ijlpr 2023; doi 10.22376/ijlpr.2023.13.4.SP6.L87-L99

International Journal of Life science and Pharma Research

ISSN 2250-0480

Research Article

Case Reports Using Continuous Glucose Monitoring: Analysis For Application Of Digitalization In Management Of Diabetes Mellitus

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Abstract : Diabetes has emerged as a burgeoning health challenge in the last two decades. Specifically, there is an alarming rate of adult-onset diabetes mellitus, a point of deep concern. Therefore, cohesive steps are essential for the management of symptoms of diabetes mellitus to regulate its prevalence rate globally. Continuous glucose monitoring (CGM) technology can aid in this effort by allowing for safe therapy intensification with HbA1c (hemoglobin-a1c) reduction and by assisting in lowering some of the psychosocial impacts of diabetes. We aim to analyze the application of the digital device Freestyle Libre Pro in the management of diabetes mellitus. Using the FreeStyle Libre Pro CGM system, we analyzed the datasets for eight patients over 14 days. In addition, regular 12-hour data was monitored on a fortnight basis. Two of the eight cases were on insulin, and the rest were administered oral medications for diabetes care. Ambulatory Glucose Profiles, Average Glucose Levels, Time in Range, Time Below Range, Time Above Range, and, afterward, calculation of HbA1c levels were determined for eight patients using the FreeStyle Libre Pro system's current glucose measurements. We observed that for four patients, the average glucose levels were maintained in range, and for f our patients, the average glucose levels were above range. Regarding Time, four were above range, and four were in range. Our analysis shows that the Freestyle Libre Pro offers an alternative to current CGM devices for professional use as it may aid clinics and patients.

Keywords: Type 1 Diabetes Mellitus, Type 2 Diabetic Mellitus, Estimated A1c, Continuous Glucose Monitoring, And Innovative DM Management Method

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Received On 13 April 2023

Revised On 18 May 2023

Accepted On 25 May 2023

Published On 01 July 2023

Citation Rajesh Saxena, Dr. Anurupa B Singh Dr. N. P.Singh , Case Reports using continuous glucose monitoring: Analysis for application of digitalization in management of diabetes mellitus.(2023).Int. J. Life Sci. Pharma Res.13(4), L87-L99 http://dx.doi.org/10.22376/ijlpr.2023.13.4.SP6.L87-L99

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1. INTRODUCTION

Globally, 422 million people have been inflicted with diabetes mellitus, which is anticipated to overtake homicide as the seventh leading cause of mortality if current morbidity trends continue [1]. The BG levels in diabetic patients can vary greatly throughout the day, resulting in serious complications like kidney disease, strokes, cardiac failures, hypertension, loss of vision, and coma [2,3]. The abnormal concentration of BG is produced as a result of a lack of insulin secretion (type I diabetes, T1D) or by defective insulin secretion and activity (type 2 diabetes, T2D). However, in both the scenarios of type I and type 2 diabetes, abnormal BG levels could be finely controlled by insulin. For T2D and T1D patients, the BG concentration should be measured at least twice and four times a day, respectively, along with a combinational therapy that includes medication, exogenous insulin administration, food, and physical exercise [4,5,6]. With the introduction of glucose sensors, patients can now keep track of their blood glucose levels themselves to control their insulin levels and reduce their risk of developing diabetes mellitus. Electrochemical glucose sensors are the main component of conventional glucose detection devices [7]. The routine blood glucose diabetes test necessitates a small blood sample (1 L) collected by the uncomfortable "finger-pricking" procedure, which has a low patient compliance rate. In addition, those tests disregard fluctuations that occur at night and may approximate BG variations. Furthermore, as instantaneous monitoring sensors are unable to give real-time BG data, they cannot forewarn users in instances of hypoglycemia (low blood sugar <= 3.0 mM) and hyperglycaemic (high blood sugar, >11.1 mM) incidents.

1.1 Diabetes Ranges And Profiles

Normal fasting blood glucose concentrations are estimated to be between 70 mg/dL (3.9 mmol/L) and 100 mg/dL (5.6 mmol/L). Lifestyle adjustments and glycaemic monitoring are advised when fasting blood glucose levels range from 100 to 125 mg/dL (5.6 to 6.9 mmol/L). Diabetes is diagnosed when fasting blood glucose levels are 126 mg/dL (7 mmol/L) or greater on two independent tests. Low fasting blood glucose concentration (hypoglycemia) - less than 70 mg/dL (3.9 mmol/L) - causes dizziness, sweating, palpitations, blurred vision, and other symptoms that must be monitored. Hyperglycemia (high fasting blood glucose concentration) is a sign of an increased risk of diabetes. Fasting blood plasma glucose (FPG) levels in an individual may be normal because the individual does not have diabetes or because of efficient therapy with glucose-lowering medication in people with diabetes. At the national level, mean FPG is used as a proxy for promoting healthy diets and behaviors and treating diabetes.

1.2 Classification Of Diabetes Mellitus

The type of diabetes that the patient is suffering from is frequently determined by the conditions that existed at the time of their diagnosis, and many people with diabetes do not neatly fall into one category. Consequently, it is more crucial for the clinician and patient to comprehend the pathophysiology of hyperglycemia and properly treat it than to identify the specific type of diabetes. [8-21] Type I diabetes (also known as juvenile diabetes with β-cell destruction, usually leading to absolute insulin deficiency) This type of diabetes, Autoimmune diabetes which only inflicts 5–10% of people with the disease and was formerly referred to as type I diabetes, insulin-dependent diabetes, or juvenile-onset diabetes, is brought on by an organ-specific autoimmune mechanism that damages the pancreatic beta cells on a cellular level. The pace of cell degeneration in this kind of diabetes varies, occurring quickly in some people (infants and children) and slowly in others (adults). Ketoacidosis may be the first sign of the illness in some people, especially children and teenagers. Several genetic predispositions are linked to autoimmune beta-cell destruction, and environmental factors that are still poorly understood are also involved. Although individuals with this kind of diabetes are rarely obese when they first come, the condition's existence does not preclude the diagnosis.

