigricans and a positive modified FINDRISC screening score. Participants were monitored using both BGM and CGM devices, with data collected on glycaemic variability, time-in-range (TIR), and episodes of hyperglycaemia and hypoglycaemia. The rationale for selecting this mixed-method approach lies in its capacity to capture both the continuous data offered by the CGM and the real-world applicability of the BGM. Statistical analyses, including predictive modelling and comparative analyses, were employed to evaluate the relative performance of both methods.

Recent studies indicate that while CGM offers continuous real-time monitoring and can better capture glycaemic variability, it may not always translate into improved clinical outcomes owing to issues such as patient adherence and sensor calibration[22,23]. Conversely, BGMs, despite being less technologically sophisticated, remain the standard in many clinical settings owing to their simplicity and lower cost[15]. However, the intermittent nature of BGM monitoring limits its effectiveness in detecting glycaemic patterns, particularly in children, where glucose levels may be influenced by erratic eating habits and physical activity levels.

This study is among the first to directly compare the predictive accuracy of BGM and CGM in children at risk of diabetes, providing a unique contribution to both the theoretical framework and practical applications in diabetes management. By integrating real-world adherence data with predictive metrics, this research offers insights that extend beyond the current literature, potentially informing more effective screening protocols. The study's novelty also lies in its focus on paediatric populations, addressing an underrepresented demographic in diabetes research.

This paper is structured to present a comprehensive examination of glucose monitoring technologies, commencing with an introduction to the problem and concluding with a discussion of the implications for clinical practice and future research directions. The anticipated outcomes include an enhanced understanding of which glucose monitoring system is more efficacious for the early prediction and management of diabetes in children, thereby informing both clinical practice and health policy.

Methodology

This study employed a Quasi Experimental design conducted at a single centre to evaluate the effectiveness of Blood Glucose Meters (BGM) and Continuous Glucose Monitoring (CGM) in predicting the onset of diabetes mellitus in children. The research was conducted at *the Health Polytechnic of the Ministry of Health Sorong*, Indonesia, from January to September 2024, and was registered under clinical trial number NCT03240432. Ethical approval was obtained from the Ethics Committee of *Health Polytechnic of the Ministry of Health Sorong* number DM.03.01/4.3/1001/2024, dated 5 January 2024. Written informed consent was obtained from the parents or guardians, with additional assent acquired from participants aged > 12 years. All data collected were treated with strict confidentiality in accordance with data protection protocols, including anonymisation and secure data storage on protected servers.

The study population comprised 76 participants, who were selected based on power analysis calculations to ensure adequate statistical power. Inclusion criteria encompassed children aged 10 to 18 years with visible acanthosis nigricans on the neck, axillae, or groin; no prior HbA1c testing; and a positive modified Finnish Diabetes Risk Score (FINDRISC) for children. Exclusion criteria included a history of diabetes mellitus, use of medications affecting glucose metabolism, or presence of acute illnesses during the study period. Additionally, individuals consuming ascorbic acid (vitamin C) or salicylates (e.g. aspirin) were excluded.

The study commenced with a screening phase, during which all participants were assessed using the modified FINDRISC[24]. A physical examination was conducted to confirm the presence of AN, and anthropometric measurements, including height, weight, body mass index (BMI), and waist circumference, were recorded. Following screening, participants were randomly assigned to two groups: one group utilised BGM and the other utilised CGM. The BGM was employed to monitor glucose levels every three days at the same time (e.g. in the morning before meals), with regular calibration of the device. Quality control measures were implemented using strict procedures, and all measurements were performed by trained personnel.
Participants in the CGM group were monitored using the FreeStyle Libre 14 Day device, which provided

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continuous glucose monitoring at 15-minute intervals. The CGM sensor was applied to the upper arm in accordance with the manufacturer's guidelines and replaced every 14 days. Data from the sensor were automatically collected and analysed to obtain information on glycaemic variability, including time in range (TIR), mean glucose levels, and episodes of hypoglycaemia and hyperglycaemia. The secondary outcomes included adherence rates, device accuracy metrics, and potential technical failures or adverse events.

