QUALITY IN SPORT
eISSN 2450-3118 · Open Access · Peer-reviewed
apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

KOWALCZYK, Maja, WOLFF, Magdalena, SOBCZAK, Agata, GŁUSZKIEWICZ, Lena, KREFT, Kalina and WALDMAN, Anna. Continuous Glucose Monitoring in Adolescents with Type 1 Diabetes: Impact on Quality of Life, Physical Activity, and Health Education: A Narrative Review. Quality in Sport. 2026;69:74508. https://doi.org/10.12775/QS.2026.69.74508

ARTICLE TIMELINE
Received: 20.07.2026. Revised: 15.08.2026. Accepted: 16.08.2026. Published: 20.08.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

Continuous Glucose Monitoring in Adolescents with Type 1 Diabetes: Impact on Quality of Life, Physical Activity, and Health Education: A Narrative Review

Maja Kowalczyk
Karol Marcinkowski University Hospital in Zielona Góra
Zyty 26 65-046 Zielona Góra, Poland
https://orcid.org/0009-0000-0074-1405, maja.u.kowalczyk@gmail.com

Magdalena Wolff
Karol Marcinkowski University Hospital in Zielona Góra
Zyty 26, 65-046 Zielona Góra, Poland
https://orcid.org/0009-0003-8972-0273, magda.wolff@o2.pl

Agata Sobczak
University Clinical Center in Gdańsk
Dębinki 7, 80-952 Gdańsk, Poland
https://orcid.org/0009-0009-0396-3578, asobczak@uck.gda.pl

Lena Głuszkiewicz
University Clinical Center in Gdańsk
Dębinki 7, 80-952 Gdańsk, Poland
https://orcid.org/0009-0009-3627-0364, lgluszkiewicz@uck.gda.pl

Kalina Kreft
Karol Marcinkowski University Hospital in Zielona Góra
Zyty 26, 65-046 Zielona Góra, Poland
https://orcid.org/0009-0001-9584-7305, kreft.kalina@gmail.com

Anna Waldman
Poznan University of Medical Sciences,
Aleksandra Fredry 10, 61-701 Poznań, Poland
https://orcid.org/0009-0001-2332-1814, anna.waldman29@gmail.com

Corresponding Author Maja Kowalczyk, maja.u.kowalczyk@gmail.com

Abstract

Background: Adolescence introduces unique clinical, biological, and psychosocial complexities to type 1 diabetes (T1D) management. While continuous glucose monitoring (CGM) systems significantly improve metabolic outcomes, their impact on the overall quality of life (QoL) and psychological well-being remains nuanced.

Objective: This narrative review synthesizes current literature on the effects of CGM on QoL, psychosocial dynamics, and physical activity in adolescents with T1D, aiming to identify optimal strategies for integrated care**.**

Methods: A comprehensive search of PubMed, Scopus, and Web of Science (2015–2026) was conducted. Inclusion criteria covered peer-reviewed studies assessing CGM use, metabolic control, health-related QoL, and behavioral outcomes in pediatric populations and their caregivers.

Results: CGM use optimizes metabolic control by increasing time in range (TIR) and reducing hypoglycemia, particularly when integrated with automated insulin delivery (AID) systems. However, technological implementation alone does not guarantee improved QoL. This phenomenon can be framed as a "paradox of technological burden," emerging *through decision fatigue* , alarm fatigue, and potential peer stigmatization. Therapeutic success heavily relies on subjective satisfaction, the perceived balance of benefits and burdens (the ABC Model), and socioeconomic equity. Furthermore, while CGM facilitates vigorous physical activity, it may induce a behavioral paradox characterized by technological over-reliance and reduced hypoglycemia avoidance behaviors.

Conclusions: CGM is a clinical milestone in T1D care, but maximizing its potential requires a shift from purely metabolic endpoints to holistic, patient-centered metrics. Addressing current literature gaps demands standardized psychometric tools and longitudinal, diverse cohorts. Routine mental health screening, family-centered health education, and equitable access policies are crucial for successful therapy.

Keywords: type 1 diabetes; continuous glucose monitoring; adolescents; quality of life; physical activity; health education; psychosocial outcomes

1. Introduction

Type 1 diabetes (T1D) is among the most burdensome chronic diseases in childhood, demanding strict and lifelong self-management by patients (Azar et al., 2024; Bombaci et al., 2024). Global epidemiological data show a persistent and concerning increase in the incidence of T1D (Ogle et al., 2025). The introduction of the T1D Index (version 3.0) has highlighted the magnitude of the “missing prevalence” issue, which accounts for millions of premature deaths attributable to diagnostic delays, limited medical access, and inadequate metabolic control (Ogle et al., 2025). Consequently, optimizing and personalizing diabetes care for pediatric patients is a critical priority in global public health.

Adolescence introduces unique clinical, biological, and behavioral complexity to the therapeutic process (Azar et al., 2024; Bombaci et al., 2024). This period is distinguished by rapid somatic growth, intensive remodeling of the central nervous system, and significant hormonal dynamics. The physiological surge of growth hormone and sex hormones during puberty induces transient peripheral insulin resistance, leading to destabilization of glycemic profiles and the highest HbA1*c* values among all age groups (Azar et al., 2024; Bombaci et al., 2024). At the same time, a strong need for social acceptance, fear of peer stigmatization, and the process of building autonomous identity remain in constant conflict with the strict demands of managing a chronic disease (Azar et al., 2024; Bombaci et al., 2024).