1.3 Idiopathic Diabetes

Type I diabetes, whose causes are unknown. Some patients lack autoimmune signs yet have persistent insulinopenia and a propensity for ketoacidosis. Most type I diabetes individuals who fulfill this description—a modest percentage—have African or Asian descent. This kind of diabetes causes episodic ketoacidosis, and those with it display varied degrees of insulin insufficiency between episodes. Although there is no scientific proof of -cell autoimmunity, and this form of diabetes is not HLA related, it is highly inherited. In afflicted patients, insulin replacement medication may or may not always be necessary.

1.4 Type 2 Diabetes

Formerly known as non-insulin-dependent diabetes, type 2 diabetes, or adult-onset diabetes, this kind of diabetes affects people with insulin resistance and often has a relative (rather than an absolute) insulin shortage. It accounts for about 90–95% of people with diabetes. However, some people can thrive without insulin therapy, at least initially and frequently, throughout the rest of their lives. This type of diabetes most likely has a wide range of reasons. For example, patients do not experience autoimmune destruction of -cells, and none of the other causes of diabetes described above or below exist, even though the precise aetiologies are unknown. In addition, many people with this type of diabetes are obese, contributing to some degree of insulin resistance. As a result, insulin secretion impairment occurs in these patients, which cannot be made up later. Although, in hyperglycemia, weight loss and pharmacological therapy may improve insulin resistance, it seldom returns to normal. There is an increase in the probability of acquiring this type of diabetes with age, obesity, and lack of physical activity. It happens more commonly in women who have had previous GDM and those who have hypertension or dyslipidemia, and its occurrence varies depending on a person's race or ethnicity. More than the autoimmune form of type I diabetes, it is often associated with a high hereditary predisposition. However, the genetics of this type of diabetes are complex and poorly understood.

1.5 Other Specific Types Of Diabetes

1.6 Genetic Defects Of The B-Cell.

Diabetes of several forms is associated with monogenetic defects in -cell function. In these kinds of diabetes, the onset of hyperglycemia is frequently observed as happening at a young age (typically before age 25). They are referred to as maturity-onset diabetes of the young (MODY), and they are distinguished by diminished or nonexistent aberrations in insulin action but compromised insulin production. They inherit in an autosomal dominant manner. We have identified anomalies at six genetic sites on different chromosomes. Hepatic transcription factor Hepatocyte Nuclear Factor (HNF)-1 is associated with the most common form of chromosome 12 mutations. Due to mutations in the glucokinase gene on chromosome 7p, the glucokinase molecule in the second form is harmed. The -cell secretes insulin in response to the metabolism of glucose-6-phosphate, which is created by glucokinase. In light of this, the "glucose sensor" Glucokinase is for the -cell. People with glucokinase gene defects need higher plasma glucose levels to start producing appropriate quantities of insulin. Less common variations are brought on by mutations in NeuroD1, HNF-4, HNF-1, insulin promoter factor (IPF)-1, and other transcription factors. Point mutations in mitochondrial DNA have been associated with diabetes and hearing loss. The most prevalent mutation in the tRNA leucine gene resulted in an A-to-G transition at position 3,243. Diabetes is not a part of the MELAS syndrome (mitochondrial myopathy, encephalopathy, lactic acidosis, and stroke-like syndrome), which shows that this genetic abnormality has several clinical symptoms. Genetic flaws that prevent proinsulin from being converted to insulin have been reported in a few families; these traits are inherited via an autosomal dominant mechanism. It leads to mild glucose intolerance. It has also been discovered that a small number of families create mutant insulin molecules, which negatively affects receptor binding. However, this autosomal recessive disease is characterized by a hardly altered or even regular glucose metabolism.

1.7 Genetic flaws in insulin action-

Diabetes can have unique origins, including genetically predetermined insulin function anomalies. The metabolic problems linked to insulin receptor mutations might range from severe diabetes to hyperinsulinemia and mild hyperglycemia. Some people who carry these mutations could develop acanthosis nigricans. In addition, ovaries that are swollen and cystic are possible in virilized women. Type A insulin resistance was the previous name for this syndrome. Alterations in the insulin receptor gene cause altered function and severe insulin resistance in pediatric disorders such as leprechaunism and Rabson-Mendenhall syndrome. The former has characteristic facial traits and is often fatal in infancy. At the same time, the latter has been connected to abnormalities of the teeth and nails and pineal gland hyperplasia. Patients with insulin-resistant lipoatrophic diabetes do not exhibit changes to the insulin receptor's structure or functionality. Therefore, the lesion(s) must be located within the post-receptor signaling pathways.

