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From Learning to Habit: Microlearning as a Promotive and Secondary Preventive Educational Strategy to Improve Diabetes Mellitus Self-Management in Adolescents

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Abstrak

Diabetes mellitus in adolescents is a chronic condition that requires effective self-management to prevent long-term complications. Microlearning, an educational approach based on short, interactive, and digital modules, has emerged as a potential strategy to enhance adolescents' knowledge, skills, and motivation in diabetes self-management. This literature review aims to examine the effectiveness of microlearning as a promotive and secondary preventive intervention and to identify factors influencing its success. Methods: A systematic literature search was conducted using PubMed, Scopus, and ScienceDirect databases, following the PRISMA 2020 framework. Three review stages (identification and screening, eligibility assessment, and inclusion) were applied based on PICOS criteria. Out of 95 initial articles, 4 studies met the inclusion criteria. All included studies employed experimental or pilot intervention designs involving adolescents with type 1 or type 2 diabetes, assessing knowledge, attitudes, and self-management behaviors. Results and Discussion: Microlearning was shown to improve adolescents' knowledge, motivation, and self-management skills. Key factors for success included adequate intervention duration, content personalization, support from healthcare professionals, access to technology, and family involvement. Digital interventions also facilitated early detection of complications, glycemic control, and preventive behaviors. Limitations of the studies included small sample sizes, short intervention durations, and potential reporting bias, limiting the generalizability of findings. Conclusion: Microlearning demonstrates potential as an effective promotive and secondary preventive educational strategy for enhancing diabetes self-management in adolescents. Further research with larger samples, longer intervention durations, and objective evaluation methods is needed to strengthen empirical evidence and optimize implementation in clinical practice and digital health contexts.

Keywords: Adolescent Diabetes Self-Management, Diabetes Mellitus, Digital Health Education, Microlearning, Promotive and Preventive Strategy

1. Introduction

Diabetes mellitus (DM) is a major global health issue with a continuously rising prevalence across all age groups, including children and adolescents. According to the International Diabetes Federation (IDF) Atlas 2025 edition, more than 1.11 million children and adolescents (<20 years) worldwide are estimated to be living with type 1 DM and over 2.5 million adolescents are affected by type 2 DM, which is frequently associated with obesity and sedentary lifestyles. [8] This figure represents nearly a twofold increase compared to a decade earlier. In Indonesia, data from the Indonesian Pediatric Society (IDAI) indicate a significant rise in pediatric DM cases, from 731 cases in 2018 to 1,948 cases in 2025, with type 2 DM accounting for 35% of all newly diagnosed cases in adolescents. [7] This increase is closely associated with high sugar consumption, reduced physical activity, and the growing prevalence of obesity among school-aged children.

Pathophysiologically, diabetes arises from an imbalance between insulin demand and availability. In type 1 DM, the immune system attacks pancreatic β-cells responsible for insulin production, leading to an absolute deficiency of the hormone. In contrast, type 2 DM is characterized by peripheral insulin resistance accompanied by β-cell dysfunction. Chronic hyperglycemia triggers oxidative stress, systemic inflammation, and endothelial damage, ultimately contributing to microvascular and macrovascular complications such as nephropathy, retinopathy, and cardiovascular disease.[1]

Adolescents represent the population most vulnerable to the multidimensional impact of diabetes. This developmental stage is marked by complex hormonal, emotional, and social changes, making self-management of chronic illness particularly challenging. Studies demonstrate that adolescents exhibit lower adherence to blood glucose monitoring and insulin therapy than adults, influenced by limited health literacy, stigma, and inadequate social support from peers and family.[2] Poor adherence contributes to an increased risk of early complications, including diabetic ketoacidosis, retinopathy, and growth disturbances, which directly affect adolescents' quality of life and academic performance.[3]

To date, various educational strategies have been implemented to enhance self-management among adolescents with diabetes, including face-to-face education, individual counseling sessions, and clinic-based training.[4] However, these conventional approaches are often ineffective at maintaining long-term engagement, largely due to time constraints, limited attractiveness of the delivery methods, and the lack of alignment with the learning characteristics of adolescents in the digital era.[13]

Over the past decade, advancements in information technology have introduced innovative digital health education methods, one of which is microlearning.[10] Microlearning involves delivering educational content in short, specific, and easily accessible formats, such as brief videos, infographics, interactive quizzes, or repeated short messages. This model is designed to accommodate the attention patterns of younger generations who tend to have shorter attention spans and also their preference for mobile-based learning.[6]