Data management and analysis were conducted using Jamovi statistical software. Missing data were addressed using multiple imputations, and outliers were identified using boxplot analysis. Descriptive statistics were employed to characterise the sample, while comparative tests (t-test) were applied to analyse the differences between the BGM and CGM groups. Pearson or Spearman correlation analyses were performed to assess relationships between TIR, mean glucose levels, and episodes of hypoglycaemia and hyperglycaemia. Additionally, predictive modelling using logistic regression was employed to evaluate the efficacy of each method in predicting diabetes onset. A significance level of $p < 0.05$ was established for all analyses.

Assessment of Adherence

Participant adherence to glucose monitoring methods was assessed by calculating the percentage of completed monitoring sessions relative to the recommended sessions over the nine-month study period. Adherence to Blood Glucose Meters (BGM) was determined based on the number of self-monitoring blood glucose measurements performed per day in accordance with usage guidelines. In contrast, adherence to Continuous Glucose Monitoring (CGM) was measured based on the number of days with at least 80% recorded glucose data within a 24-hour period.

Assessment of Device Accuracy

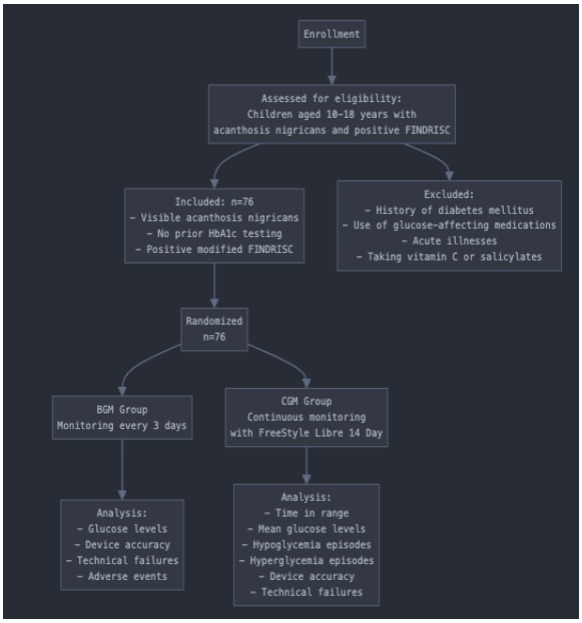
Device accuracy was evaluated using the Mean Absolute Relative Difference (MARD), calculated as the mean of the absolute relative differences between device measurements and laboratory reference values. A lower MARD indicates higher measurement accuracy.

Technical Failures

The occurrence of technical failures for each device was recorded to assess device reliability. Technical failures were defined as incidents that hindered the acquisition of valid glucose data, including sensor malfunctions, software errors, or user-related issues leading to data loss or unusable results.

Reliability and validity assessments were conducted using the Clarke Error Grid for device agreement, and accuracy was assessed using the Mean Absolute Relative Difference (MARD). Furthermore, quality control procedures encompassed regular calibration of devices, staff training prior to study commencement, and validation of the data collected. All standard operating procedures were adhered to ensure the accuracy and reliability of the study results.

To guide the workflow of the study, a CONSORT flowchart was utilised, commencing with the screening phase and randomisation of participants into the two intervention groups, followed by daily monitoring with BGM and CGM, and concluding with data analysis and reporting of the results.



Results

Respondent Characteristics

This study comprised 76 participants aged 10–18 years who fulfilled the inclusion criteria, specifically the presence of acanthosis nigricans and a positive screening result utilising the modified Finnish Diabetes Risk Score (FINDRISC). The demographic and clinical characteristics of the participants are presented in Table 1.

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Table 1. Demographic and Clinical Characteristics of Participants

Variable	Mean (SD) / n (%)
Age (years)	13.8 (±2.4)
Gender (Male/Female)	35 (46%) / 41 (54%)
BMI (kg/m²)	24.5 (±4.3)
Waist Circumference (cm)	82.1 (±10.7)
Acanthosis Nigricans	76 (100%)
FINDRISC Score	12.4 (±3.2)

Note: Distribution of age, sex, body mass index (BMI), waist circumference, and FINDRISC score.