In response to these multidimensional barriers, a modern dual-care model has been implemented, combining advanced digital technologies with non-pharmacological lifestyle modifications (Azar et al., 2024; Bombaci et al., 2024). Continuous glucose monitoring (CGM) systems have revolutionized disease control, replacing traditional self-monitoring of blood glucose (SMBG) with real-time analysis of glycemic trends (Bombaci et al., 2024; Giani et al., 2017). These solutions are increasingly integrated with artificial intelligence (AI) algorithms and automated insulin delivery (AID) systems, enabling automatic dose adjustments and easing the patient's burden (Łoskot et al., 2025). Physical activity also remains a key element of therapy, significantly improving insulin sensitivity, protecting the cardiovascular system, and enhancing overall patient well-being (Gaszyńska et al., 2025).

Despite the availability of advanced technologies, implementing CGM systems alone does not ensure improvements in mental health or full adherence to therapeutic recommendations among adolescents (Azar et al., 2024; Giani et al., 2017; Franceschi et al., 2021). Clinical success in this population is influenced by the individual balance of benefits and burdens associated with daily technology use, as described in the literature (Messer, 2019). This balance forms a complex network of dependencies, which can be conceptualized in this review as a "sensor–psyche interface," encompassing factors such as caregivers' fear of hypoglycemia - which frequently exceeds that of adolescents themselves (Glocker et al., 2022) - as well as concerns regarding stigmatization, family conflict, and socioeconomic barriers (Azar et al., 2024; Bombaci et al., 2024). This review aims to synthesize recent literature on the effects of CGM satisfaction on youth quality of life (Franceschi et al., 2024), psychosocial dynamics (Giani et al., 2017; Glocker et al., 2022), and safe participation in vigorous physical activity (Gaszyńska et al., 2025; Jabbour & Bragazzi, 2021), with the goal of identifying optimal strategies for integrated health education.

2. Literature Search Methodology

The material for this review was collected by searching international databases: PubMed, Scopus, and Web of Science. The analysis included peer-reviewed publications from 2015–2026, identified using a combination of keywords and logical operators: ("continuous glucose monitoring" OR "CGM") AND ("type 1 diabetes" OR "T1D") AND ("adolescents" OR "children") AND ("quality of life" OR "psychosocial outcomes" OR "family functioning" OR "physical activity").

Inclusion criteria covered studies evaluating the impact of CGM on glycemic control (Laffel et al., 2020), health-related quality of life (HRQoL), adherence to therapeutic recommendations, and physical activity among children and adolescents (Franceschi et al., 2021; Franceschi et al., 2024; Gaszyńska et al., 2025; Giani et al., 2017; Jabbour & Bragazzi, 2021; Messer, 2019). Due to the key role of the home environment in the process of patient independence, studies analyzing the perspective of parents and their fear of hypoglycemia were also included (Glocker et al., 2022; Rusak et al., 2021). Epidemiological background and clinical efficacy criteria were based on official reports and consensus statements from international scientific societies (Battelino et al., 2019; Ogle et al., 2025; Tauschmann et al., 2024).

Reports concerning type 2 diabetes, adult patients (except in the context of family relationships), and publications of a purely technological nature lacking assessment of psychosocial, behavioral, or educational aspects were excluded from the synthesis.

3. State of Knowledge

3.1. Clinical and Metabolic Outcomes: Beyond HbA1*c*

The contemporary paradigm for assessing metabolic control in T1D has evolved from relying solely on glycated hemoglobin (HbA1*c*) measurements to advanced metrics derived from continuous glucose monitoring (CGM) systems (Battelino et al., 2019; Tauschmann et al., 2024). The HbA1*c* metric, which reflects average glycemia over the past three months, does not capture day-to-day fluctuations, nocturnal hypoglycemia, or glycemic variability - features characteristic of labile diabetes during adolescence. According to the ATTD consensus and ISPAD guidelines, the key criterion of therapy effectiveness is now time in range (TIR, 70–180 mg/dL), complemented by time below range (TBR) and time above range (TAR) (Battelino et al., 2019; Tauschmann et al., 2024). Increased TIR is directly associated with a significant reduction in the risk of developing long-term microvascular complications (such as retinopathy or nephropathy), and even a 5% increase in this metric yields clinically significant benefits, making it a primary clinical endpoint (Battelino et al., 2019).

The durability of metabolic benefits resulting from sensor monitoring in adolescents is confirmed by multicenter prospective studies and retrospective analyses (Miller et al., 2023; Rubelj et al., 2021). Results from the 12-month observational phase of the CITY study (CGM Intervention in Teens and Young Adults) demonstrate that regular use of CGM systems by youth and young adults allows for long-term lowering of HbA1*c* levels (Miller et al., 2023). These findings are consistent with groundbreaking randomized controlled trials (RCTs), which confirmed that in adolescents and young adults, the use of rtCGM systems leads to a statistically significant, lasting reduction in HbA1*c* without a concomitant increase in the frequency of hypoglycemia episodes (Laffel et al., 2020). However, the main clinical success in this age group remains the marked reduction in time spent in hypoglycemia (decrease in median TBR), which minimizes the risk of acute metabolic complications while maintaining a high safety profile of the therapy (Miller et al., 2023).