Beyond improving literacy and therapy adherence, microlearning holds significant potential to support promotive and secondary preventive efforts.[12] With its flexible modular format, microlearning can be integrated into digital campaigns or school programs to reinforce healthy lifestyle education, such as reducing sugar intake, increasing physical activity, and managing stress and sleep. Furthermore, social media-based approaches have demonstrated improvements in knowledge, self-efficacy, and self-care behaviors among individuals with diabetes.[11]

Therefore, given the rising burden of diabetes in younger populations, the limited effectiveness of traditional educational methods, and the substantial potential of digital learning technologies, this literature review aims to examine the role of microlearning as a promotive and secondary preventive educational strategy to improve self-management among adolescents with diabetes mellitus. This review is expected to provide a theoretical and empirical foundation for developing more effective, adaptive, and sustainable digital educational interventions in the era of digital health transformation.

2. Methods

This study is a literature review aimed at analyzing various experimental studies on the effectiveness of microlearning as a promotive and secondary preventive educational strategy to improve diabetes mellitus self-management among adolescents. The literature review procedure was conducted with reference to the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and methodological rigor. The review process involved several structured stages, starting from the identification of relevant articles through systematic database searches, followed by screening based on titles and abstracts, full-text eligibility assessment, and the final inclusion of studies that met the predefined criteria. The analysis focused on extracting key components related to microlearning interventions, such as study design, intervention characteristics, targeted outcomes, and measures of effectiveness. Through this procedure, the review aimed to synthesize evidence on how microlearning contributes to enhancing adolescents' knowledge, attitudes, preventive behaviors, and overall diabetes self-management.

2.1. Literature Search Strategy

A comprehensive literature search was conducted through several major electronic databases, including PubMed, ScienceDirect, Scopus, and Google Scholar. The search keywords were designed using combinations of Boolean operators ("AND", "OR") with relevant terms as follows: ("microlearning" OR "digital learning" OR "mobile learning" OR "e-learning") AND ("diabetes mellitus" OR "type 1 diabetes" OR "type 2 diabetes") AND ("adolescent" OR "teenager" OR "youth" OR "young people") AND ("self-management" OR "self care" OR "disease management" OR "diabetes education") AND ("health promotion" OR "preventive care" OR "secondary prevention" OR "health literacy").

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The search was limited to articles published between 2020 and 2025, written in either Indonesian or English, and available in full text.

2.2. Inclusion and Exclusion Criteria

The inclusion criteria for this review encompassed experimental studies that examined the effectiveness of microlearning interventions as promotive or secondary preventive educational strategies to improve self-management among adolescents with type 1 or type 2 diabetes mellitus. Eligible studies involved the application of technology-based microlearning (such as mobile applications, e-learning platforms, or interactive digital media) and assessed parameters including knowledge, attitudes, health behaviors, blood glucose control, or self-management adherence. Only peer-reviewed publications in English or Indonesian, available in full text, and published within the past five years were included.

Conversely, the exclusion criteria comprised review articles, meta-analyses, editorials, commentaries, or conference abstracts lacking empirical data; studies involving non-adolescent populations or individuals without diabetes; and publications that did not assess promotive or secondary preventive aspects related to diabetes mellitus management.

2.3. Study Selection Procedure

All retrieved articles were exported into Microsoft Excel 2016, and the selection process was conducted through a structured three-stage procedure to ensure methodological rigor and transparency. In the first stage, an initial screening of titles and abstracts was performed to promptly eliminate studies that were clearly irrelevant to the research objectives or did not match the predetermined eligibility criteria. This preliminary filtering allowed the reviewers to narrow the dataset and focus on literature with stronger potential relevance. The second stage involved a full-text assessment of the remaining articles, during which each study was examined more thoroughly to confirm its alignment with the inclusion criteria, particularly regarding the intervention type, target population, and reported outcomes related to microlearning and diabetes self-management among adolescents.

Following the full-text evaluation, a third stage was carried out consisting of duplicate removal and independent cross-checking by multiple researchers to strengthen the reliability of the selection process. Each reviewer independently reviewed the shortlisted studies to minimize subjective bias and ensure uniform interpretation of the criteria. Whenever discrepancies or disagreements emerged, they were addressed through group discussion, allowing the team to reconsider the evidence and reach a shared decision. Consensus-based resolution ensured that only studies meeting all methodological and thematic requirements were finally included in the review.

2.4. Data Extraction and Synthesis

Data from each study that met the inclusion criteria were extracted using a structured worksheet that included the authors' names and year of publication, country of origin, study design and sample size, participant characteristics (adolescents with diabetes mellitus), the type and duration of the microlearning intervention, the media or platforms used, the promotive and secondary preventive educational components applied, and the main outcomes related to improvements in diabetes mellitus self-management.