1.8 Diseases of the exocrine pancreas

Any process that inadvertently affects the pancreas might result in diabetes. Examples of acquired processes include pancreatitis, trauma, infection, pancreatectomy, and pancreatic cancer. Diabetes has been associated with adenocarcinomas that involve just a small portion of the pancreas; nevertheless, in addition to damage caused by cancer, the pancreas must be substantially injured for diabetes to occur. Therefore, this offers an alternative mechanism to a simple loss of cell mass. Hemochromatosis and cystic fibrosis may damage beta cells and lower insulin production if severe enough. Fibrocalculous pancreatopathy may also be accompanied by stomach discomfort that radiates to the back and pancreatic calcifications seen on an X-ray. In addition, pancreatic fibrosis and calcium stones in the exocrine ducts were found at autopsy. Diabetes can arise from any process that unintentionally damages the pancreas. Pancreatitis, trauma, infection, pancreatectomy, and pancreatic cancer are a few examples of acquired processes. Even though diabetes has been linked to adenocarcinomas that only affect a tiny area of the pancreas, the pancreas must also be seriously damaged for diabetes to develop. This provides a different mechanism from a straightforward decrease in cell mass. If severe enough, hemochromatosis and cystic fibrosis may harm beta cells and reduce insulin production. Pancreatic calcifications seen on an X-ray and stomach ache radiating to the back are additional symptoms of fibro calculous pancreatopathy. Calcium stones in the exocrine ducts and pancreatic fibrosis were discovered at autopsy.

1.9 Drug- or chemical-induced diabetes

Several drugs can hamper the secretion of insulin. Even though these drugs may not directly cause diabetes, they may worsen the condition in those with insulin resistance. In certain circumstances, the relative relevance or order of insulin resistance and -cell dysfunction must be clarified, making categorization challenging. Numerous poisons, such as intravenous pentamidine and the rat poison Vacor, can cause irreversible damage to pancreatic beta-cells. Fortunately, these side effects are not frequent. Potentially decreasing the effectiveness of insulin are several drugs and hormones. Glucocorticoids and nicotinic acid are two examples. In addition, there have been situations when individuals who received -interferon had significant insulin insufficiency and diabetes associated with islet cell antibodies. *Infections.* Beta cell death has been connected to a few viruses. For example, despite immunological markers and HLA usually associated with type I diabetes, patients with congenital rubella acquire diabetes. Some incidences of the condition have also been connected to Coxsackievirus B, CMV, adenovirus, and mumps. *Rare forms of immune-mediated diabetes.* There are now two identified conditions in this group, and there are possibly more. "Stiff-man syndrome" is an autoimmune central nervous system disorder defined by axial muscular stiffness and painful spasms. About one-third of individuals will eventually develop diabetes, and most patients have high levels of GAD autoantibodies. Anti-insulin receptor antibodies can cause diabetes by binding to the insulin receptor and obstructing insulin's ability to bind to its receptor in target tissues. However, in rare cases, these antibodies may act as an insulin agonists and cause

hypoglycemia after binding to the receptor. Sometimes people with systemic lupus erythematosus and other autoimmune diseases exhibit anti-insulin receptor antibodies. Like other high insulin resistance disorders, patients with anti-insulin receptor antibodies usually exhibit acanthosis nigricans. Type B insulin resistance was the previous name for this disorder. Diabetes can occasionally be linked to several inherited illnesses. Diabetes is more common in several hereditary disorders. They include chromosomal abnormalities, including Down, Klinefelter, and Turner syndrome. In addition, -cells are absent at autopsy, and insulin-deficient diabetes is two characteristics of Wolfram's syndrome, an autosomal recessive disorder. Other signs include optic atrophy, hypogonadism, neural deafness, and diabetes insipidus.

1.10 Gestational diabetes mellitus

Any degree of glucose intolerance that starts or is first observed during pregnancy is called GDM. Even though most instances resolved with delivery, the criteria were valid whether or not the issue persisted after delivery and did not completely rule out the possibility that undiagnosed glucose intolerance may have started before or at the same time as the pregnancy. Although its limitations were long recognized, this definition made it simpler to provide a standardized method for identifying and classifying GDM. In addition, the rising obesity and diabetes epidemic among women of reproductive age has led to a rise in the number of pregnant women with untreated type 2 diabetes.

1.11 Treatment of Diabetes Mellitus

High-calorie intake and inactivity are the main causes of type 2 diabetes and the key therapeutic goals. Drug therapy should be begun (or increased) and monitored depending on the HbA1c fraction if altering one's lifestyle does not provide adequate improvement. The HbA1c goal value should be determined with the patient's input and consider patient-specific characteristics. HbA1c goal levels are recommended to be between 6.5% and 7.5%. For first-line medication management, metformin is suggested. If metformin is ineffective, poorly tolerated, or contraindicated, there are a variety of therapeutic options and dietary supplements accessible. Sulfonylureas and insulin have been demonstrated to be advantageous about patient-relevant endpoints in clinical trials, but no other antidiabetic medication has similar data to date (except metformin). Due to things like a lower risk of hypoglycemia, less weight gain, oral delivery, and the ability to be administered in the context of renal insufficiency, other drugs may be more useful for particular people. The therapy is customized for each patient based on age, illness stage, body weight, comorbidities, employment circumstances, adherence, and personal goals. Combining more than two anti-diabetic drugs is not recommended [22].

1.12 Telemedicine

The epidemic of COVID-19 has pushed telemedicine to the forefront of medical care. As more clinicians and patients are exposed to home telemedicine, they find its benefits. T1D treatment, in particular, lends itself nicely to this type of remote care because most of the appointment is around data review and therapy discussions. For individuals who use such devices, the evolution of constantly linked devices (such as the Dexcom G6) allows for the smooth transfer of data from the patient to the clinician. Remote monitoring allows physicians and other healthcare workers to be notified about patients whose status is deteriorating based on available metrics (e.g., A1C, FPG, glucose profiles [AGP] collected by SMBG or CGM, resulting in early action). Direct data entry into electronic medical records via CGM, linked insulin pens, and insulin pumps may and should enhance data utilization and clinical results.