Most participants were female (54%), with a mean age of 13.8 years (SD ±2.4). The mean BMI of the participants indicated an overweight classification, and all participants exhibited clinical manifestations of acanthosis nigricans. The FINDRISC score suggested that all participants were at an elevated risk for type 2 diabetes mellitus.

Comparison between Blood Glucose Meter (BGM) and Continuous Glucose Monitoring (CGM)

To evaluate the efficacy of BGM and CGM in predicting the onset of diabetes mellitus in paediatric populations, glycaemic variability, mean glucose levels, and glycaemic episodes were assessed. The results are presented in Table 2.

Table 2. Comparison of Glycaemic Metrics between BGM and CGM

Metric	BGM (Mean ± SD)	CGM (Mean ± SD)	p-value
Time in Range (TIR, %)	63.4 (±12.7)	78.9 (±10.3)	<0.001
Mean Glucose Level (mg/dL)	162.7 (±20.4)	145.3 (±18.6)	0.003
Hypoglycaemia Episodes (frequency)	2.8 (±1.2)	1.1 (±0.7)	0.015
Hyperglycaemia Episodes (frequency)	4.5 (±1.7)	2.6 (±1.1)	0.002

Note: $p < 0.001$ for all comparisons.

The study results indicated that the CGM method demonstrated a significant advantage over BGM in predicting diabetes onset. Participants utilising CGM exhibited a higher Time in Range (TIR) (78.9% vs. 63.4%, $p < 0.001$) and a lower mean glucose level (145.3 mg/dL vs. 162.7 mg/dL, $p = 0.003$). Furthermore, the frequency of both hypoglycaemic and hyperglycaemic episodes was significantly lower in the CGM group than in the BGM group.

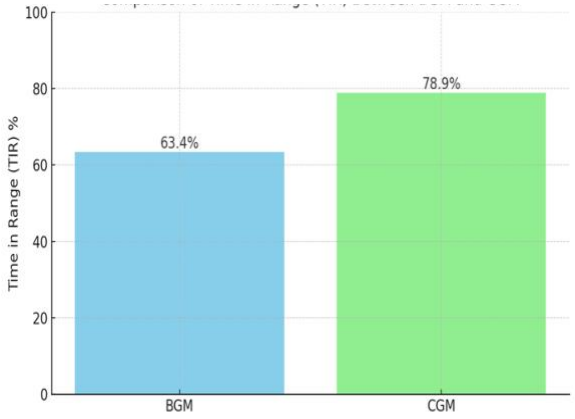

Figure 1 Comparison of Time in Range (TIR) between BGM and CGM

Adherence and Accuracy Analysis

The investigation also assessed participant adherence to both glucose monitoring methodologies and the precision of the utilised devices. The results are presented in Table 3.

Table 3. Adherence and Accuracy between BGM and CGM

Parameter	BGM (n = 38)	CGM (n = 38)	p-value
Adherence (%)	71.3 (±15.4)	88.7 (±10.2)	<0.001
Mean Absolute Relative Difference (MARD, %)	10.8 (±2.6)	7.2 (±1.9)	0.004
Technical Failures (frequency)	5 (13.2%)	2 (5.3%)	0.046

Note: Comparison of user adherence and device accuracy between BGM and CGM.

As demonstrated in Table 3, participants utilising CGM demonstrated significantly higher adherence (88.7% vs. 71.3%, $p < 0.001$) and a lower Mean Absolute Relative Difference (MARD), indicating superior accuracy (7.2% vs. 10.8%, $p = 0.004$). Moreover, technical failures occurred with greater frequency in BGM than in CGM.