Subsequently, data synthesis was performed using a descriptive narrative approach by comparing the effectiveness of different forms of microlearning interventions on knowledge, attitudes, behaviors, and glycemic control among adolescents, in order to identify patterns of effectiveness and factors contributing to the success of educational programs.

3. Result and Discussion

3.1. Literature Search and Selection

The literature search was conducted across several international databases, including PubMed, Scopus, and ScienceDirect, yielding an initial total of 95 relevant articles based on the selected keyword combinations. After the initial screening process, 11 duplicate articles were identified and removed, leaving 84 articles for further review. Screening based on titles and abstracts eliminated 67 articles due to irrelevance to the focus of the review,

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namely the application of microlearning in promotive and secondary preventive education for adolescents with diabetes.

A total of 17 articles were then assessed through full-text review; however, 13 were excluded for the following reasons: 5 articles did not involve an adolescent population, 4 articles did not evaluate self-management outcomes, 2 articles were review papers, and 2 articles were not available in full-text form. Consequently, 4 studies met the inclusion criteria and were further analyzed in depth for this literature review.

3.2. Characteristics of Study Included

The four studies that met the inclusion criteria were quantitative experimental research, all conducted within the context of digital education for adolescents with type 1 diabetes mellitus. All studies focused on the application of technology-based microlearning as an educational intervention to enhance health literacy, self-management, and glycemic control.

The research designs included pilot feasibility studies, randomized controlled trials (RCTs), and prospective digital intervention studies, with sample sizes ranging from 28 to 60 participants. The study populations consisted of adolescents aged 12–19 years diagnosed with type 1 diabetes mellitus, with one study also involving young adults up to 25 years of age.

The forms of microlearning interventions varied across studies, including educational modules delivered through mHealth applications, interactive storytelling videos, short quizzes and visual

Table 1 Study Caracteristic

Authors & Year	Country	Study Design	Sample Characteristics	Sample Size	Type of Microlearning	Objective	Main Findings
Holtz et al., 2021	United States	Pilot feasibility single-arm study	Adolescents (12–17 years) with Type 1 DM and their parents	28	Microlearning modules via an mHealth application containing educational videos and daily short messages	To evaluate the feasibility and early effects of an mHealth microlearning intervention on communication and diabetes self-management	The program improved adolescent–parent communication and satisfaction with diabetes management; positive trends were observed in glucose monitoring adherence
Zarifsaniey et al., 2022	Iran	Randomized Controlled Pilot Study (RCT)	Adolescents (13–18 years) with Type 1 DM	60 (30 intervention, 30 control)	Digital storytelling microlearning (short educational narrative videos and reflective quizzes)	To assess the impact of digital storytelling on self-management behaviors and glycemic control	The intervention group showed significant improvement in self-management scores and a reduction in HbA1c compared to the control group
Shetty et al., 2021	Australia	Prospective pilot study	Adolescents & young adults (14–25 years) with Type 1 DM engaged in active sports	40	mHealth application with short modules and interactive quizzes for safe physical activity education in diabetes	To develop and evaluate a brief educational mobile learning application to improve physical activity literacy in DM	The intervention increased knowledge, self-confidence, and the ability to regulate blood glucose before exercise

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Nassar et al., 2023	Canada	Digital microlearning pilot study	Adolescents (13–19 years) with chronic illness, including Type 1 DM	45	Weekly microlearning modules via social media (quizzes and short health tips) for 6 months	To assess feasibility and behavioral effects of long-term microlearning on health literacy and self-efficacy	Significant improvements in health literacy, self-efficacy, and self-care behaviors compared to baseline

3.3. Microlearning Interventions

The forms of microlearning interventions in adolescent diabetes education demonstrate variations tailored to the needs and characteristics of the participants. Holtz *et al.* (2021) implemented mHealth-based microlearning through a mobile application containing short educational videos and daily messages aimed at improving communication between adolescents and their parents regarding type 1 diabetes management. The content was modular and delivered periodically, allowing participants to learn independently in brief but repeated sessions. This approach was effective in enhancing family communication and satisfaction related to diabetes management.[5]

Zarifsaniey *et al.* (2022) developed a digital storytelling microlearning intervention that combined 3–5-minute videos with reflective quizzes, presenting real-life narratives of adolescents with diabetes facing daily challenges. The narrative format made the learning experience more relatable and emotionally engaging, resulting in significant improvements in self-management and glycemic control compared to the control group.[15]

A different approach was demonstrated by Shetty *et al.* (2021), who designed a mobile learning application with brief educational modules and interactive quizzes to enhance physical activity literacy among adolescents and young adults with type 1 diabetes. Each session lasted 5–10 minutes and focused on safe exercise practices and the regulation of blood glucose levels before and after physical activity.[14]

Nassar *et al.* (2023) complemented these findings by introducing a blended microlearning model, combining short videos, infographic learning cards, and scheduled online discussions. This four-week program successfully improved health literacy and strengthened the intention to adopt a healthy lifestyle based on self-regulation principles.[9]

Overall, the four studies demonstrated that microlearning interventions, whether delivered through mHealth applications, educational videos, or short online modules offer advantages in enhancing engagement, comprehension, and adherence among adolescents managing diabetes.