1.13 Reorganization of the healthcare system

Regulatory change that allows for sustained access to home telemedicine is required, and it may prove to be one of the current situation's long-term benefits. The mechanisms and infrastructure for managing and supervising type 2 diabetes, particularly for those who do not use insulin, differ significantly from the T1D patient examples described. Telemedicine and digitalized medicine are projected to enable and facilitate the extensive reorganization of healthcare delivery systems, with the potential for significant cost savings and yet-unknown implications on the quality of treatment and long-term results. The use of frequent communications with the patient (real-time online, asynchronous, texting, e-mail, telephone, smartphones) driven by artificial intelligence and clinical decision support systems, nurse practitioners, CDCES, primary care physicians, and nurses, with oversight by diabetes specialists using remote monitoring and algorithms, could potentially replace or augment the typical visit to the physician's office or clinic at 3- to 6-month intervals. Approaches like this are at various stages of development and look promising, while no definite cost-benefit analysis has been recorded.

1.14 Diabetes control and management

The main goals of glucose management in diabetes are to prevent complications from diabetes, such as problems with the eyes, kidneys, or nerves, and to ensure that patients managing the condition do not have dangerously high or low blood sugar levels (hyperglycemia). Over time, advancements in the management of diabetes have been made thanks to innovative technology. There are currently several technologies that can help you manage your diabetes. The ideal instrument for managing your blood sugar will change as technology advances and depend on your preferences. With your doctor and a diabetes educator, you should discuss the best option. Making decisions that fit your lifestyle is simpler if you are aware of the differences between each. Modern technology is easily available and can considerably aid in blood sugar management. Many of these technologies are becoming increasingly popular and could be covered by insurance. However, some patients may find the added features of more expensive apps overwhelming. Diabetes Log, available for free in the Apple iTunes store, provides the fundamentals for diabetes monitoring. Still, Diabetes Buddy, which costs $6.99, is a complete program with extra capabilities for more detail-oriented users. The most appropriate app for a certain patient

will consider the need for lifestyle changes, such as food and exercise, as well as the user's expertise and smartphone experience. Furthermore, new and upcoming gadgets such as iBGStar and Eyesense may allow consumers to measure their glucose levels while on the go, making SMBG easier than ever.

1.15 Glucose management indicator

With the increasing availability of CGM, the mean glucose and TIR may be easily calculated. An estimate of the expected A1C may be calculated from the mean glucose, known as the Glucose Management Indicator (GMI), to emphasize that it is not a direct A1C test. This GMI, incorporated in Clarity and other software, provides a critical input that may be obtained with just a few days of CGM readings, eliminating the need to wait three months for direct measurement of A1C. A new advanced algorithm that detects pending hypoglycemia and then suspends basal insulin delivery is also introduced in the market, known as the hypoglycemia prediction algorithm (HPA). This approach can solve the problem of nocturnal hypoglycemia, a major concern of patients with diabetes. This device runs with a programmed algorithm and alarm system, as shown in Fig.1.

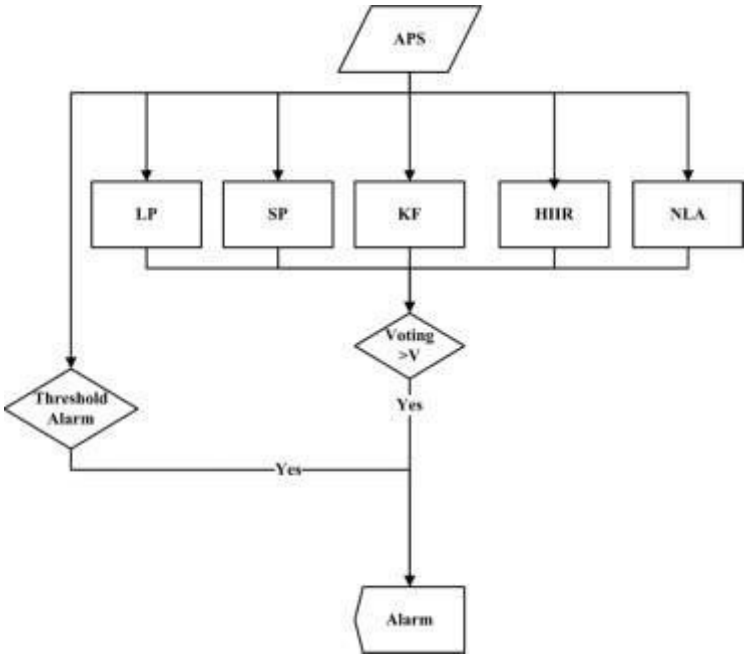

Fig.1 Hypoglycemia alarm flowchart.

1.16 Endocrine Connection

Blood glucose, sometimes called blood sugar, helps the body's tissues get the energy they need. To effectively manage diabetes, blood glucose levels must be monitored. You may prevent short-term problems like excessively high or low blood sugar (hyperglycemia and hypoglycemia) and long-term problems like nerve damage by regularly checking your blood glucose levels and maintaining safe blood sugar levels. Continuous glucose monitoring, or CGM, allows people with diabetes to monitor their blood glucose levels continuously. CGM measures the quantity of glucose in the medium flowing between body cells every few minutes day and night. CGMs use a small sensor to measure the fluid between the body's cells. This sensor measures the glucose level every few minutes. The glucose levels are then shown by a reader when the data is electronically transferred to it. Some CGMs can even send this information straight to your phone so you may share it with a friend or a doctor. There are several CGM products available. However, the procedures employed by various systems to measure and show glucose levels differ somewhat.