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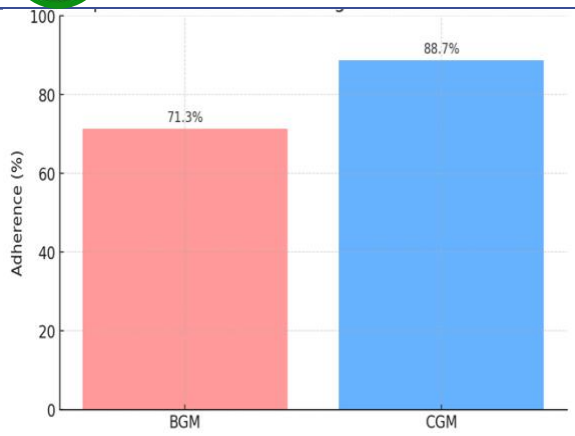

Figure 2 *Adherence to Monitoring between BGM and CGM*

Evaluation of Glycaemic Episodes and Time in Range (TIR)

This investigation also assessed glycaemic episodes to further elucidate glucose fluctuation patterns in the study participants. Table 4 illustrates the distribution of hypoglycaemic and hyperglycaemic episodes stratified by age category.

Table 4. Distribution of Glycaemic Episodes by Age Category

Age (years)	Hypoglycaemic Episodes (BGM vs CGM)	Hyperglycaemic Episodes (BGM vs CGM)
10-12	3.2 (±1.4) vs 1.5 (±0.8)	5.1 (±1.9) vs 3.0 (±1.2)
13-15	2.7 (±1.1) vs 0.9 (±0.6)	4.3 (±1.5) vs 2.4 (±1.0)
16-18	2.3 (±1.0) vs 0.8 (±0.5)	4.0 (±1.3) vs 2.1 (±0.9)

Note: Hypoglycaemic and hyperglycaemic episodes in different age ranges for BGM and CGM.

As demonstrated in Table 4, the younger age cohort (10-12 years) exhibited higher frequencies of glycaemic episodes, encompassing both hypoglycaemia and hyperglycaemia, particularly with the utilisation of BGM. The CGM consistently recorded fewer episodes across all age groups.

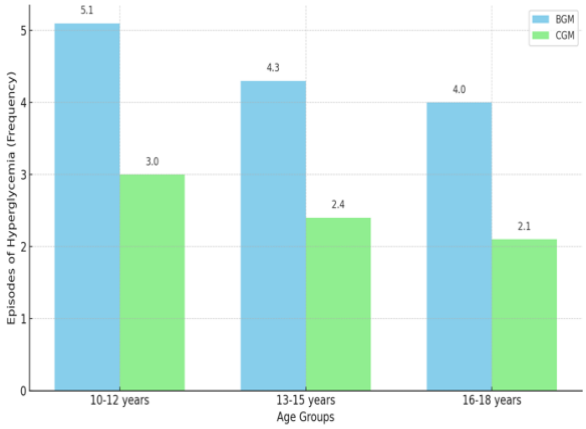

Figure 3 *Distribution of Hyperglycaemic Episodes by Age*

Discussion

This study elucidates critical insights into the comparative efficacy of Blood Glucose Meters (BGM) and Continuous Glucose Monitoring (CGM) systems in predicting diabetes mellitus risk among paediatric patients. The findings indicate that CGM demonstrates superior performance in terms of glycaemic variability, time in range (TIR), and reduction of hyperglycaemic episodes compared to BGM. Consistently, CGM users exhibit fewer fluctuations and better glycaemic control, aligning with the study's objective of determining which monitoring method is more effective for early detection of diabetes in children. Notably, the significant reduction in hypoglycaemia episodes among CGM users also indicates enhanced safety and monitoring accuracy. These results align with the hypothesis that continuous monitoring can capture real-time glucose dynamics more effectively than intermittent monitoring can.

The unanticipated discovery that CGM not only improves glycaemic control but also correlates with higher compliance among participants is noteworthy. This finding highlights CGM's capacity of CGM to seamlessly integrate into patients' daily routines, potentially improving long-term adherence to glucose monitoring. The trend towards better compliance among older children also suggests that age-related factors, such as comprehension of the benefits of continuous data, may influence the efficacy of CGM in diabetes risk management.