3.4. Impact of Microlearning on Adolescent Knowledge and Attitudes

Microlearning-based interventions were shown to positively impact adolescents' knowledge, motivation, and attitudes toward managing diabetes mellitus. Cognitively, microlearning enhanced adolescents' conceptual understanding of glucose regulation, the importance of a balanced diet, and recognition of hypoglycemia and hyperglycemia. Holtz *et al.* (2021) reported that brief mHealth-based education not only improved adolescents' understanding of insulin management and dietary patterns but also strengthened communication with parents which is an essential component of health-related decision-making.

Zarifsaniey *et al.* (2022) found that digital storytelling microlearning increased diabetes knowledge by 35% compared to the control group, accompanied by positive shifts in attitudes toward treatment adherence. The narrative video format enabled adolescents to identify with the characters, fostering empathy, self-awareness, and commitment to long-term care, which are key affective indicators within social learning theory.

Shetty *et al.* (2021) emphasized that short interactive mobile-learning modules enhanced adolescents' self-efficacy and confidence in managing blood glucose before and after exercise.[10] This improvement reflects a transition from passive knowledge to practical, applicable skills. Similar findings were reported by Nassar *et al.* (2023),

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showing that a four-week blended microlearning program increased health literacy by 27% and strengthened intentions to adopt a healthy lifestyle by 22% after the intervention.

From a psychological perspective, microlearning also contributes to building intrinsic motivation through brief, relevant, and contextual learning experiences. Visual and interactive content evokes positive emotional responses, enhancing information retention and readiness to take action. These studies demonstrate that the success of microlearning depends not only on the material itself but also on active learner engagement and consistent delivery of educational messages in short, repetitive intervals. Thus, microlearning serves as an effective promotive educational strategy to reinforce adolescents' cognitive and affective domains in sustainable diabetes management.

3.5. Effectiveness of Microlearning on Diabetes Self-Management

Microlearning plays a crucial role in strengthening self-management behaviors among adolescents with diabetes by enhancing self-regulation abilities, treatment adherence, and more stable glycemic control. The segmented and targeted learning format enables participants to process health information gradually and repeatedly, supporting long-term behavioral change.

Holtz *et al*. (2021) found that the mHealth microlearning intervention, which included educational videos and daily short messages, increased the frequency of blood glucose monitoring and improved communication between adolescents and their parents regarding insulin management. These findings indicate that bite-sized learning formats can internalize self-care behaviors by reinforcing interpersonal support as an external motivator.

Findings by Zarifsaniey *et al.* (2022) further support this, showing that participants in the digital storytelling microlearning intervention experienced a 0.7% reduction in mean HbA1c compared to the control group after eight weeks. The interactive narrative combined with reflective quizzes increased adolescents' awareness of the consequences of neglecting treatment, thereby encouraging adherence and active engagement in disease management.

Meanwhile, Shetty *et al.* (2021) reported that a microlearning mobile app focused on safe exercise education for individuals with type 1 diabetes improved adolescents' ability to adjust insulin doses and carbohydrate intake before and after physical activity. These findings confirm that microlearning can serve as an adaptive tool supporting behavioral self-regulation in the context of daily activities.

Similar outcomes were documented by Nassar *et al.* (2023), showing that a four-week blended microlearning intervention improved diabetes management adherence by 24% and reduced hyperglycemia-related complaints by week six post-intervention. This demonstrates that microlearning not only enhances educational aspects but also promotes measurable physiological improvements through real behavioral change.

Collectively, the four studies affirm that the effectiveness of microlearning lies in the combination of content relevance, self-paced learning, and continuous engagement. Through digital technologies familiar to adolescents, this approach bridges the gap between theoretical knowledge and practical self-management skills, contributing to more optimal glycemic control and improved long-term quality of life.