1.17 Most CGM devices are composed of these three components

• A tiny, disposable sensor is implanted under the skin to measure the quantity of glucose in bodily fluids. Depending on the kind, The sensor changes every 3 to 7 days. The sensor and emitter are connected via a small device applied to the skin. It transmits glucose level information through radio waves to a wireless receiver, sometimes called a monitor. The monitor, a device roughly the size of a smartphone, shows information regarding glucose levels on its screen. The user wears the gadget on their belt or keeps it in their pocket. When the target glucose level has been surpassed, the monitor contains an alert that sounds. In certain designs, insulin pump information may be displayed immediately. CGM devices provide a variety of information concerning glucose levels. One research, for instance, depicts the normal glucose levels across time, such as a full day and night. Additionally, users of CGM devices have access to a range of data on their blood glucose levels. One research, for instance, depicts the normal glucose levels across time, such as a full day and night. Additionally, users of CGM devices may log when they take prescriptions or

eat meals, which might be useful for understanding their glucose patterns. Glucose levels can change drastically or very quickly. If you need to take insulin for type 1 or type 2 diabetes, a CGM device could be your best option. Children as young as 2 years old may use CGMs depending on the CGM. According to studies, CGMs can help people with diabetes maintain their target blood glucose levels while lowering their risk of severe hypoglycemia. Adherence to a schedule is possible to reduce short-term and long-term health problems. However, CGM may only be appropriate for some. They have trouble getting used to dealing with alerts and having a sensor embedded beneath their skin. In addition, the amount of information CGM offers may scare some people or make them uncomfortable utilizing technology. A CGM can be used in various ways, and each individual will use it differently and more frequently. For example, CGMs can be used if you use an insulin pump or an insulin injection; they can be worn constantly or only occasionally; discuss your options with your healthcare team. In recent years, CGMs have improved in accuracy to the point where they are as precise as blood glucose meters. CGMs show the changes in glucose levels around the clock; this can help you choose insulin, food, and exercise. Allowing for direct insulin dosing and decision-making from the CGM. They aid in decision-making about the necessary changes to help keep glucose levels within a safe range by demonstrating how quickly they change. Provide insightful reports on your glucose patterns to aid in treatment selection. Alarms or alerts may be delivered when blood sugar levels are too high or low. Additionally, they can forecast if blood sugar levels will be high or low in the next few days. Make communicating with medical staff and family members simple. Both CGMs and blood glucose meters display your present blood glucose level. However, CGMs can also record previous and current levels and forecast future glucose levels. Using a CGM has a lot of benefits, especially trend indicators. Small lines called trend arrows usually indicate the direction in which your blood sugar level is moving. For instance, you can anticipate a decrease in your glucose level if trend arrows indicate downward. This can aid in planning and allow you to detect dangerously high or low blood sugar levels. Using trend arrows, you can alter how much insulin you consume with meals. Because not all trend arrows are created equal, the precise quantity of insulin to add or subtract depends on the individual taking the medication and the kind of CGM system you use. Before adjusting your insulin using trend arrows, it's crucial to discuss the meaning of the trend arrows with your medical staff. Every widely used continuous glucose monitor has unique features, including restrictions on who can use them, instructions for inserting the sensor, and methods for gathering, displaying, and sharing data [23].

1.18 Estimation of Plasma Glucose levels with Continuous Glucose Monitoring systems

The ability of continuous glucose monitors (CGM) to offer non-invasive, high-frequency, adjunctive data makes them useful in clinical and research settings [23]. CGMs use a sensor implanted into the subcutaneous interstitial space to provide glucose readings more 15 frequently than possible with traditional testing, improving clinical treatment [24,25]. Several studies have demonstrated that CGM use can enhance clinical outcomes for diabetic children and adults [24,26-33]. In addition, CGMs could be used by people without diabetes to analyze changes in glucose tolerance over time and estimate glycaemic ranges in particular demographic populations [34-38]. Most of the time, diabetic patients have discovered that these instruments are simple to use, somewhat painless, and preferable to conventional finger-prick ways of monitoring glucose [28,32,39,40]. The accuracy of CGMs in comparison to venous measures, however, may need to be corrected for time lags and may be impacted by the macronutrient makeup of meals, according to some published evidence [41-44]. As more and more CGMs are made accessible, it is crucial to understand each one's accuracy and limitations, as well as the range of applications they can be used for. A subset of CGM called masked glucose monitoring systems gives patients and healthcare professionals historical data on glycemic patterns that may impact long-term behavior and treatment choices in diabetes patients [27,33,45]. A masked glucose monitoring device called the FreeStyle Libre Pro (FLP) can track patterns and trends in glucose concentration for up to 14 days [33,45]. In contrast to early CGM devices, the FLP is factory calibrated and does not call for or permit user-performed finger-stick calibration at any time [31,33,45]. According to published research, the mean absolute relative difference between the FLP system and the BG reference was just 11.4% [44]. In samples of children and people with diabetes, studies have shown that the FLP system offers good glucose readings compared to conventional glucose monitoring methods [30,31,39,45-47]. The study aims to assess the Freestyle Libre Pro device's impact on blood glucose control and its ability to monitor and manage diabetes. The study objectives is evaluate the accuracy and reliability of the Freestyle Libre Pro device in measuring blood glucose levels compared to traditional monitoring methods. To assess the impact of using the Freestyle Libre Pro device on patients' blood glucose control and their ability to manage their diabetes.