The results are consistent with the theoretical framework, suggesting that continuous, real-time monitoring offers a more accurate representation of

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blood glucose levels, thereby enhancing the early diagnosis of diabetes-related complications. Prior studies have similarly emphasised CGM's advantages of CGM over BGM, particularly in paediatric populations, for providing a comprehensive picture of glucose trends and reducing adverse glycaemic events[15,21,25]. However, contrasting studies, such as Christiansen et al., argue that the initial cost and technological learning curve of CGM may limit its widespread adoption, despite its benefits[26]. This study contributes to the ongoing debate by providing empirical evidence that supports the long-term cost-effectiveness of CGM in paediatric care due to its potential to prevent severe complications through early detection.

Additionally, the alignment of this study with recent literature reinforces the significance of utilising advanced glucose monitoring technologies in populations at high risk for diabetes. Consistent findings across studies suggest that integrating CGM into routine paediatric screenings could redefine diabetes prevention strategies, especially in regions where diabetes prevalence is increasing[27–29].

The superior performance of CGM over BGM in reducing glycaemic variability and maintaining glucose levels within the target range is a crucial finding with theoretical and practical implications. From a physiological perspective, CGM's ability of CGM to continuously capture glucose levels allows for timely adjustments in diet and activity, which are critical for managing early diabetes risk. This finding supports previous assertions that CGM offers an advantage by enabling proactive interventions rather than reactive adjustments based on sporadic BGM readings[30]. The study also revealed that CGM provides more reliable data for assessing glycaemic control, which is essential for predicting long-term outcomes in children with prediabetes.

The results align with those of multiple studies conducted in recent years. For instance, research by Levy et al. indicates that paediatric patients using CGM show better long-term outcomes in controlling hyperglycaemia than those using traditional BGM[31]. Furthermore, the findings of this study challenge the earlier conclusions of Schierloh et al., who suggested that intermittent monitoring could be sufficient for children with mild glucose irregularities.[32] The present research demonstrates that even minor fluctuations can go undetected with BGM, emphasising the value of continuous data provided by CGM for early intervention.

However, discrepancies with some previous studies highlight the need for further investigation of contextual factors, such as socioeconomic status and access to technology, which may affect the efficacy of CGM. The lower rates of compliance among younger children observed in this study suggest that age-specific interventions may be necessary to optimise CGM use.

One unanticipated outcome was the significant difference in adherence rates between the two monitoring systems, with CGM users demonstrating higher compliance despite their more complex setup. This could be attributed to the less invasive nature of CGM and its ability to provide continuous feedback, which may encourage users to maintain consistent monitoring practices. This finding contrasts with studies that have noted higher dropout rates in CGM trials due to discomfort or device complexity[33,34]. This discrepancy may be explained by advancements in CGM technology, rendering it more user-friendly and less intrusive.

This study extends the existing theoretical models of diabetes management by demonstrating the practical benefits of continuous glucose monitoring in paediatric populations. It addresses a critical gap in current diabetes prevention frameworks, which often rely on intermittent monitoring methods that may not capture the dynamic nature of glucose fluctuations in at-risk children. The evidence presented suggests that integrating CGM into routine screening could enhance early diagnosis and management strategies, thereby reducing the incidence of full-blown diabetes in high-risk groups.

Additionally, this research provides new insights into the behavioural aspects of glucose monitoring, particularly how device usability influences adherence among different age groups. These findings contribute to refining theoretical models that link technology adoption with health outcomes, especially in younger populations.

From a practical standpoint, the results indicate that healthcare providers should prioritise CGM over traditional BGM for children at risk of diabetes, especially those presenting with prediabetic symptoms such as acanthosis nigricans. Evidence suggests that adopting CGM in clinical settings can improve patient outcomes, reduce long-term healthcare costs, and promote proactive disease management. For stakeholders such as healthcare policymakers, the

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findings support the integration of CGM into paediatric diabetes screening programmes, which could lead to earlier interventions and reduced healthcare burdens.
Moreover, given the higher compliance rates associated with CGM, this technology could be recommended as a standard practice in managing paediatric prediabetes, potentially transforming current approaches to diabetes prevention.