These observations require a redefinition of efficacy criteria for patients who were previously optimally controlled, as illustrated by the results of a Polish cohort analysis in the pediatric population (Kowalczyk et al., 2021). In children with initially excellent glycemic control

(HbA1*c* < 7%), the use of CGM does not further lower this parameter and is even associated with a slight, statistically significant increase (Kowalczyk et al., 2021). This phenomenon is interpreted as the result of revealing and eliminating hidden hypoglycemia—through automatic actions such as Low Glucose Suspend (LGS) or caregivers intentionally modifying alarm thresholds due to fear of hypoglycemia (Kowalczyk et al., 2021). In this specific subgroup, the paramount value of technology becomes the stabilization of the glycemic profile and protection against severe hypoglycemia, rather than merely reducing HbA1*c* values (Kowalczyk et al., 2021).

Maximizing these protective clinical effects is achieved through the technological synergy of CGM with advanced automated insulin delivery (AID) systems, also known as closed-loop systems (Tauschmann et al., 2024). Artificial intelligence (AI) algorithms integrated with insulin pump software analyze CGM data in real-time, autonomously making micro-adjustments to basal insulin delivery and suspending insulin administration before predicted glucose drops (Łoskot et al., 2025). This automation relieves adolescents and their caregivers from the constant burden of dose calculations. Digital management of insulin therapy effectively compensates for both pubertal insulin resistance and patient behavioral errors, serving as a key mechanism for preventing severe hypoglycemia and building trust in the implemented treatment model (Bombaci et al., 2024; Łoskot et al., 2025; Tauschmann et al., 2024).

3.2. Quality of Life and Empowerment: The Role of CGM Satisfaction

The introduction of advanced diabetes technologies, despite their effectiveness in optimizing metabolic parameters, does not guarantee an automatic improvement in patients' psychological well-being. Results from meta-analyses and population-based observational studies show that the mere implementation of continuous glucose monitoring (CGM) systems does not directly correlate with higher overall quality of life (QoL) for every adolescent (Bratke et al., 2022; Yeşil et al., 2024). The physical presence of a sensor on the body is not the sole factor improving psychosocial functioning and often generates new emotional burdens and specific behavioral challenges for young people (Patton & Clements, 2016).

A significant challenge in daily therapy is *alarm fatigue* and *decision fatigue*, resulting from the constant need to process streams of glycemic data (Stamford, 2022). The continuous influx of information forces the patient to make numerous decisions each day, leading to cognitive overload and increased anxiety. This phenomenon also affects families - for more than a quarter of caregivers, disruptive nocturnal alarms are a negative side effect of therapy, resulting in chronic fatigue and frustration (Rusak et al., 2021). The need for nighttime monitoring lowers parent-reported quality of life, which is especially evident among parents of younger children (Glocker et al., 2022).

A key mediator determining real psychological benefits is the subjective satisfaction with technology use (Franceschi et al., 2024). It has been shown that a high level of satisfaction with CGM systems (Franceschi et al., 2024), supported by effective glycemic control (Bai et al., 2024), is directly associated with better quality of life in its crucial dimensions - physical, emotional, social, and school-related. Systematic reviews demonstrate that rtCGM systems clearly increase parent and patient satisfaction, while intermittently scanned systems (isCGM) help reduce family conflicts and fear of hypoglycemia (Franceschi et al., 2021). This highlights that the health-related quality of life (HRQoL) of children with T1D is closely linked to both the degree of metabolic stabilization and subjective satisfaction with the chosen monitoring method (Bai et al., 2024; Franceschi et al., 2021). At the same time, in selected age groups such as children aged 8 - 12, the implementation of such devices yields higher well-being scores compared to control groups (Yeşil et al., 2024).

In this context, conscious use of CGM becomes a tool of *empowerment* for adolescents. By providing continuous insight into glycemic trends, this technology reduces the fear of unexpected incidents, enabling adolescents to regain a sense of agency and control over their own bodies (Williams et al., 2023). Instead of seeing diabetes solely through the lens of limitations, motivated teenagers can adapt to life with a chronic disease, successfully integrating the demands of daily therapy with their own autonomous identity (Williams et al., 2023). CGM use promotes more frequent vigorous physical activity (VPA) by reducing fear of hypoglycemia. However, this pattern may be interpreted as a behavioral paradox: constant data access weakens adolescents' vigilance and reduces hypoglycemia avoidance behaviors, increasing their vulnerability to exercise-induced hypoglycemia (Jabbour & Bragazzi, 2021).