2. METHODOLOGY

2.1 Study setting

Using the FreeStyle Libre Pro CGM system, we analyzed the datasets for eight patients selected randomly suffering from diabetes mellitus. We monitor them over 14 days regularly; 12-hour data was monitored fortnightly. Two of the eight cases were on insulin, and the rest were administered oral medications for diabetes care. Ambulatory Glucose Profiles, Average Glucose Levels, Time in Range, Time Below Range, Time Above Range, and, afterward, calculation of HbA1c levels were determined for eight patients using the FreeStyle Libre Pro system's current glucose measurements.

2.2 Device

The Freestyle Libre Pro measures interstitial fluid glucose levels using subcutaneous, linked enzyme glucose sensing technology [48]. Values are stored for 15 minutes and are measured automatically every minute. The Libre Reader is put close to the sensor when a glucose reading is required. The reading device will then show the eight-hour glucose history, the current glucose level, a trend graph, and a trend arrow. In addition, the direction and speed of the patient's current

glucose level are shown by the arrow. Patients do not need to calibrate this technology using blood sample glucose meter data because it is factory calibrated [49].

2.3 *Data collection*

Standardised continuous glucose monitoring (CGM) metrics for clinical care

- ➢ CGM wear time – recommend 14 days minimum
- ➢ Percentage time for which CGM is active – recommended time 70% of data from 14 days
- ➢ Mean glucose
- ➢ Glucose management indicator (GMI)
- ➢ Percentage Time Above Range (TAR) >13.9 mmol/L
- ➢ Percentage Time Above Range (TAR) 10.1–13.9 mmol/L
- ➢ Percentage Time in Range (TIR) 3.9–10.0 mmol/L
- ➢ Percentage Time Below Range (TBR) 3.0–3.8 mmol/L
- ➢ Percentage Time Below Range (TBR)

The Freestyle Libre was free to participants instructed to apply a 10-day sensor to the back of the arm following the manufacturer's written instructions and demonstration video. Clinical coordinators were available by phone, video conferencing, or in-person to troubleshoot CGM sensor placement for those with difficulties. The small CGM subcutaneous sensor measures interstitial glucose values every 15 min, which can be transmitted using near-field communications. Participants obtained their glucose values after scanning for up to 8 h of data (i.e., Flash CGM). No alarms were used.

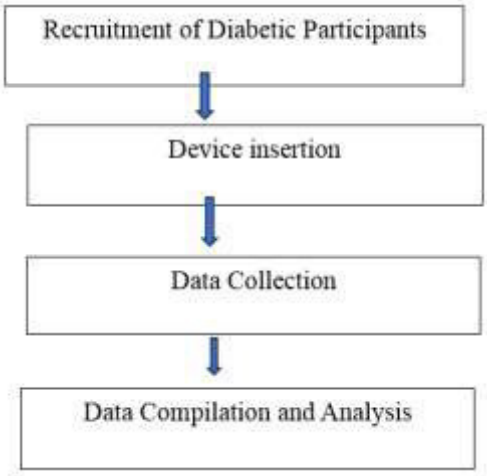

Fig 1: Study Plan Model

2.4 *Outcomes*

The Freestyle Libre Pro competes with CGM substitutes. It promotes user friendliness and raises clinic income. Thanks to the Freestyle Libre for personal use, patients now have another way to check their blood sugar levels. It can replace a glucose meter and reduce the number of finger sticks required to get glucose readings, giving patients access to that data whenever needed. It may not be appropriate for everyone, but it will give patients and medical providers another choice.

3. RESULTS

Using the FreeStyle Libre Pro CGM system, we analyzed the datasets for eight patients over 14 days. In addition, regular 12-hour data was monitored on a fortnight basis. Two of the eight cases were on insulin, and the rest were administered oral medications for diabetes care. Ambulatory Glucose Profiles, Average Glucose Levels, Time in Range, Time Below Range, Time Above Range, and, afterward, calculation of HbA1c levels were determined for eight patients using the FreeStyle Libre Pro system's current glucose measurements (supplementary data).

Table 1- The data in this table depicts the diabetic score of the enrolled participants over the 14 days

S. no.	RFNO	Estimated hbA1c	TIR%	TBR%	TAR%	Avg glucose
1.	PID-001	5.4 %	56 %	26 %	18 %	107 mg/dL
2.	PID-002	5.0 %	71 %	29 %	0 %	97 mg/dL
3.	PID-003	5.7 %	53 %	20 %	27 %	116 mg/dL
4.	PID-004	8.0 %	22 %	1 %	77 %	182 mg/dL
5.	PID-005	7.3 %	26 %	22 %	52 %	164 mg/dL
6.	PID-006	7.6 %	59 %	0 %	41 %	172 mg/dL
7.	PID-007	5.4 %	96 %	2 %	2 %	107 mg/dL
8.	PID-008	7.8 %	47 %	0 %	53 %	178 mg/dL