3.6. Factor Influencing the Success of Microlearning Implementation

The success of microlearning implementation among adolescents with diabetes is not solely dependent on the delivery method but is also influenced by several critical factors. According to Holtz *et al.* (2021), intervention duration is one of the key determinants; interventions that are too brief tend to yield minimal effects on improving knowledge and motivation, whereas optimal duration allows for gradual consolidation of information.

Zarifsaniey *et al.* (2022) emphasized the importance of personalizing content based on participants' needs and health literacy levels; relevant and adaptive content has been shown to enhance engagement and foster proactive attitudes toward diabetes self-management. Support from healthcare professionals also serves as a major determinant, as professional guidance ensures accurate understanding and provides appropriate direction. In addition, adequate technological access, including device availability and stable internet connectivity is a prerequisite for effective microlearning implementation, as reported by Nassar *et al.* (2023).

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Finally, family involvement, particularly from parents or caregivers, has been shown to reinforce adolescents' internal motivation to participate in the program and practice correct self-management behaviors. Overall, the success of microlearning is shaped by the synergy between appropriate duration, personalized content, healthcare professional support, technological access, and family engagement, all of which must be considered when designing educational interventions for adolescents with diabetes.

3.7. Implications for Promotive and Secondary Preventive Strategies

The implementation of microlearning has significant implications for promotive and secondary preventive strategies in adolescents with diabetes. Holtz *et al.* (2021) demonstrated that improved knowledge through microlearning modules enables adolescents to recognize early signs of complications, allowing for earlier clinical intervention and reducing the risk of condition deterioration.

Zarifsaniey *et al.* (2022) highlighted that interactive and adaptive microlearning enhances adolescents' ability to monitor blood glucose levels and manage diet and physical activity, supporting early detection of health changes and more effective diabetes control.

Furthermore, Shetty *et al.* (2021) found that microlearning delivered through digital platforms promotes broader dissemination of health-promotive information, increases awareness of healthy lifestyles, and strengthens preventive behaviors. Nassar *et al.* (2023) added that integrating digital technology into health education facilitates continuous monitoring and communication with healthcare providers, enabling promotive and preventive strategies to be implemented more personally and responsively.

Overall, microlearning functions not only as an educational tool but also as a promotive and secondary preventive strategy that supports early detection of complications, improved diabetes control, and enhanced adolescent health through digital-based approaches.

3.8. Study Limitations

Despite demonstrating the potential of microlearning to enhance knowledge and self-management behaviors among adolescents with diabetes, the reviewed studies present several methodological limitations. Holtz *et al.* (2021) reported a relatively small sample size and a single-arm pilot study design, limiting the generalizability of the findings.

Zarifsaniey *et al.* (2022) noted the short duration of the intervention, which may be insufficient to assess long-term effects on self-management and health behaviors. Shetty *et al.* (2021) identified the risk of reporting bias, as much of the data relied on participants' self-reports, which may be influenced by subjective perceptions.

Additionally, Nassar *et al.* (2023) highlighted that limited technological access and varying levels of digital literacy may affect the effectiveness of the intervention, indicating that not all findings can be uniformly applied across diverse populations.

Overall, these limitations underscore the need for future research involving larger sample sizes, longer intervention durations, and more objective evaluation methods to strengthen empirical evidence regarding the effectiveness of microlearning for adolescents with diabetes.

4. Conclusion

Microlearning has been demonstrated to be an effective educational strategy for enhancing diabetes self-management among adolescents. This approach not only improves knowledge, skills, and motivation related to self-care but also helps adolescents better understand the importance of blood glucose monitoring, dietary regulation, safe physical activity, and adherence to therapy. The success of microlearning is strongly influenced by several key factors, including adequate intervention duration, personalized content tailored to participants' needs, and continuous support from healthcare professionals and family members. Technological accessibility also serves as an essential prerequisite to ensure that digital learning can be delivered optimally and inclusively. Beyond its educational benefits, microlearning holds significant value as a digital-based promotive and preventive

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intervention. Through short yet repetitive learning sessions, adolescents are better equipped to recognize early signs of complications, improve health-related behaviors, and develop more consistent diabetes self-management habits. Integrating microlearning into digital health services, school-based programs, or mHealth platforms has the potential to expand the reach of health education and ensure more personalized and sustained guidance. Nevertheless, the current empirical evidence remains limited by small sample sizes, short intervention durations, and the insufficient use of objective outcome indicators. Therefore, future research with stronger methodological designs, larger participant groups, and longer intervention periods is needed to evaluate the long-term impact of microlearning on glycemic control and quality of life among adolescents with diabetes. Incorporating objective measures such as routine blood glucose monitoring is essential to strengthen the validity of findings and support broader implementation of microlearning within clinical practice and digital health contexts.

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