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Comparing Continuous Glucose Monitoring Versus Standard Fingerstick Testing in Optimizing Insulin Therapy among Adolescents with Type 1 Diabetes

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ABSTRACT

Continuous glucose monitoring (CGM) and self-monitoring of blood glucose (SMBG) via fingersticks testing are two primary methods used to guide insulin therapy in adolescents with type 1 diabetes mellitus (T1DM). This review compared CGM and SMBG in optimizing insulin therapy by analyzing their impact on glycemic control, treatment adherence, psychological well-being, and long-term metabolic outcomes. A narrative review methodology was employed, synthesizing existing literature to evaluate the benefits and limitations of each monitoring strategy. CGM has demonstrated superior glycemic control, reduced glycated hemoglobin (HbA1c) levels and increased time in range while minimizing hyperglycemia and hypoglycemia. Additionally, CGM enhances treatment adherence, reduces the burden of frequent fingerstick, and contributes to improved quality of life by alleviating diabetes-related distress. Long-term CGM use is associated with better metabolic outcomes, including reduced glycemic variability and decreased risk of diabetes-related complications. While SMBG remains a valuable tool, its episodic nature limits its ability to capture real-time glucose fluctuations. Although CGM adoption faces challenges such as device cost and sensor-related issues, its benefits make it a preferable option for optimizing insulin therapy in adolescents with T1DM. Future research should address barriers to CGM accessibility and explore its integration with advanced diabetes technologies.

Keywords: Continuous Glucose Monitoring (CGM), Self-Monitoring of Blood Glucose (SMBG), Type 1 Diabetes Mellitus (T1DM), Insulin Therapy Optimization, Glycemic Control and Adherence.

INTRODUCTION

Type 1 diabetes mellitus (T1DM) is a chronic autoimmune disorder characterized by the destruction of pancreatic beta cells, leading to an absolute insulin deficiency [1, 2]. Optimal glycemic control in adolescents with T1DM is critical in preventing both acute complications, such as diabetic ketoacidosis, and long-term microvascular and macrovascular complications [3–5]. Insulin therapy, the cornerstone of T1DM management, requires frequent blood glucose monitoring to ensure appropriate dosing and to mitigate risks associated with hypoglycemia and hyperglycemia. Traditional self-monitoring of blood glucose (SMBG) through fingerstick testing has been the standard method for decades [6, 7]. However, it presents limitations, including the inability to capture glycemic variability and the burden of frequent testing. Continuous glucose monitoring (CGM) technology has emerged as a transformative tool, offering real-time and retrospective glucose data that can improve insulin therapy adjustments [8, 9]. CGM devices provide interstitial glucose readings every few minutes, alerting users to trends and potential glycemic excursions. This review aims to compare CGM and standard fingerstick testing in optimizing insulin therapy among adolescents with T1DM. It examines their impact on glycemic outcomes, treatment adherence, psychological well-being, and long-term metabolic control. By analyzing current literature, this review provides insights into whether CGM confers superior benefits in managing insulin therapy in this high-risk population.

Glycemic Control and Insulin Optimization

Effective insulin therapy in adolescents with T1DM requires precise glucose monitoring to adjust basal and bolus insulin doses accurately [10, 11]. SMBG, despite being widely used, provides only discrete glucose readings, which

may not fully reflect daily glycemic variability. CGM, on the other hand, continuously measures interstitial glucose levels, offering real-time feedback on trends, patterns, and fluctuations. Studies have demonstrated that CGM use is associated with improved glycemic control, as evidenced by reductions in glycated hemoglobin (HbA1c) levels and increased time spent in the target glucose range [12, 13]. CGM users can also respond promptly to glucose excursions, reducing the frequency and severity of hyperglycemia and hypoglycemia. Conversely, SMBG users often rely on preprandial and postprandial readings, which may not detect nocturnal hypoglycemia or asymptomatic hyperglycemia, leading to suboptimal insulin adjustments. Furthermore, insulin dosing decisions based on CGM data allow for dynamic and individualized therapy modifications. Adolescents using CGM often report improved insulin sensitivity and better postprandial glucose control, reducing glycemic variability and minimizing long-term complications. While SMBG remains a valuable tool, its limitations in detecting rapid glucose fluctuations underscore the superiority of CGM in optimizing insulin therapy.