3.3. Physical Activity and CGM: Overcoming Exercise Barriers

Regular physical activity constitutes a non-pharmacological foundation for T1D treatment, exerting a crucial influence on increasing insulin sensitivity, improving lipid profiles, and preventing long-term vascular complications. Despite these proven benefits, adolescents with T1D often exhibit lower aerobic capacity and engage in physical activity less frequently compared to their healthy peers (Bombaci et al., 2024; Jabbour & Bragazzi, 2021). The main psychological and clinical barrier limiting teenagers' participation in sports is a strong fear of exercise-induced hypoglycemia (Jabbour & Bragazzi, 2021).

Difficulties in peri-exercise diabetes management result from the body's varied metabolic response depending on the type of exercise. Prolonged aerobic activity (e.g., running, cycling) significantly lowers blood glucose, increasing the risk of late hypoglycemia, which can occur even 24–48 hours after exercise cessation (Gaszyńska et al., 2025; Tauschmann et al., 2024). In contrast, anaerobic exercise (e.g., resistance training, sprinting) can paradoxically trigger peri-exercise hyperglycemia due to catecholamine release and intensified hepatic glycogenolysis (Gaszyńska et al., 2025). The constant need to balance the risk of hypoglycemia and hyperglycemia poses a considerable cognitive burden for adolescents and can lead to discontinuation of physical activity.

The implementation of CGM systems fundamentally changes glycemic management during the peri-exercise period, neutralizing many of these barriers. These devices provide continuous insight into current glucose values and, with trend arrows and predictive alarms, enable early prediction and prevention of fluctuations in real time before, during, and after exercise. The availability of such data facilitates precise and safe planning of carbohydrate intake in response to ongoing metabolic changes (Gaszyńska et al., 2025; Tauschmann et al., 2024).

The psychological aspect of this technological support directly translates into the level and intensity of activity. Studies show that CGM use is statistically associated with more frequent engagement in vigorous physical activity (VPA) among adolescents with T1D. Reduced fear of unexpected hypoglycemia restores a sense of safety for young patients; however, researchers highlight a significant risk. Excessive trust in the device (technological over-reliance) may lead to a dangerous reduction in hypoglycemia avoidance behaviors, resulting in more frequent episodes of peri-exercise hypoglycemia in this group (Jabbour & Bragazzi, 2021). Therefore, to fully and safely benefit from the device's potential, active adolescents with CGM cannot rely solely on technology - they must still develop appropriate preventive habits and the ability to correctly interpret glycemic dynamics, which again underscores the vital role of targeted diabetes education (Tauschmann et al., 2024).

3.4. Risk-Taking Behaviors, Peer Pressure, and Social Challenges

Adolescence is associated with an intense need for social acceptance and cohesive integration with peer groups. For adolescents with T1D, the necessity of performing visible medical procedures - such as operating insulin pumps, scanning sensors, or administering insulin injections in school settings - often creates a subjective sense of otherness, increasing their susceptibility to stigmatization and peer victimization and bullying. The fear of exclusion and the strong need to belong to a peer group lead young patients to intentionally neglect diabetes self-management tasks in social situations. Avoiding displaying medical devices and deliberately skipping insulin doses during social gatherings are common avoidance behaviors that directly and dangerously destabilize metabolic control and lead to acute complications (Azar et al., 2024; Bombaci et al., 2024).

Another significant challenge in adolescence is the tendency toward risky behaviors, including experimentation with psychoactive substances. Alcohol consumption poses a particular danger for youth with T1D, as ethanol inhibits gluconeogenesis and glycogenolysis in the liver, dramatically increasing the risk of severe, delayed hypoglycemia and diabetic ketoacidosis (DKA). Moreover, typical symptoms of alcohol intoxication - such as confusion, visual disturbances, or unsteady gait - mimic and mask the early warning signs of hypoglycemia, impairing the patient’s perception and preventing timely intervention. The use of cannabinoids (such as marijuana) in this patient group is associated with more than a twofold increase in the risk of developing diabetic ketoacidosis (DKA), while tobacco smoking is an independent risk factor that accelerates the development of cardiovascular complications (Azar et al., 2024; Bombaci et al., 2024).

Peer pressure and related dissatisfaction with body image predispose youth with T1D - especially females - to the development of specific eating disorders. Strict dietary control, combined with fear of weight gain as a result of insulin therapy, often leads to the practice of deliberately omitting or reducing insulin doses to lose weight. This phenomenon, referred to in the literature as diabulimia, leads to chronic hyperglycemia, which drastically accelerates the manifestation of microvascular complications (retinopathy, neuropathy, and nephropathy), increases the frequency of hospitalizations due to DKA, and directly induces higher mortality rates (Bombaci et al., 2024).

In the context of modern technology, the physical presence of devices on the patient’s body is perceived by some adolescents as a source of appearance-related stigmatization, prompting them to hide their equipment from peers. This indicates the absolute necessity of integrating routine diabetes care with systematic psychological support and screening for mental health disorders. Comprehensive psychosocial support makes it easier for young patients to develop mechanisms for assertive and safe functioning in peer groups without simultaneously compromising treatment adherence (Azar et al., 2024; Bombaci et al., 2024).