Despite the strengths of this study, several limitations warrant discussion. The single-centre design may limit the generalisability of the findings to broader paediatric populations. Additionally, the relatively small sample size could have reduced the statistical power of the analyses, particularly in subgroup comparisons. The reliance on self-reported data for adherence measures also introduces potential bias. Another limitation is the lack of consideration of socioeconomic factors that might influence access to CGM technology, which could impact the study's external validity.
Future studies should consider multicentre trials with larger and more diverse populations to validate these findings. Exploring the impact of socioeconomic status on CGM adoption and effectiveness could provide more nuanced insights into how healthcare disparities affect diabetes management outcomes. Additionally, further research should examine the psychological factors influencing adherence to CGM among younger children, which may lead to tailored interventions for different age groups. Longitudinal studies are also recommended to assess the long-term impact of CGM on diabetes prevention in paediatric populations.

Conclusion

This study aimed to compare the efficacy of blood glucose meter (BGM) and Continuous Glucose Monitoring (CGM) systems in predicting the onset of diabetes mellitus in children, with a focus on identifying which method offers superior predictive accuracy and control over glycaemic fluctuations. The findings reveal that CGM significantly outperforms BGM in managing glucose variability, optimising time-in-range (TIR), and reducing both hyperglycaemic and hypoglycaemic episodes. These results underscore the potential of CGM as a more effective tool in early diabetes intervention, particularly by providing continuous data that support proactive adjustments in paediatric care. This study contributes to the existing literature by confirming that real-time glucose monitoring facilitates improved compliance and long-term management outcomes in children, thereby enhancing diabetes prevention strategies. However, the research acknowledges limitations, including its relatively small sample size and the single-centre design, which may affect the generalisability of the findings. Future studies are encouraged to explore multicentre trials and incorporate socioeconomic factors that could influence CGM adoption and outcomes. Given the demonstrated advantages of CGM, healthcare providers and policymakers should consider its broader integration into paediatric diabetes prevention programs, which could potentially improve early diagnosis and reduce the progression to full-blown diabetes in at-risk children.

Declarations

Author Contributions: Conceptualisation: E.S. and A.C.M.; methodology: E.S.; software: E.S.; validation: E.S. and A.C.M.; formal analysis: E.S.; investigation: E.S.; resources: E.S.; data curation: E.S.; writing—original draft preparation: E.S.; writing—review and editing: E.S. and A.C.M.; visualisation: E.S.; supervision: A.C.M. and WASP; project administration: E.S.; and funding acquisition: A.C.M. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (Ethics Committee) of the Health Polytechnic of the Ministry of Health, Sorong (protocol code DM.03.01/4.3/1001/2024, approved in 2024). Participants provided informed consent after being fully informed of the study's objectives and procedures. Data confidentiality was ensured through coding and limited access to authorised research team members.

Informed Consent Statement

Informed consent was obtained from all the participants involved in the study. Written informed consent was obtained from the participants to publish this paper.

Data Availability Statement

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The data presented in this study are available upon request from the corresponding author owing to privacy and ethical restrictions. Data confidentiality was ensured, and access was restricted to authorised personnel to protect the privacy of participants.

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Conflicts of Interest: The authors declare no conflict of interest regarding the publication of this paper.

