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How modern technologies improve daily diabetic control

Jak nowoczesne technologie poprawiają kontrolę cukrzycy na co dzień?

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Abstract

Introduction: Diabetic children who live surrounded by modern technologies such as Facebook, Google, and GPS want their treatment to stand up to the times, especially if it accompanies them for their whole life.

Aim of the study: In this review we aim to analyse which technologies help diabetics in their everyday struggle to keep up with diabetes as well as whether those inventions catch up to the reality of 21st century.

Material and methods: We decided to discuss the most outstanding inventions in the field of diabetology. We chose insulin pumps, constant glucose monitoring (CGM) systems, mobile apps, and, last but not least, social media and the Internet as the most promising and fastest developing areas. Thanks to all of these technologies and devices we are now able to monitor patients all time. We have to take into account that the limitations of technology, the possibility of technical malfunction, and human error might prove to be fatal.

Conclusions: To sum up, technology simplifies treatment and aids patients in daily diabetic control.

Key words:
diabetes, technology, insulin pumps, social media, continuous glucose monitoring.

Streszczenie

Wprowadzenie: Dzieci chorujące na cukrzycę, które żyją w otoczeniu nowoczesnych technologii, takich jak Facebook, Google, GPS, chcą, aby ich leczenie było adekwatne do poziomu osiągnięć technologicznych, szczególnie jeśli towarzyszy im całe życie.

Cel pracy: Przegląd technologii, które zostały wprowadzone na rynek medyczny w celu pomocy pacjentom w codziennej walce z cukrzycą, a także ocena, czy te innowacje przystają do XXI wieku.

Materiał i metody: Postanowiono przedyskutować najwybitniejsze wynalazki z zakresu diabetologii. Analizie poddano wpływ pomp insulinowych, systemów stałego monitorowania glikemii (*constant glucose monitoring* – CGM), aplikacji mobilnych oraz media społecznościowe i Internet jako najbardziej obiecujące i najszybciej rozwijające się obszary w dziedzienie medycyny. Dzięki tym wszystkim technologiom i urządzeniom możliwe jest monitorowanie pacjentów przez cały czas. Jednakże należy wziąć pod uwagę ograniczenia technologii, możliwość wystąpienia usterki technicznej oraz błędu ludzkiego, które mogą być śmiertelne.

Wniosek: Obecne rozwiązania technologiczne upraszczają leczenie i pomagają pacjentom w codziennej kontroli cukrzycy.

Słowa kluczowe:
cukrzyca, technologie, pompa insulinowa, media społecznościowe, system stałego monitorowania glikemii.

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Introduction

People living in the era of modern technologies such as Facebook, Google, and GPS want their treatment to stand up to the times. This is especially true for patients with diabetes because in this disease it is crucial for the patient not only to receive insulin, but also to receive it in a way that correlates with the food they eat, the emotions they are feeling, as well as their physical activity. For this group of patients, the support they require is not limited only to drug delivery; they also need constant feedback on their blood glucose level, they want a device that will help relieve some of the burden they suffer due to diabetes.

Aim of the study

The idea of this study was to analyse how medical devices and technologies help people in their everyday struggle to keep up with diabetes as well as whether those devices catch up to the reality of the 21st century. In order to make this review clearer for our readers we have decided to compare a few of the most outstanding inventions in the field of diabetology. We chose insulin pumps, constant glucose monitoring (CGM) systems, mobile apps, and, last but not least, social media and the Internet as the most promising and fastest developing areas.

Insulin pumps

Use of insulin pumps started in the 1970s [1] as a simple tool for delivering insulin in a constant fashion, and as time passed they became more advanced. They are becoming more popular not only because of their safety, effectiveness, and prevention of long-term complications such as retinopathy or neuropathy [2], but also because they enable patients to significantly reduce the amount of insulin costs, which caqn be as much as $1011 per year compared to multiple daily injections (MDI), as shown by David *et al.* [3]. Considering the increasing rates of obesity in patients, insulin pump therapy (CSII) seems to be a tool of choice when managing diabetes in this group of patients, as shown by Wainstein *et al.* [4], who presented data proving that CSII is far more superior to MDI in obese patients without weight or insulin dose change, which is important because it negates the factors that might have interrupted the results. Another study, which used the most advanced artificial pancreas, Renard [5], concluded that although CSII seems to be more effective than MDI the main factor that determines the outcome of the therapy is the patient, which means the role of the doctor is crucial in managing the patients and their disease. The data collected from the OpT2mise study, presented by Conget *et al.* [6], strongly suggest usage of CSII because the glucose profile increases greatly, with more time spent in the target range and without increasing the number of hypoglycaemia episodes. Another point made by the authors was the continuous data collection while using sensors, which, in contrast to self-monitoring blood glucose, provides more data for analysis and therefore allows doctors make better profiles of the patients.