Adherence and Usability

One of the challenges in adolescent diabetes management is adherence to glucose monitoring protocols. SMBG requires multiple daily fingersticks, which can be painful and inconvenient, leading to poor compliance [14, 15]. Many adolescents struggle with maintaining the recommended frequency of testing, which can negatively impact glycemic control. CGM offers a more user-friendly alternative, with continuous data collection that reduces the need for frequent fingersticks. Modern CGM systems integrate with insulin pumps or smartphones, allowing for seamless glucose tracking and decision-making. Additionally, CGM provides automated alerts for hypo- and hyperglycemia, empowering adolescents and caregivers to take timely corrective actions. Despite its advantages, CGM adherence may be influenced by device-related factors such as sensor discomfort, skin irritation, and the need for periodic sensor replacements. Additionally, initial device costs and insurance coverage may pose barriers to widespread adoption. However, real-world studies suggest that once adolescents adapt to CGM, they demonstrate higher adherence rates compared to SMBG users, highlighting its feasibility in long-term diabetes management.

Psychological and Quality-of-Life Considerations

The psychological burden of diabetes management is a critical consideration in adolescents [16]. Frequent blood glucose monitoring, insulin injections, and dietary restrictions can contribute to diabetes-related distress, anxiety, and burnout [17]. The method of glucose monitoring plays a significant role in shaping the overall diabetes experience. SMBG, due to its intrusive nature, can be a source of frustration and noncompliance [18]. Adolescents may avoid testing due to pain, social stigma, or fear of high glucose readings. In contrast, CGM provides a less invasive alternative that reduces the stress associated with frequent fingersticks [19]. The ability to visualize glucose trends in real time can also empower adolescents to take a proactive approach to their diabetes management, fostering a greater sense of control and self-efficacy. Moreover, CGM technology enables remote monitoring by caregivers and healthcare providers, alleviating parental anxiety and enhancing overall diabetes support. This feature is particularly beneficial in adolescents with poor glycemic control or those at risk for severe hypoglycemia. By reducing the psychological burden of diabetes management, CGM may contribute to improved mental well-being and overall quality of life.

Long-Term Metabolic Outcomes and Complications

The long-term effectiveness of glucose monitoring methods in preventing diabetes-related complications is a critical factor in determining the superiority of CGM versus SMBG [20, 21]. Poor glycemic control during adolescence is strongly associated with an increased risk of diabetic nephropathy, retinopathy, and cardiovascular disease in adulthood. Therefore, strategies that enhance glucose regulation during this period are paramount.

Research indicates that adolescents using CGM achieve better long-term metabolic outcomes compared to those relying solely on SMBG. Reduced HbA1c levels, lower glycemic variability, and decreased incidence of severe hypoglycemia contribute to improved overall health. Additionally, CGM use has been linked to better lipid profiles and insulin sensitivity, factors that are crucial in preventing future cardiovascular complications.

While SMBG remains an essential tool in diabetes care, its episodic nature limits its ability to capture real-time glucose fluctuations. Adolescents with erratic glucose patterns or frequent hypoglycemia unawareness particularly benefit from the continuous feedback provided by CGM. The early adoption of CGM during adolescence may set the stage for lifelong diabetes self-management and complication prevention.

CONCLUSION

The comparison between CGM and SMBG in optimizing insulin therapy among adolescents with T1DM highlights significant advantages of CGM in glycemic control, adherence, psychological well-being, and long-term metabolic outcomes. CGM provides continuous real-time data that facilitates timely insulin adjustments, enhances treatment adherence, and reduces diabetes-related distress. Its ability to minimize glycemic variability and detect asymptomatic hypoglycemia offers a distinct advantage over traditional SMBG. Despite barriers such as device cost and sensor-

related challenges, CGM adoption is increasing, driven by advancements in technology and improved accessibility. The integration of CGM with insulin pumps and smartphone applications further enhances its utility in personalized diabetes management. While SMBG remains a valuable tool, CGM represents a paradigm shift in glucose monitoring, offering a more effective and patient-friendly approach to optimizing insulin therapy.

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