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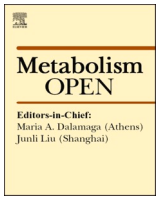

How do gamified digital therapeutics work on obesity self-management?

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ABSTRACT

Obesity management can effectively reduce the risks and complications associated with obesity and improve the quality of life of patients. After assessing the advantages and limitations of various obesity management approaches, self-management has been strongly recommended due to the advantages of minimal side effects and lower costs compared to treatment via drugs and surgery. However, successfully implementing lifestyle intervention strategies requires scientific guidance and strong determination. With the development of electronic and information technology, lifestyle intervention has transformed considerably. A new concept, called Gamified Digital Therapeutics (GDTx), represents a gaming format with Digital Therapeutics (DTx). It can effectively enhance patient compliance and accessibility to chronic disease management. Here, we review recent studies on the application of GDTx for the self-management of obesity and discuss three aspects surrounding its completion rates, satisfaction levels, and effectiveness. In contrast to traditional approaches to obesity self-management, implementing GDTx effectively corrects unhealthy dietary and lifestyle habits, markedly enhancing the dissemination of nutritional and exercise-related health knowledge. Of particular significance is the evident improvement in the adherence of obese patients to weight loss programs. Despite numerous studies indicating that GDTx may offer an effective solution for obesity self-management, there are still several limitations in the medicalization of GDTx for self-management of obesity. This review aimed to provide a reference for subsequent studies and promote the widespread application of GDTx in obesity self-management to help reduce the obesity rate and alleviate the burden on obese patients.

1. Introduction

Obesity is a chronic metabolic disorder characterized by excessive accumulation of body fat and abnormally high body weight, resulting from the interaction of various genetic and environmental factors. It is a risk factor and pathological basis for chronic noncommunicable diseases, such as hypertension, diabetes, cardiovascular diseases, and tumors [1–4]. Since 1975, the prevalence of global obesity has nearly doubled [5]. The number of obese individuals is increasing annually, making clinical management important and challenging for the prevention and control of obesity.

Obesity management includes methods such as lifestyle interventions, pharmacological interventions, and surgical interventions [6]. The types of pharmacotherapeutic agents available are relatively limited [7–9]. The main anti-obesity medication approved for the long-term treatment of adults is orlistat. However, it can cause side effects, such as abdominal discomfort and oily stools, making it difficult for patients to adhere to the treatment [10]. Other pharmacotherapeutic agents, such as glucagon-like peptide-1 (GLP-1) receptor agonists, have gastrointestinal effects, while phentermine and naltrexone–bupropion are associated with adverse neuropsychiatric effects [11,12]. In clinical practice, bariatric surgery is the only intervention that can promote short-term and long-term sustained weight loss, decrease complications and mortality, and increase quality of life. However, it is expensive and involves risks of surgical complications [6,13,14].

Based on the abovementioned issues, lifestyle intervention is recommended as the first-line treatment for obesity. Lifestyle intervention mainly involves structured behavioral interventions designed to reduce dietary calorie intake, increase physical activity, and improve adherence to diet and physical activity [15,16]. Dietary changes are a key component of lifestyle intervention in weight management, and physical activity (PA) is a crucial part of lifestyle intervention. Understanding and gaining knowledge about dietary and lifestyle-related health habits forms the foundation for behavioral changes. As obesity is a chronic and

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recurrent disease state, a new approach is urgently needed to tackle challenges such as long-term weight maintenance and avoidance of weight regain. With the development of electronic information technology, several new treatment methods known as digital therapeutics (DTx) were found to be promising in the field of healthcare and were used for managing obesity [17]. DTx is an evidence-based intervention program driven by software. It is an evidence-based medical approach used to treat, manage, or prevent diseases [18].

Gamified digital therapeutics (GDTx) combine clinical therapeutic effects delivered through software and digital gaming. This novel treatment strategy incorporates the characteristics of two widely accepted concepts: gamification and serious games. Gamification involves integrating gaming mechanisms and elements into nongaming activities to motivate individuals to engage in certain behaviors [19]. Implementing gamification in the field of obesity management involves the integration of gaming mechanisms and elements with diet education, health promotion, exercise guidance, etc., to motivate individuals to actively participate in the process. Gamification does not need to closely resemble traditional games; its principle involves maintaining the appeal of the activity and promoting the inherent motivation of users. In contrast, serious games are a type of video game, but they are not played primarily for entertainment [20,21]. Therefore, serious games do not follow the one-dimensional entertainment nature of games; they possess educational and persuasive functions. Disease management requires long-term adherence; since serious games are playful and amusing, they can keep users engaged for a long time. Some medical electronic games have been developed. This treatment method effectively enhances the compliance and accessibility of patients, facilitating the management of chronic conditions. It is an innovative approach that can overcome the limitations of traditional drug treatments. Akili Interactive was the first company to apply GDTx. In 2020, the digital therapeutic product Endeavor Rx manufactured by Akili for pediatric attention deficit hyperactivity disorder (ADHD) received FDA certification, becoming the first approved “game prescription drug” [22].