Despite CSII being superior to MDI [7] in terms of efficiency and safety it does not provide long-lasting results in lowering the glycated hemoglobin (HbA_{1c}) level [8]. While being a golden standard for treatment of type 1 diabetes, CSII cannot be of use for patients with type 2 diabetes because they seem not to benefit from this type of treatment [9].

Constant glucose monitoring

By 1999 MiniMed received FDA approval for the first CGM device in the USA. Since then, engineers have been improving the system to monitor blood glucose levels in real time without constant pricking; it also shows trends in the change of current blood glucose levels and is able to sound an alarm in case of hyperglycaemia or hypoglycaemia, which greatly affects both quality of life as well as glycaemic control – Miller *et al.* [10] presented data from a study in which they compared their group with a cohort obtained from a national registry, supporting the thesis that frequent blood glucose monitoring helps in lowering HbA_{1c}, due to the patient being more engaged in the treatment. An interesting study was performed by Walker [11] in which the authors aimed to establish whether knowing the blood glucose level which is shown in the CGM might have effect on the therapy. Therefore, their experimental group received a modified CGM where glucose numbers were obscured, while the control group received an unmodified CGM. Both groups noted a reduction of HbA_{1c}, but the group with hidden values were more influenced. CGM not only helps to ease the patient with their struggle, but also helps to achieve good glycaemic control. The most important study on safety and application of CGM was performed by Choudhary *et al.* [12], in which they showed the reduction of severe hypoglycaemia in a group that was particularly susceptible to low blood glucose level due to limited awareness of it. The study by van Beers *et al.* [13] was done within two groups of patients who were first assigned to CGM or SMBG and were then washed out and altered to the second form of blood glucose measuring. The SMBG was a control, and the results obtained clearly show the reduction of severe hypoglycaemia in the CGM patients. Modern CGM devices are also a great tool for measuring blood glucose levels during exercises because they operate accurately and reliably in changing metabolic conditions as proven by Bally *et al.* [14]. However, while CGM is a highly useful tool for monitoring patients' blood glucose, it should be noted that more care should be taken when examining data from patients whose HbA_{1c} exceeds 8.0% in short-term monitoring due to the higher risk of both overestimating and underestimating the mean glucose, as presented by Yamada *et al.* All patients in this study underwent CGM training in the facility of the authors. The data consisted of at least one 24-h profile during two of seven days of monitoring without gaps longer than two hours. There were 145 patients

screened, but due to exclusion criteria including factors known to interfere with glucose levels, as well as blood glucose over 400 mg/dl, only 51 patients were included [15].

Sensor-augmented pumps

The combination of above technologies is called sensor-augmented therapy (SAP), where the pump cooperates with the sensor in order to better adjust the parameters of insulin delivery, and, as Bergenstal *et al.* [16] proved, such a combination is of great benefit to the patient's safety and long-term outcome of therapy. A first study on the subject of SAP by Hirsch *et al.* [17] showed a positive correlation between sensor usage and both reduced risk of hypoglycaemia and better reduction of HbA_{1c}, as compared to the control group, i.e. CSII patients with self-monitored blood glucose (SMBG). Roselund *et al.* [18] demonstrated that SAP is not only a great device when it comes to controlling glucose parameters but also helps in reduction of microalbuminuria.

Prevention of hypoglycaemia and artificial pancreas

The MiniMed 640G system is equipped with SmartGuard technology, which enables a pump to suspend an insulin delivery before hypoglycaemia occurs. The system helps not only in achieving desired blood glucose levels without increasing the risk of going into hyperglycaemia but also the patients who use it report great assurance and confidence while using it [19]. These findings are aligned with the study by Zhong *et al.* [20], who also reported a reduction of blood glucose fluctuations.

670G

However, as great as the 640G system is, there is a new pump, the 670G, which was recently approved by the FDA and works on a first hybrid closed-loop, which, thanks to advanced algorithms, is able to automatically decide about the dosage of basal insulin. The study performed Bergenstal *et al.* [21] showed no severe hypoglycaemia or ketoacidosis during the study period; the only adverse events observed were device related and were solved at home. Even though closed loop systems are able to prevent nocturnal hypoglycaemia, they struggle to maintain blood glucose within the normal range during exercise or when the sensor is malfunctioning. To tackle this issue de Bock *et al.* [22] performed a study in which eight patients were treated with 670G in clinic conditions for four days and three nights. Patients prior to the study had their VO_2 measured. During the study patients had their sensor over calibrated on day 2 and day 3. The results obtained showed that algorithms were able to prevent patients from severe hypoglycaemia during sensor malfunctioning and exercising. The limits of the study include its short period and small number of patients.

