

The impact of wearable technology on health and daily habits in people with diabetes.

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Abstract

The significance of technology in healthcare has always been prominent, particularly in revolutionising the management of certain chronic health conditions, such as diabetes. This literature review examines the implications of wearable technology on health outcomes among diabetics and behavioral changes by interaction with these design systems. It aims to understand how wearable devices such as closed-loop systems, Continuous Glucose Monitoring (CGM) devices, integration of smart sensor technology and AI with mobile applications etc, enhances self-management of diabetes. The review analyses the research on association between real-time monitoring and maintenance of healthy glycemic index, prediction alerts to resolve hypo and hyperglycemia by subsequent decision making, behavioural adaptation to the interactive design systems for long-term lifestyle changes. Additionally, it also addresses the importance of interface design, awareness and education, accessibility, affordability and limitations of this technology, and how user-centered design and iteration can improve effectiveness and acceptability. Synthesising the results from various studies, the review highlights how wearable technology can not just improve health outcomes but empowers its users with greater confidence and motivation for optimal management of diabetes.

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The impact of wearable technology in people with diabetes highlights how useful and supportive wearable devices can be to significantly improve self-management of diabetes for overall optimal health outcomes. Diabetes is a chronic medical condition that affects the body's ability to produce insulin, leading to its inability to regulate blood glucose, which can cause hypo (low blood sugar) and hyper (high blood sugar) glycemic events. Both, Type 1 and Type 2 diabetes, requires constant vigilance and monitoring of blood glucose levels as diabetics need to take specific units of insulin in order to manage a good range of their blood glucose levels (between 100-180). This can be challenging as each patient is different, with varying lifestyle habits and underlying health issues.

There are various factors that affect glycemic readings, such as nutrition, stress, lifestyle etc, which can lead the levels to fluctuate at frequent intervals of time. Traditional methods of monitoring BG levels have been replaced with better interaction and data systems such as insulin pumps, Continuous Glucose Monitors (CGM's), smart readers integrated with mobile and smartphone apps via bluetooth and AI driven insights. Using wearable technology to view trends and insights supports decision making, particularly units of insulin taken per meal, eliminating the challenge of analysing dose required by trial and error. The research topic explores how accessible tools such as wearable technological devices and mobile health platforms have improved diabetes management by enabling users to monitor real-time readings, receive alerts about their hypo/hyperglycemic events and the ability to manage insulin intake with more ease, based on accurate real-time and customised data. Interaction of users with these technological design systems for improved self-management of diabetes empowers users to be more confident and in control of their health. The goal of this literature review is to understand the research on

how design, functionality and interaction with wearable technology has improved health outcomes in diabetics, as well as their behavioural change in lifestyle with support of this technology.

Literature Review

To understand the impact of wearable technology, not just on health, but also on behavioural changes in lifestyle of diabetics, various research papers were analysed, which highlighted the importance of technology and interaction design in improvement of self-management of diabetes, which lead to significant positive outcomes in overall health. Across the sources, three major themes emerged which help us understand how this evolutionary technology assisted in the transition of making decisions based on limited data to taking action based on real-time, accurate data and insights, enabling confidence and ease amongst the users, how the users interact and adapt this technology within their daily routines as well as advantages, disadvantages of using this technology, and its accessibility for its intended users.

Real-time Monitoring of Blood Glucose Levels to Enhance Self-management of Diabetes

Traditional methods to view one's blood glucose levels would require an at home Capillary Blood Glucose test, where the user has to prick skin and draw blood so that it can be placed on a test strip to be analysed by a glucose meter and provide a digital reading of the glucose levels. These methods have been replaced by better interaction and data systems such as Continuous Glucose Monitoring (CGM) devices, smart readers integrated with apps and Artificial Intelligence for accurate and data-driven insights. Several studies highlight how real-time monitoring of BG levels helps understand the factors influencing fluctuation and the appropriate action to be taken to reduce risk of severe glycemic events. Dunn et al. (2018) identified how checking levels at frequent intervals of time established quantitative data to

determine association between frequency of testing and optimistic glycemic outcomes with improved levels of HBA1c by helping users identify patterns and insights, in respect to daily activities, and take respective action.