3.5. Predictors of Optimal CGM Use (The ABC Model) and Socioeconomic Barriers

The primary condition for the effectiveness of continuous glucose monitoring (CGM) systems is their regular use, defined in clinical studies as wearing the sensor actively for at least 6–7 days per week (Giani et al., 2017; Kubiak et al., 2016). Such consistency directly determines the sustained improvement in metabolic control and significant reduction in glycated hemoglobin (HbA1*c*), whereas sporadic or inconsistent use does not bring long-term clinical benefits for adolescents (Giani et al., 2017; Kubiak et al., 2016).

A significant predictor of continued technology use is the behavioral habits developed by patients even before its implementation; adolescents who initially have a high frequency of self-monitoring of blood glucose (SMBG) are much more likely to maintain consistency in wearing the sensor (Giani et al., 2017; Kubiak et al., 2016).

To comprehensively understand the psychological factors determining adolescents' daily therapeutic decisions, the Adolescent Beliefs and Coping (ABC) Model is used in the literature. This model distinguishes between patients who optimally use technology (CGM Optimizers) and those who use it suboptimally (CGM Sub-users) (Messer, 2019). According to this model, the key cognitive mechanism for device acceptance is the subjective calculation of the balance of benefits and burdens, where the perception of individual benefits and barriers is the main predictor of therapeutic success (Messer, 2019). Optimizers perceive much greater benefits from monitoring (such as protection against hypoglycemia), while simultaneously experiencing less burden from having the device on their body (discomfort, visibility) compared to Sub-users (Messer, 2019). Importantly, general stress coping strategies and self-efficacy do not differentiate these two groups, which shows that during adolescence, the use of CGM is determined by a pragmatic assessment of the device's disadvantages and advantages, further supported by a low level of intra-family conflict related to chronic disease (Messer, 2019).

In addition to psychological barriers, an independent and fundamental predictor of CGM effectiveness remains the family's socioeconomic status (Azar et al., 2024; Messer, 2019). Maintaining continuity of treatment with advanced diabetes technologies generates high and ongoing costs, which strictly ties access to advanced treatment to reimbursement policies, healthcare system structure, and private insurance (Azar et al., 2024). Financial limitations and lack of adequate insurance mean that adolescents from lower socioeconomic backgrounds are less likely to initiate continuous monitoring therapy, and when they do, they have a much higher rate of premature discontinuation (Messer, 2019). Existing social disparities directly translate into poorer metabolic outcomes in economically disadvantaged groups, highlighting the clinical and ethical need to create systemic solutions that guarantee universal and equal access to technologies that improve quality and length of life for people with diabetes (Azar et al., 2024).

4. Limitations and Gaps in Current Literature

It is important to acknowledge that the reviewed studies present certain limitations and potential biases which may impact the generalizability and interpretation of these findings. Many available studies are observational or cross-sectional in design, which can introduce selection bias and limit causal inference regarding CGM use, quality of life, and behavioral outcomes. There is considerable heterogeneity in patient populations, intervention protocols, and measured endpoints between studies, which complicates direct comparison and synthesis. Moreover, the predominance of research conducted in high-income countries and tertiary care centers may not accurately reflect the experiences of patients in lower-resource settings. The possibility of publication bias, where studies with positive outcomes are more likely to be published, should also be considered.

Although CGM systems have reached a high level of clinical maturity, these limitations underscore the need for more rigorous, long-term, and diverse research. Significant research gaps have been identified in psychosocial and organizational aspects that require addressing in future scientific work. Providing concrete solutions to these gaps - through targeted study designs and clearly defined research questions - should be prioritized in future investigations. A summary of these identified gaps and proposed research directions is presented in Table 1.

Table 1: Summary of Literature Gaps and Future Research Directions

Research Domain	Identified Gap in Current Literature	Directions for Future Research & Clinical Practice
Psychometrics & Assessment Tools	Lack of standardized tools to measure alarm fatigue, decision fatigue, and technology-related stress.	Develop and validate age-appropriate, reliable questionnaires and establish normative data across diverse cultural settings (Kubiak et al., 2016; Stamford, 2022).
Health Equity & Longitudinal Studies	Disparities in research regarding underrepresented populations (ethnic minorities, low socioeconomic status, rural environments).	Conduct longitudinal cohort studies to assess CGM adoption, adherence, and unique psychosocial challenges in these specific groups over time (Azar et al., 2024; Franceschi et al., 2024).

Educational & Psychosocial Interventions	Insufficient evidence on the effectiveness of structured family-centered and school-based support models.	Execute rigorous intervention trials evaluating parent-adolescent workshops, peer education, individualized care plans, and multidisciplinary teams (Bombaci et al., 2024; Glocker et al., 2022; Tauschmann et al., 2024).