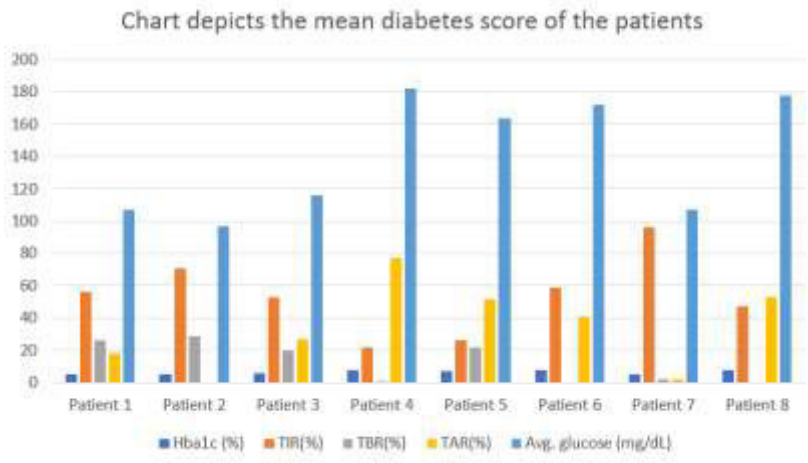

Fig 2: Chart depicts the mean diabetes score of the patients

We observed that the average glucose levels were maintained in the range for four patients, and the average glucose levels were above the range for four patients. Regarding Time, four were above range, and four were in range. Therefore, using CGM in place of or in addition to self-measured blood glucose levels can help reduce self-measured blood glucose inaccuracies caused by human error, physiological discrepancies, medication interference, or extreme environmental conditions, and may be thought to be more tolerable by patients and research participants.

Table 3- Properties of antihyperglycemic drugs

Drug name	Special properties	Typical application
Metformin	side effects on the GIT system	the initial line of defense against type II diabetes
Sulfonylureas	recognized as effective antihyperglycemic medications	affordable substitute for metformin if the latter is not well tolerated; economic combination with metformin
Glinides	They are more versatile because of their quicker onset and shorter duration of action than sulfonylureas.	Superior to sulfonylureas for individuals with renal failure and irregular or unreliable mealtimes.
DPP-4 inhibitors	Better advantage as compared to GLP-1 receptor agonists	overweight, increased risk of hypoglycemia, inadequate glycemic control with metformin alone
SGLT-2 inhibitors	concurrent weight reduction and a higher incidence of genital urosepsis	increased risk of urogenital infections and concurrent weight loss
GLP-1 Receptor agonists	Compared to DPP-4 inhibitors, subcutaneous injection is more efficient and has the benefit of promoting weight reduction.	Metformin alone may not provide appropriate glycemic control and overweight an increased risk of hypoglycemia.
Acarbose	Side effects on GIT system	Early stage type 2 diabetes, or else as a partner in a combination
Pioglitazone	Increased risk of bone fractures, fluid retention, and heart insufficiency; may be increased risk of bladder cancer	combination medication for people with severe renal insufficiency and an increased risk of hypoglycemia
Insulin		Useful in severe illness stages; may be coupled with metformin.

Table 4- Diagnosis guidelines for diabetes
1. A1C ≥6.5%. A technique that is NGSP accredited and standardized to the DCCT assay should 2. be used to conduct the test in a lab.
OR
2. FPG less than 126 mg/dl (7.0 mmol/l). No calorie intake for at least 8 hours is considered to be fasting.
OR
3. During an OGTT, 2-h plasma glucose was less than 200 mg/dl (11.1 mmol/l). Therefore, the World Health Organisation recommends doing the test with a glucose load equivalent to 75 g of anhydrous glucose dissolved in water.
OR
4. A random plasma glucose reading of less than 200 mg/dl (11.1 mmol/l) in a patient with hyperglycemia or hyperglycemic crisis.

Supplementary data (files S1-S8) – Freestyle Libre Pro data for PID 1-8

4. DISCUSSION

To determine similar values for Time in Range (TIR), Beck et al. [50] examined central laboratory assessments of HbA1c in persons with type 1 diabetes. A TIR of 70% is similar to an HbA1c of 53 mmol/mol (7.0%), according to their research. A 50% TIR corresponds to an HbA1c of 64 mmol/mol (8.0%). Additional research by the same team supported the association between TIR and the advancement of diabetic retinopathy and the development of microalbuminuria in individuals with diabetes. Consequently, this implies the following: More issues are observed when less time is spent in the target range. There is a greater risk ratio for a 64% rise in retinopathy for every 10% drop in TIR. Therefore, continuous glucose monitoring throughout a cycle of 14 days may be able to explain and present the information in this way, as well as guide patients and physicians down a new route for optimal diabetes care.