Use of CGMs and Closed-loop Systems

CGMs are a wearable technology, which acts as a sensor placed under the skin, that provides real-time data of BG levels. While having ample data is useful, users need to know how this data and insights can be used to take aligned actions. Grady et al. (2023) found that CGM devices with an integrated mobile application via bluetooth improved glycemic control in diabetics, by enabling them to identify key information and alerts about their BG levels. The research signifies the importance of how interaction design of mobile interfaces, such as use of colour to identify trends and alerts, provision of clear, simple and visual information to correlate insulin dosage with food and activity, improved glycemic readings and enhanced overall health outcomes.

Other wearable technology used by diabetics include closed-loop systems, which is also referred to as an artificial pancreas, comprising of a CGM, an insulin pump and a computer-based algorithm which helps translate CGM metric data in real-time to calculate the amount of insulin needed to be delivered via the insulin pump. The research study by Rankin et al. (2021), addresses how challenging it is for adolescents with diabetes to adapt and manage the condition within their daily lives and the impact these issues have on their physical and mental health. It showed how a closed-loop system addressed the issues in a positive outcome, with the design system alerting the users of hypo and hyperglycemic events, in turn helping them keep their levels within range by clear decision making, allowing flexibility in food choices and enhancing confidence and assurance that the system is reliable.

Integration with Smart Technology

One key feature which has changed how diabetes can be managed is the prediction of levels, particularly for hypo and hyperglycemia. Zhu, Uduku and Li (2022) studied how the data entries from a CGM device utilised by an embedded algorithm on a smartphone application called ARISES helped in prediction of glycemic events. Input from users about meals, insulin intake, exercise, health conditions enabled the app to create glucose trajectories, overall daily logs to predict fluctuations and create alerts of different glycemic events. The app along with Dexcom CGM and Empatica E4 wristband wearables accurately provided real-time BG levels along with alerts which helped users visualise information in a systematic way, leading to efficient and confident decision making.

Facchinetti et al. (2013) is another research study which focused on improvement in CGM monitoring accuracy with smart sensor technology (sCGM). Issues such as processing time which cause delay in readings (due to blood-to-interstitium glucose transport), as well as calibration issues, can lead to inaccuracy. The sCGM comprises software modules which denoise, enhance and predict levels in real time. Use of the three modules resulted in significant improvement of health, with prediction forecast on an average of 15 minutes before hypo/hyperglycemia, exhibiting the value of processing insights and data algorithmically.

Behavioural Change and Interaction with Technology

One key study in Human Computer Interaction is to understand the ways in which diabetics interact with wearable technology, their understanding of the technological design system, how they manage the system's user interface and utilization of feedback and automation,

and whether this interaction elicits any behavioural change in everyday decision making and lifestyle choices.

Tolerance and Acceptability of Wearable Technology

With wearable technology, it is understandable why users might feel initial hesitation of use due to lack of awareness, misinformation or just that it is not in common use, particularly when it is on a daily basis. Since it is not considered ‘natural’ to wear devices, it is important for us to understand the stress use of wearables to manage diabetes on the regular, and the motivation for change in order to provide easier transition in the acceptance of the idea of it.

Taylor et al. (2019) set out to understand users tolerance and acceptability of use of CGMs and how it impacted behavioural change in patients with Type 2 diabetes. They found that access to data and insights provided evidentiary information and guidance lead to improved readings based on mere observations and actions by users, not just allowing them to accept the use of wearables but also motivating them to significantly change behaviour for better results. Increasing awareness and familiarity with right informational sources, ensure complete safety in use of it with education, instructive support and feedback can make use of this technology feel reliable and credible.

Incorporation in Daily Life and Changes in Behaviour

Chang et al. (2025) aimed to understand how self-regulating health education is impactful in taking better decisions towards managing glucose levels and whether it developed any behavioral change among users. Self-monitoring, self-judgement and self-reflection are three fundamental factors of the self regulation theory which are necessary to be incorporated by the user beyond medical intervention. These factors are also responsible for fundamental behavioural

change in how users not just interact with the interface design systems but how they incorporate these into their daily routines and take action based on the information provided. Within the study, users were given instructions to self-regulate glycemic control via meal and diet logs, insulin dosage logs, observation and tracking of trends and readings, exercise etc, to help them identify different patterns and understand what caused fluctuation of levels. The users were then provided with feedback and encouraged to make changes in food intake, lifestyle changes to promote healthier behavioural changes and improved readings. This proved successful as there was significant reduction in HbA1c levels and also identified positive behavioural changes by end of study.

It can be concluded that while this technology is proven to improve glycemic levels, it highly depends on the user's discipline and motivation to stay on track and make better choices, as any change in behaviour/habit formation takes consistency over the duration of at least 3 months.