5. Conclusions

The implementation of continuous glucose monitoring (CGM) systems represents a milestone in the clinical management of type 1 diabetes (T1D) in adolescents. Regular use of these devices directly optimizes metabolic control by increasing time in range (TIR) and lowering glycated hemoglobin (HbA1*c*) levels (Laffel et al., 2020), as well as reducing incidents of severe hypoglycemia and diabetic ketoacidosis (DKA) (Tauschmann et al., 2024). This technology ensures favorable long-term metabolic trajectories from the time of diagnosis, facilitates safe engagement in physical activity, and reduces fear of hypoglycemia (Jabbour & Bragazzi, 2021; Tauschmann et al., 2024). Additionally, it allows for compensation of insulin resistance triggered by rapid endocrine changes during adolescence, which can destabilize glycemic control regardless of the patient's treatment adherence (Azar et al., 2024; Bombaci et al., 2024). From a psychosocial perspective, however, the accumulation of these challenges constitutes what may be viewed as a ''paradox of technological burden''. While these devices remove biological barriers, they introduce unique cognitive costs in the form of decision fatigue and alarm fatigue (Stamford, 2022). Additionally, the physical visibility of the equipment on the body is often a source of peer stigmatization and embarrassment for adolescents (Bombaci et al., 2024). Ultimately, the success of therapy depends not on the technical parameters of the equipment, but on the subjective balance of benefits and burdens within the ABC model (Messer, 2019) and on the family's socioeconomic and insurance status (Azar et al., 2024). The literature also highlights the asymmetry in the psychological perception of technology between the patient and their family. Constant data access leads caregivers to experience a higher level of fear of hypoglycemia than the adolescents themselves, resulting in a lower parent-reported quality of life for the child, especially as responsibility for treatment is gradually transferred (Glocker et al., 2022). Meanwhile, among youth, subjective satisfaction with CGM - completely independent of objective metabolic improvement - determines their quality of life (QoL) and well-being, which requires a clinical redefinition of therapeutic success (Franceschi et al., 2024). To avoid escalating family conflicts, remote data monitoring by caregivers requires the implementation of strict family contracts (*rules of engagement*) that protect the emerging autonomy of the adolescent (Tauschmann et al., 2024).

In the area of physical activity, technology carries the risk of technological over-reliance. CGM use promotes more frequent engagement in vigorous physical activity (VPA), yet simultaneously reduces hypoglycemia avoidance behaviors, which paradoxically predisposes patients to peri-exercise hypoglycemia (Jabbour & Bragazzi, 2021). A significant long-term medical barrier remains the lack of biocompatibility of adhesives; contact dermatitis caused, for example, by acrylates is a common reason for discontinuing therapy (Tauschmann et al., 2024). These issues are exacerbated by systemic inequalities and limited access to equipment among ethnic minorities (Azar et al., 2024).

To successfully translate these findings into clinical and educational practice and mitigate the aforementioned psychosocial burdens, a set of actionable recommendations has been developed and summarized in Table 2.

Table 2. Actionable Clinical and Educational Recommendations for CGM use in adolescents with T1D.

Area of Intervention	**Actionable Recommendation**
Clinical Practice	Promote consistent CGM use in all eligible adolescents with individualized support to address adherence barriers (Giani et al., 2017; Tauschmann et al., 2024).
Health Education	Provide routine education on CGM data interpretation, focusing on glycemic patterns, alarm management, and time in range (TIR) metrics (Stamford, 2022; Tauschmann et al., 2024).
Family Support	Implement family-centered interventions to align remote monitoring expectations and establish healthy rules of engagement (Glocker et al., 2022; Tauschmann et al., 2024).
Mental Health	Integrate routine mental health screening into diabetes care to address technological burnout, peer stigma, and risk-taking behaviors (Azar et al., 2024; Bombaci et al., 2024).
Institutional Care	Develop standardized care plans for schools to ensure safe device management, physical activity, and prevention of peer exclusion (Azar et al., 2024; Bombaci et al., 2024).

Health Policy	Advocate for equitable CGM access for socioeconomically disadvantaged groups through collaboration with policymakers and insurers (Azar et al., 2024).

Ultimately, transforming adolescent diabetes care requires a holistic, patient-centered approach. By pairing the clinical benefits of continuous glucose monitoring with dedicated emotional support, healthcare teams can ensure that CGM is not just a tracking device, but a true tool of empowerment. This approach is essential to help youth safely engage in physical activity, overcome social barriers, and achieve a better quality of life.

Disclosure section Author's contribution:

Conceptualisation: Maja Kowalczyk, Agata Sobczak, Magdalena Wolff
Methodology: Maja Kowalczyk, Agata Sobczak, Magdalena Wolff
Validation: Maja Kowalczyk
Formal analysis: Maja Kowalczyk
Investigation: Kalina Kreft, Lena Głuszkiewicz
Resources: Kalina Kreft, Lena Głuszkiewicz
Data curation: Anna Waldman
Writing – original draft preparation: Maja Kowalczyk
Writing review and editing: Maja Kowalczyk, Anna Waldman
Project administration: Maja Kowalczyk
All authors have read and agreed with the published version of the manuscript.
Funding Statement: The study did not receive special funding.
Institutional Review Board Statement: Not applicable (narrative review).
Informed Consent Statement: Not applicable.
Data Availability Statement: Not applicable.
Acknowledgments: Not applicable.
Conflict Of Interest: The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process During the preparation of this work, the authors used generative AI tools (Gemini, NotebookLM) to assist with preliminary literature analysis and academic language refinement. These tools were used strictly as assistive instruments. The final interpretation of the literature and clinical synthesis were determined solely by the authors, who reviewed and edited the content as needed and take full responsibility for the substantive content of the publication.