4.1 Metrics of glucose control

Foreseeing and developing future strategies is useful for looking at past and present practices and measures. These practices also condition people with diabetes after using HbA1c for years to determine how well their blood glucose is being managed. Clinicians and CGM researchers have long utilized HbA1c as their main focus and goal. This recognizes the established relationship between increasing HbA1c levels and the onset of chronic issues. HbA1c measures the average glucose level over the previous 60–90 days. However, it cannot measure the frequency or severity of hypoglycemic episodes [50]. Moreover, the accuracy and usefulness of the test are compromised by other medical diseases, including hemoglobinopathies, iron insufficiency, pregnancy, and chronic renal disease. Despite this, HbA1c will continue to be used in clinical practice because it is the only measure for the risk of long-term diabetes problems that has undergone prospective evaluation. Similar findings were seen in studies including persons with insulin-dependent diabetes 2, where rtCGM usage was related to decreased A1c and reduced hypoglycemia [51]. A recent randomized clinical trial in people with type 2 diabetes who were given basal insulin but not prandial insulin found that using rtCGM was associated with lower A1c (adjusted difference 0.4%, p =.02) and more time in the target glucose range of 70-180 mg/dl (adjusted difference 15%, p =.001) than using fingerstick glucose monitoring [52]. Furthermore, the HypoDE clinical study showed that using rtCGM in persons with DM1 who had a history of severe hypoglycemia resulted in fewer bouts of hypoglycemia and sustained A1c decrease over three years [53]. Furthermore, clinical research shows that using rtCGM inside closed-loop controlled insulin pump systems is related to better glycemic control and decreased incidence of hypoglycemia in patients with T1DM [54]. In both T1DM and intensively managed insulin-dependent T2DM, intermittently scanned CGM (isCGM) usage is related to greater glucose duration in range, decreased glucose variability, and improved quality-of-life scores [55,56]. Recent research suggests that using newer models of isCGM is related to fewer DKA hospitalizations, a modest drop in A1c, and a lower incidence of hypoglycemia [57,58]. Head-to-head trials, however, show that rtCGM is linked with a considerably lower incidence of severe hypoglycemia than conventional CGM [59,60,61]. Using the FreeStyle Libre system is associated with a reduction in the amount of time that adults with T1DM or T2DM on insulin spent with glucose in the hypoglycemic zone below 3.9 mmol/L (70 mg/dL) [62,63], with significant improvements in both daytime and nocturnal hypoglycemia. In IMPACT research [62], similar improvements were shown in the intervention arm with a mean baseline HbA1c of 6.8%, indicating that the benefits of utilizing the FreeStyle Libre System extend beyond HbA1c. Adults, children, and adolescents with T1DM, as well as adults with T2DM on insulin, exhibit decreases in measures of glycemic fluctuation using the FreeStyle Libre system in some studies. [62,63,64.] Observational studies are now emerging that corroborate the link between flash glucose monitoring and fewer hospitalizations for acute diabetes events (ADEs) such as diabetic ketoacidosis, severe hypoglycemia, or coma. The RELIEF study [65] found that among 74,011 people with T1DM or T2DM who used the FreeStyle Libre system, hospitalizations for ADEs decreased by 49.0% in T1DM and 39.4% in T2DM in the 12 months following FreeStyle Libre initiation compared to the previous 12 months. This includes decreases in DKA admissions in T1DM (56.2%) and T2DM (52.1%). Similar results are evident in the ABCD FreeStyle Libre countrywide assessment in the United Kingdom [66.]

4.2 Time In Range

HbA1c goals are embedded in diabetes treatment, but the benefits of CGM and its ability to show real-time glucose data, together with other components of glucose fluctuation, enable a change in focus and the creation of a new therapeutic story. Time In Range (TIR), which quantifies how much of the day is spent with blood glucose levels between, by consensus, 3.9 and

10.0 mmol/L, is the most crucial of these new indicators. Recent studies show that TIR, clinical outcomes, and HbA1c are highly linked. These correlations might be used to explain to CGM users, for example, that a TIR of 70% (i.e., 70% of time spent with blood glucose levels 3.9-10.0 mmol/L) equates to an HbA1c of 53 mmol/mol (7.0%); or that a 10% increase in TIR would decrease their HbA1c by 5 mmol/mol. With CGM, it is possible to identify the Time Below Range (TBR), Time Above Range (TAR), and Time Outside of Range (TIR), but even learning the new vocabulary is challenging. People with diabetes commonly refer to TBR and TAR as "hypos" and "hypers," or "running high," to characterize their blood sugar levels. The graphical representation of the glucose data aim can solve some challenges in comprehending these novel notions. For people with type 1 and type 2 diabetes, the TIR goal is to stay within this range for at least 70% of the time. This approach may be changed so that users are informed and motivated to undertake lifestyle and treatment regimen adjustments that will improve glucose control and, in turn, diabetes management. This is plausible given the suggestions about glucose measures from CGM data and how these are shown alongside the AGP.

4.3 Ambulatory glucose profile

Concentrate on TIR; the ideal glucose range is 3.9–10.0 mmol/L. The physician must explain to patients that 60% TIR, or an HbA1c of 58 mmol/mol (7.5%), is a relatively excellent level of control. Even greater control, though, is indicated by a TIR of 70%, which is equivalent to an HbA1c of up to 53 mmol/mol (7.0%).

5. CONCLUSION

The Freestyle Libre Pro CGM system may offer several benefits. The clinic pays very little upfront for the Pro version. Patients are only given disposable parts of the system to take home. No reusable components need to be cleaned in between patients. All patients are read by the same handheld equipment, which the healthcare provider always carries. The clinic can use LibreView, a free program for downloading and reporting, without charge. Patients can also get the Freestyle Libre Pro system from retail pharmacies. It doesn't require authorizations through specialized distributors like other CGMs. Additionally, the only acetaminophen-unaffected CGM device available is the Freestyle Libre. It is possible to keep the sensor's accuracy without regularly calibrating it using data from a blood glucose meter. This makes it possible to acquire important glucose data even when people check their blood sugar infrequently. Consequently, practically every healthcare setting may benefit from the Freestyle Libre Pro as a tool for care coordination. When the sensor is implanted at the healthcare provider's office, patients have 14 days to remove and return it. The necessary treatment modifications can be made over the phone or through the patient portal/electronic medical record. The sensor is a small, covert device around the size of a quarter. Patients can wear it without disturbing their daily activities for 10 to 14 days.

5.1 Future Clinical Implication as an Operational Innovation Tool

As can be seen from the case studies, the Freestyle Libre Pro offers an alternative to current CGM devices for professional use. It increases revenue for clinics and facilitates user-friendliness. Due to its use for private purposes, patients now have another means to check their blood sugar. Patients can avoid multiple fingersticks and obtain glucose information on demand using them instead of a glucose meter. It may not be appropriate for everyone, but it will give patients and medical professionals another good option for the acute treatment of both type 1 and type 2 diabetes mellitus.

6. CONFLICT OF INTEREST

Conflict of interest declared none.

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