Design and Interaction

While we understand that it takes a certain duration of time to incorporate wearable technology into daily routine, let us now try to focus on why that is and what will make users feel more comfortable using these systems. Users are more likely to adapt technology which is accessible, user-friendly, efficient and has a clear feedback design. Any interface which does not provide information in a clear, concise manner will lead to users not being able to utilise it to its maximum capacity, causing confusion and frustration. When it comes to technology in health, it is even more crucial to design technology which will be accurate, without excess data and information overload due to time sensitivity and the high stakes of the situation. Rankin et al. (2021) showed how adolescents were able to better adapt life with diabetes with technology, they

still voiced concerns, such as the pump being too bulky which lead to being protrudingly visible over clothes, alarms for alerts going off unexpectedly, unable to perform certain activities such as swimming, sports etc. This type of feedback will allow designers to keep iterating and make wearable devices more efficient, comfortable, flexible and easy to use, and can be further developed for better user experience.

Accessibility, Affordability and Limitations

With any technology comes the concern for its limitations and accessibility to its users. Hence, we understand the high importance of research to not just evolve and iterate technology based on evidentiary studies but to also reiterate design systems for a diverse range of users.

Affordability and Accessibility Concerns

Advancement in technology has its benefits, but also limitations. While technology in healthcare is highly beneficial, it may not always be accessible to everyone, particularly those who come from a lower income and lower socioeconomic background, as well as low educational achievement communities. Diabetes medication is associated with a substantial financial burden for patients, as insulin prices are notably high. As seen from Vigersky (2015), the research highlights the relation between glycemic events and cost of diabetes care, providing readers with benefits and limitations of various advanced technological systems such as insulin pumps, sCGM, Artificial Pancreatic systems to give us an overview of its cost effectiveness by stating it as an investment.

However, it concludes with the necessity to study cost effectiveness of wearable technology with recent development of newer pharmacological agents, acknowledging that while wearables have potential to help improve overall health, the cost of it determines its usage and

accessibility. It is important to study and iterate user centered design systems to ensure safe and effective results, providing credibility and reassurance to users who decide to invest in these technologies.

Safety and Privacy Concerns

The success of any wearable technological system relies heavily on personal data of any user, which can be a concern, especially when there is complete reliance on the device to regulate blood glucose levels. While these systems are thoroughly tested for safety and accuracy of information, there can be anomalies which cause system errors, leading to inaccuracy in prediction of levels and insights. This can be a major health safety concern, especially when decision making for insulin delivery is controlled by algorithms. Hence, users should not be completely dependent on the technology and must have self-judgment and self-reflection towards their management of diabetes. (Chang, Yeh, Huang and Li, 2025).

Diabetes can be seen to prominently increase among children and adolescents as well, and while young teens can self-monitor wearable devices with supervision, the research from Mauras et al. (2012) assessed the safety and efficacy of real-time monitoring for children aged 10 and below. The study exhibited no significant change in glycemic control as less percentage of children actually wore the device regularly for the duration of the study, leading to incomplete data for assessment. I can understand how the technology could not have been utilized to its full potential as my sister was diagnosed with Type 1 diabetes as a child, and no one truly understood what she was going through. She was unable to express it either due to lack of proper understanding of the events. We want wearable technology to be accessible to everyone, and children with diabetes are no exception. While they themselves will be unable to observe and take action, their parents, who are their primary caregivers, can use it to be aware of fluctuating

glycemic events. The effectiveness and safety of wearable technology can only be understood with careful, proper use and discipline, and this warrants further study and research to address concerns and bridge the gap.

Conclusion

From this literature review, we can conclude that the use of various wearable devices significantly enhanced management of diabetes, leading to overall improved glycemic index. The utilisation of these devices with discipline and careful self-reflection is important for optimal health changes and consistency along with decision-making towards better lifestyle choices is what will determine long term behavioural change. While ongoing research within this area of domain using prior data and feedback has helped improve this technology over time, it is important to understand the concerns and limitations of use of wearable devices, addressing safety and accuracy above all else and the users responsibility of interpreting provided information, analysing it and initiating appropriate action. Incorporating user feedback and data can improve interface designs for more efficient and comfortable wearable devices while continued iteration and refinement of design systems and interfaces that integrate smart technology and artificial intelligence can enhance both health outcomes and overall user experience.

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