References

Azar S, Maroun Abou Jaoude N, Kędzia A, Niechciał E. Barriers to Type 1 Diabetes Adherence in Adolescents. *J Clin Med*. 2024;13(19):5669. doi:10.3390/jcm13195669

Bai H, He N, Zhang Y, et al. Quality of Life and Glucose Regulation in Pediatric Patients with Type 1 Diabetes: A Study in the Ningxia Hui Autonomous Region. *Diabetes Metab Syndr Obes*. 2024;17:1267-1278. doi:10.2147/DMSO.S446387

Battelino T, Danne T, Bergenstal RM, et al. Clinical Targets for Continuous Glucose Monitoring Data Interpretation: Recommendations From the International Consensus on Time in Range. *Diabetes Care*. 2019;42(8):1593-1603. doi:10.2337/dci19-0028

Bombaci B, Torre A, Longo A, et al. Psychological and Clinical Challenges in the Management of Type 1 Diabetes during Adolescence: A Narrative Review. *Children (Basel)*. 2024;11(9):1085. doi:10.3390/children11091085

Bratke H, Biringer E, Margeirsdottir HD, Njølstad PR, Skrivarhaug T. Relation of Health-Related Quality of Life with Glycemic Control and Use of Diabetes Technology in Children and Adolescents with Type 1 Diabetes: Results from a National Population Based Study. *J Diabetes Res*. 2022;2022:8401328. doi:10.1155/2022/8401328

Franceschi R, Micheli F, Mozzillo E, et al. Intermittently Scanned and Continuous Glucose Monitor Systems: A Systematic Review on Psychological Outcomes in Pediatric Patients. *Front Pediatr*. 2021;9:660173. doi:10.3389/fped.2021.660173

Franceschi R, Pertile R, Marigliano M, et al. Satisfaction with continuous glucose monitoring is associated with quality of life in young people with type 1 diabetes regardless of metabolic control and treatment type. *Diabet Med*. 2024;41(6):e15307. doi:10.1111/dme.15307

Gaszyńska M, Drzewiecka A, Drzewiecki A, et al. The role of physical activity in type 1 diabetes: a review of the literature. *J Educ Health Sport*. 2025;80:59766. doi:10.12785/jehs.80.59766

Giani E, Snelgrove R, Volkening LK, Laffel LM. Continuous Glucose Monitoring (CGM) Adherence in Youth With Type 1 Diabetes: Associations With Biomedical and Psychosocial Variables. *J Diabetes Sci Technol*. 2017;11(3):476-483. doi:10.1177/1932296816676280

Glocker V, Bachmann S, Hess M, Szinnai G, Burckhardt MA. Fear of hypoglycemia and quality of life in young people with type 1 diabetes and their parents in the era of sensor glucose monitoring. *Front Endocrinol (Lausanne)*. 2022;13:958671. doi:10.3389/fendo.2022.958671

Jabbour G, Bragazzi NL. Continuous Blood Glucose Monitoring Increases Vigorous Physical Activity Levels and Is Associated With Reduced Hypoglycemia Avoidance Behavior In Youth With Type 1 Diabetes. *Front Endocrinol (Lausanne)*. 2021;12:722123. doi:10.3389/fendo.2021.722123

Kowalczyk EM, Adamczyk M, Pietrzyk J, Jastrzębska B, Szypowska A. Continuous glucose monitoring systems in well-controlled children with type 1 diabetes mellitus. *Pediatr Endocrinol Diabetes Metab*. 2021;27(3):151-158. doi:10.5114/pedm.2021.107717

Kubiak T, Mann CG, Barnard KC, Heinemann L. Psychosocial Aspects of Continuous Glucose Monitoring: Connecting to the Patients' Experience. *J Diabetes Sci Technol*. 2016;10(4):859-863. doi:10.1177/1932296816651450

Laffel LM, Kanapka LG, Beck RW, et al. Effect of Continuous Glucose Monitoring on Glycemic Control in Adolescents and Young Adults With Type 1 Diabetes: A Randomized Clinical Trial. *JAMA*. 2020;323(23):2388-2396. doi:10.1001/jama.2020.6940

Łoskot W, Szwech J, Matczak M, et al. Artificial intelligence in type 1 diabetes mellitus. *J Educ Health Sport*. 2025;79:57913. doi:10.12785/jehs.79.57913

Messer LH. *Predicting Optimal Use of Continuous Glucose Monitors in Adolescents with Type 1 Diabetes: It's About Benefit and Burden*. Doctoral dissertation. University of Colorado; 2019. ProQuest No.: 27662789.