References

1. Tinajero MG, Malik VS. An Update on the Epidemiology of Type 2 Diabetes: A Global Perspective. *Endocrinol Metab Clin North Am*. 2021;50(3):337-355. doi:10.1016/j.ecl.2021.05.013
2. Perng W, Conway R, Mayer-Davis E, Dabelea D. Youth-Onset Type 2 Diabetes: The Epidemiology of an Awakening Epidemic. *Diabetes Care*. 2023;46(3):490-499. doi:10.2337/dci22-0046
3. Pramanik S, Mondal S, Palui R, Ray S. Type 2 diabetes in children and adolescents: Exploring the disease heterogeneity and research gaps to optimum management. *World Journal of Clinical Pediatrics*. 2024;13(2). doi:10.5409/wjcp.v13.i2.91587
4. Antar SA, Ashour NA, Sharaky M, et al. Diabetes mellitus: Classification, mediators, and complications; A gate to identify potential targets for the development of new effective treatments. *Biomedicine & Pharmacotherapy*. 2023;168:115734. doi:10.1016/j.biopha.2023.115734
5. Chandrasekaran P, Weiskirchen R. The Role of Obesity in Type 2 Diabetes Mellitus—An Overview. *International Journal of Molecular Sciences*. 2024;25(3):1882. doi:10.3390/ijms25031882
6. Ruze R, Liu T, Zou X, et al. Obesity and type 2 diabetes mellitus: connections in epidemiology, pathogenesis, and treatments. *Front Endocrinol*. 2023;14. doi:10.3389/fendo.2023.1161521
7. Khan MAB, Hashim MJ, King JK, Govender RD, Mustafa H, Al Kaabi J. Epidemiology of Type 2 Diabetes – Global Burden of Disease and Forecasted Trends. *J Epidemiol Glob Health*. 2020;10(1):107-111. doi:10.2991/jegh.k.191028.001
8. Ong KL, Stafford LK, McLaughlin SA, et al. Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*. 2023;402(10397):203-234. doi:10.1016/S0140-6736(23)01301-6
9. American Diabetes Association Professional Practice Committee. 6. Glycemic Goals and Hypoglycemia: Standards of Care in Diabetes—2024. *Diabetes Care*. 2023;47(Supplement_1):S111-S125. doi:10.2337/dc24-S006
10. Sugandh F, Chandio M, Raveena F, et al. Advances in the Management of Diabetes Mellitus: A Focus on Personalized Medicine. *Cureus*. 15(8):e43697. doi:10.7759/cureus.43697
11. Jyotsna FNU, Ahmed A, Kumar K, et al. Exploring the Complex Connection Between Diabetes and Cardiovascular Disease: Analyzing Approaches to Mitigate Cardiovascular Risk in Patients With Diabetes. *Cureus*. 2023;15(8):e43882. doi:10.7759/cureus.43882
12. Xu NY, Nguyen KT, DuBord AY, et al. Diabetes Technology Meeting 2021. *J Diabetes Sci Technol*. 2022;16(4):1016-1056. doi:10.1177/19322968221090279
13. Huang J, Yeung AM, DuBord AY, et al. Diabetes Technology Meeting 2022. *Journal of Diabetes Science and Technology*. 2023;17(4):1085. doi:10.1177/19322968221148743
14. Skroce K, Zignoli A, Fontana FY, et al. Real World Interstitial Glucose Profiles of a Large Cohort of Physically Active Men and Women. *Sensors*. 2024;24(3):744. doi:10.3390/s24030744
15. Almurashi AM, Rodriguez E, Garg SK. Emerging Diabetes Technologies: Continuous Glucose Monitors/Artificial Pancreases. *J Indian Inst Sci*. 2023;103(1):205-230. doi:10.1007/s41745-022-00348-3
16. Tian T, Aaron RE, Yeung AM, et al. Use of Continuous Glucose Monitors in the Hospital: The Diabetes Technology Society Hospital Meeting Report 2023. *J Diabetes Sci Technol*. 2023;17(5):1392-1418. doi:10.1177/19322968231186575
17. Yoo JH, Kim JH. Advances in Continuous Glucose Monitoring and Integrated Devices for Management of Diabetes with Insulin-Based Therapy: Improvement in Glycemic Control. *Diabetes Metab J*. 2023;47(1):27-41. doi:10.4093/dmj.2022.0271