Mobile apps

People are now guided by mobile apps in every aspect of their life, from GPS to meeting new people. In this abundance of applications, we wanted to check if there are any that help diabetic patients with their everyday life. Dennison *et al.* [23] designed a study in which they measured young adults' readiness and motivation for using medical apps. The study showed that they are indeed interested in apps that help them achieve a wanted change. However, some people had less compliance due to lack of the motivation for systematic use of said apps. Sutton [24] in his article regarding weight-loss-aiding apps suggests that they might be a useful tool for personalising a treatment plan for the patient, but randomised trials performed on the efficiency of remote self-monitoring as well as behavioural interventions are required. That is especially important since Baker and Kirschenbauml [25] and Tate *et al.* [26] proved that there is a strong correlation between success in weight loss and dietary self-monitoring. This leads to the conclusion that a study should be performed to determine whether apps can be efficient in motivating patients to be consistent, and whether they can be a tool that will ease doctors with their work. As this problem was bothering researchers Burke *et al.* [27] they designed a SMART study in which they tried to establish this link. What they noticed was that the apps are highly likely to be of great use in helping people to manage their weight, although at the time of the study it was just a presumption.

In 2013 the Nightscout project emerged [28]. It is an astronomical virtual project coordinated worldwide with the intention of easing parents with the fear of their child falling into hypoglycaemia. The whole system is based on open source code, which permits transmission of data from the CGM to the respective smartphone application in real-time, allowing constant blood glucose control without the necessity of being in the proximity of the child. However noble this initiative is, there are still challenges of legal and ethical issues that stand in the way of FDA approval. A major obstacle is the open code, which is susceptible to changes being made by anyone, thus limiting responsibility for a malfunction.

Social media

Facebook, Instagram, Snapchat, Twitter; these are the staples of human communication in the 21st century, and especially for young people virtual reality has become a second life. Ng [29] assessed the way social media influences the outcomes in a paediatric group of patients. In order to do so, he established three pillars of intervention: a Facebook page to communicate with parents and patients, Twinkle Net to manage remotely, and DIASEND to upload data from the CGM and insulin pump. The results were very good – patients achieved target HbA1C levels in larger numbers than before introducing technological ways, and what is also important, patients reported that their quality of life had improved. Engagement is a severe problem in managing chronic disease; therefore,

Rus [30] wanted to establish how a diabetic page should be posted in order to get as much attention as possible. What they found is that messages should contain images to involving patients and therefore mobilise them to take care of diabetes. Beasley *et al.* [31] designed a campaign in social media in order to raise awareness of obesity and increase involvement in type 2 diabetes, the results obtained from this social media campaign show that social media is a great tool for engaging people in actions regarding their disease. The newly published review on social media use in diabetes by Gabarron *et al.* [32] found that the use of the latter platforms improved or at least had no impact on the management of diabetes. While the reports on the positive aspect of social media are encouraging, one should bear in mind the possibility of finding information that may harm the treatment. Another important aspect when using both social media and mobile apps is the information required by the service provider. The personal data gathered by the provider may be sold to third parties, thus one should very carefully share such fragile data and read the terms and conditions diligently.

Non-invasive glucose level measuring

While CGM provides physicians with accurate data regarding blood glucose levels throughout the day [33], it does require to be active at least 50-60% of the time [34], which might be problematic for same patients. To combat these issues medical companies were forced to develop less invasive forms of blood glucose measurement. A flash glucose monitoring system monitors the level of interstitial glucose, which, when compared with capillary blood glucose measurement, showed a similar accuracy of glucose values [35]. However great it may be, this product still requires the patient to inject a sensor, which might be an issue for certain groups of patients. To tackle this obstacle an innovative method was introduced into the market, which requires a patient to just put a clicker onto the ear, scan, and then wait for a BG value to be displayed. It is a huge step forward in glycaemia control.

Summary

Modern technologies have revolutionised the way doctors take care of diabetic patients. Starting with the intelligent systems that are able to predict the occurrence of glycaemic excursion and reduce or increase insulin delivery. We are now closer than ever to producing a fully functional artificial pancreas and to be able to fully restore the hormonal balance in these patients. While insulin dosing is not everything, patients need to feel safe while trusting their lives with the device; GCM allows patients to further ease the everyday worries of hypoglycaemia occurrence. However, despite the advancement of technology, it is still up to patients' determination and reliability to fully utilise the potential the devices have to offer. That is where mobile apps come in handy. They remind patients to take everyday actions in their treatment plan, which makes it easier to follow a routine, increases the chances of preventing long-term complications, and raises the compliance of the patient, whilst doing it in non-invasive way and preferably playful. In the 21st century social media has become a key player in connecting people all over the world, and when used correctly it can be a huge player in the arena of informing and coordinating patients' needs and questions.

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