Miller KM, Bauza C, Kanapka LG, et al. Continuous Glucose Monitoring Provides Durable Glycemic Benefit in Adolescents and Young Adults with Type 1 Diabetes: 12-Month Follow-Up Results. *Pediatr Diabetes*. 2023;2023:6718115. doi:10.1155/2023/6718115

Ogle GD, Wang F, Haynes A, et al. Global type 1 diabetes prevalence, incidence, and mortality estimates 2025: Results from the International diabetes Federation Atlas, 11th Edition, and the T1D Index Version 3.0. *Diabetes Res Clin Pract*. 2025;225:112277. doi:10.1016/j.diabres.2025.112277

Patton SR, Clements MA. Psychological Reactions Associated With Continuous Glucose Monitoring in Youth. *J Diabetes Sci Technol*. 2016;10(3):656-661. doi:10.1177/1932296816638109

Rubelj K, Stipančić G, La Grasta Sabolić L, Požgaj Šepec M. Continuous glucose monitoring and type 1 diabetes mellitus control in child, adolescent and young adult population - arguments for its use and effects. *Acta Clin Croat*. 2021;60(4):609-616. doi:10.20471/acc.2021.60.04.07

Rusak E, Ogarek N, Wolicka K, et al. The Quality of Life and Satisfaction with Continuous Glucose Monitoring Therapy in Children under 7 Years of Age with T1D Using the rtCGM System Integrated with Insulin Pump-A Caregivers Point of View. *Sensors (Basel)*. 2021;21(11):3683. doi:10.3390/s21113683

Stamford I. CGM for children and young people with type 1 diabetes: NICE criteria and effects of decision fatigue and alarm fatigue. *Diabetes Care Children Young People*. 2022;12(1):1-5.

Tauschmann M, Cardona-Hernandez R, DeSalvo DJ, et al. International Society for Pediatric and Adolescent Diabetes Clinical Practice Consensus Guidelines 2024 Diabetes Technologies: Glucose Monitoring. *Horm Res Paediatr*. 2024;97(6):615-635. doi:10.1159/000543156

Williams L, Deacon E, Van Rensburg E, Segal D. Continuous glucose monitoring empowers adolescents to take responsibility of diabetes management. *Afr J Prim Health Care Fam Med*. 2023;15(1):e1-e6. doi:10.4102/phcfm.v15i1.3879

Yeşil F, Çövener Özçelik Ç. Effect of Wearable Technology on Metabolic Control and the Quality of Life in Children and Adolescents with Type 1 Diabetes: A Systematic Review and Meta-Analysis. *Balkan Med J*. 2024;41(4):261-271. doi:10.4274/balkanmedj.galenos.2024.2024-2-115

Streszczenie

Wprowadzenie: Okres adolescencji wiąże się z unikalnymi złożonościami klinicznymi, biologicznymi i psychospołecznymi w leczeniu cukrzycy typu 1 (T1D). Chociaż systemy ciągłego monitorowania glikemii (CGM) znacząco poprawiają wyniki metaboliczne, ich wpływ na ogólną jakość życia (QoL) i dobrostan psychiczny pozostaje niejednoznaczny.
Cel: Niniejszy przegląd narracyjny syntetyzuje aktualne piśmiennictwo dotyczące wpływu CGM na jakość życia, dynamikę psychospołeczną oraz aktywność fizyczną u młodzieży z T1D, mając na celu wskazanie optymalnych strategii zintegrowanej opieki.
Metody: Przeprowadzono kompleksowe wyszukiwanie w bazach PubMed, Scopus oraz Web of Science (2015–2026). Kryteria włączenia obejmowały recenzowane badania oceniające stosowanie CGM, kontrolę metaboliczną, jakość życia związaną ze zdrowiem oraz wyniki behawioralne w populacji pediatrycznej oraz u ich opiekunów.
Wyniki: Stosowanie CGM optymalizuje kontrolę metaboliczną poprzez wydłużenie czasu w zakresie docelowym (TIR) oraz redukcję hipoglikemii, szczególnie po integracji z systemami automatycznego podawania insuliny (AID). Jednak samo wdrożenie technologii nie gwarantuje poprawy jakości życia. Pojawia się „paradoks obciążenia technologicznego", objawiający się zmęczeniem decyzyjnym, zmęczeniem alarmami oraz potencjalną stygmatyzacją rówieśniczą. Sukces terapeutyczny w dużej mierze zależy od subiektywnej satysfakcji, postrzeganego bilansu korzyści i obciążeń (Model ABC) oraz równości społeczno-ekonomicznej. Ponadto, chociaż CGM sprzyja podejmowaniu intensywnego wysiłku fizycznego, może też wywoływać paradoks behawioralny charakteryzujący się nadmiernym poleganiem na technologii i ograniczeniem zachowań zapobiegających hipoglikemii.
Wnioski: CGM stanowi przełom w klinicznej opiece nad T1D, jednak pełne wykorzystanie jego potencjału wymaga przejścia od czysto metabolicznych wskaźników do holistycznych, zorientowanych na pacjenta miar. Uzupełnienie luk w aktualnym piśmiennictwie wymaga

standaryzowanych narzędzi psychometrycznych oraz długofalowych badań prowadzonych na zróżnicowanych populacjach. Rutynowa ocena przesiewowa stanu psychicznego, edukacja zdrowotna zorientowana na rodzinę oraz polityka równego dostępu są kluczowe dla optymalizacji terapii.

Słowa kluczowe: cukrzyca typu 1; ciągłe monitorowanie glikemii; młodzież; jakość życia; aktywność fizyczna; edukacja zdrowotna; wyniki psychospołeczne