Print ISSN: 0189-9287 Online ISSN: 2992-345X

18. Mansour M, Saeed Darweesh M, Soltan A. Wearable devices for glucose monitoring: A review of state-of-the-art technologies and emerging trends. *Alexandria Engineering Journal*. 2024;89:224-243. doi:10.1016/j.aej.2024.01.021
19. Chobot A, Piona C, Bombaci B, Kamińska-Jackowiak O, Mancioppi V, Passanisi S. Exploring the Continuous Glucose Monitoring in Pediatric Diabetes: Current Practices, Innovative Metrics, and Future Implications. *Children*. 2024;11(8):907. doi:10.3390/children11080907
20. Klupa T, Czupryniak L, Dzida G, et al. Expanding the Role of Continuous Glucose Monitoring in Modern Diabetes Care Beyond Type 1 Disease. *Diabetes Therapy*. 2023;14(8):1241. doi:10.1007/s13300-023-01431-3
21. Worth C, Hoskyns L, Salomon-Estebanez M, et al. Continuous glucose monitoring for children with hypoglycaemia: Evidence in 2023. *Front Endocrinol*. 2023;14. doi:10.3389/fendo.2023.1116864
22. Prasad-Reddy L, Godina A, Chetty A, Isaacs D. Use of Continuous Glucose Monitoring in Older Adults: A Review of Benefits, Challenges and Future Directions. *touchREVIEWS in Endocrinology*. 2022;18(2):116. doi:10.17925/EE.2022.18.2.116
23. Natale P, Chen S, Chow CK, et al. Patient experiences of continuous glucose monitoring and sensor-augmented insulin pump therapy for diabetes: A systematic review of qualitative studies. *Journal of Diabetes*. 2023;15(12):1048. doi:10.1111/1753-0407.13454
24. Rokhman MR, Arifin B, Zulkarnain Z, et al. Translation and performance of the Finnish Diabetes Risk Score for detecting undiagnosed diabetes and dysglycaemia in the Indonesian population. *PLOS ONE*. 2022;17(7):e0269853. doi:10.1371/journal.pone.0269853
25. Kong SY, Cho MK. Effects of Continuous Glucose Monitoring on Glycemic Control in Type 2 Diabetes: A Systematic Review and Meta-Analysis. *Healthcare*. 2024;12(5):571. doi:10.3390/healthcare12050571
26. Christiansen MP, Garg SK, Brazg R, et al. Accuracy of a Fourth-Generation Subcutaneous Continuous Glucose Sensor. *Diabetes Technology & Therapeutics*. 2017;19(8):446. doi:10.1089/dia.2017.0087
27. Guldemond N. What is meant by 'integrated personalized diabetes management': A view into the future and what success should look like. *Diabetes, Obesity and Metabolism*. 2024;26(S1):14-29. doi:10.1111/dom.15476
28. Mittal R, Koutras N, Maya J, Lemos JRN, Hirani K. Blood glucose monitoring devices for type 1 diabetes: a journey from the food and drug administration approval to market availability. *Frontiers in Endocrinology*. 2024;15:1352302. doi:10.3389/fendo.2024.1352302
29. Mackey ER, Tully C, Rose M, et al. Promoting glycemic control in young children with type 1 diabetes: Results from a pilot intervention for parents. *Families, systems & health : the journal of collaborative family healthcare*. 2022;40(2):239. doi:10.1037/fsh0000672
30. Miller EM. Using Continuous Glucose Monitoring in Clinical Practice. *Clinical Diabetes : A Publication of the American Diabetes Association*. 2020;38(5):429. doi:10.2337/cd20-0043
31. Levy CJ, Galindo RJ, Parkin CG, Gillis J, Argento NB. All Children Deserve to Be Safe, Mothers Too: Evidence and Rationale Supporting Continuous Glucose Monitoring Use in Gestational Diabetes Within the Medicaid Population. *J Diabetes Sci Technol*. 2024;18(5):1198-1207. doi:10.1177/19322968231161317
32. Schierloh U, Aguayo GA, Schritz A, et al. Intermittent Scanning Glucose Monitoring or Predicted Low Suspend Pump Treatment: Does It Impact Time in Glucose Target and Treatment Preference? The QUEST Randomized Crossover Study. *Front Endocrinol*. 2022;13. doi:10.3389/fendo.2022.870916
33. Schoelwer MJ, DeBoer MD, Breton MD. Use of diabetes technology in children. *Diabetologia*. 2024;67(10):2075. doi:10.1007/s00125-024-06218-0
34. Moon JS, Kang S, Choi JH, et al. 2023 Clinical Practice Guidelines for Diabetes Management in Korea: Full Version Recommendation of the Korean Diabetes Association. *Diabetes Metab J*. 2024;48(4):546-708. doi:10.4093/dmj.2024.0249

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