Self-management of obesity, similar to the treatment of ADHD, requires scientific guidance and consistent intervention. However, no FDA-certified GDTx has been developed for obesity. Therefore, we reviewed digital technologies that incorporate gaming elements and investigated the feasibility of applying GDTx in the self-management of obesity. This review may act as a reference for the future clinical practice and development of GDTx for the self-management of obesity.

2. Methods

For the purposes of this research, a exhaustive search was conducted across databases like PubMed, Scopus, Web of Science and Google Scholar. The search specifically targeted peer-reviewed English-language publications published up to October 2023. To further ensure a comprehensive coverage, the reference lists of relevant articles were manually screened to identify any additional pertinent studies. The search strategy was specifically tailored to capture research that explored the intersection of game-based methodologies and obesity. This was achieved by meticulously crafting a search string that integrated gaming-related terms such as “Gamification,” “Serious Game,” “Digital Game,” “Video Game,” and “Exergames” with obesity-related keywords such as “Obesity” and “Overweight”. Studies were considered eligible for inclusion in this review if they met specific criteria: they must be experimental, published in peer-reviewed journals, written in English, and focused on investigating the effects of digital games and gamification strategies specifically on obesity. By adhering to these inclusion criteria, the review aims to provide a comprehensively overview of research dedicated to understanding the impact of GDTx on obesity management.

2.1. Characteristics of the reviewed studies

In Table 1, the characteristics of the reviewed studies are presented. In these intervention studies, 2146 participants were included. The sample size in the reviewed studies ranged from 27 to 531. The studies included randomized controlled trials and nonrandomized controlled trials. The follow-up period ranged from four days to 10 weeks; however, most studies had a follow-up period of four weeks. The ages of the participants ranged from 5 to 61 years. Most participants received primary and secondary education. These studies were primarily conducted in economically developed regions. In most studies, the gender ratio was close to 1:1. The platforms used in the studies were predominantly personal computer-based.

2.2. GDTx affected obesity management compliance in terms of training completion and experiential satisfaction

2.2.1. Training completion of GDTx

In Table 2, the results presented above showed that the completion levels of the GDTx and traditional intervention during the training processes were similar. In long-term chronic disease management, improving patient compliance is necessary to ensure that the treatment is effective. Various factors related to patients can lead to treatment interruption and a decrease in treatment quality. Therefore, effective training, education, treatment, and alleviation of psychological anxiety in obese patients need to be performed to manage obesity. The reasons for loss to follow-up reported in these studies include absence, illness, loss of interest, monitoring, and gaming addiction. Some studies did not analyze the reasons for loss to follow-up.

In most studies, the differences in the attrition rates between the groups that underwent GDTx and their corresponding control groups were not significant. In one study [31], the common reasons for noncompletion included absence, internet connection interruption, and slow download speed of games. Therefore, the availability and stability of internet connections also need to be considered in research investigations. Spook [32] analyzed the participants who dropped out of their follow-up and found that these participants were significantly older than those who did not drop out. A study also found that students with a nonnative background were more likely to drop out than those with a native background. However, the researchers did not further investigate the reasons for these occurrences. Based on other studies [34], we speculated that older students withdrew from the study, probably due to their higher academic pressure. Additionally, older students might have more mature thinking compared to younger students; thus, GDTx might need to be tailored to different age groups to increase its appeal to a more diverse pool of users.

2.2.2. Experiential satisfaction of the GDTx

Compared to traditional intervention, GDTx has received more positive reviews. Well-designed game formats and user experiences can increase the motivation of patients to learn and participate in obesity management.

Table 3 presents experiential satisfaction of the GDTx. In most studies, interventions with gamified elements were reported to provide higher levels of satisfaction within the respective groups. Espinosa-Curiel [25] and their group evaluated the experiential satisfaction of users. They assessed playability (ease of learning and use), narrativity (having a clear history), enjoyment (fun and originality), audio aesthetics (having good music), visual aesthetics (good graphics), and personal gratification (feeling successful when overcoming game challenges). They found that satisfaction ratings in all domains were significantly higher than the neutral value, and most participants expressed a desire to experience the game again. Other researchers did not conduct surveys on game experience satisfaction. Isabelle [24] found that 92 % of participants rated the game as highly favorable, and over two-thirds of the participants reported that they would recommend

Table 1
Characteristics of the reviewed studies.

Study	Design	Size	Duration	Age (years)	Education	Region	Male (N)	Female (N)	Platform
Chang, IC et al. [23]	Nonrandomized Controlled Trial	104	4 weeks	5–6	preschool	Taiwan	59	45	PC
Mack, I et al. [24]	Cluster Randomized Controlled Trial	82	6 weeks	9–12	primary school	Germany	43	39	PC
Espinosa-Curiel, I E et al. [25]	Design and Pilot Study	27	4 weeks	8–11	primary school	Mexico	11	16	PC
Froome, HM et al. [26]	randomized controlled pilot study	95	5 days	8–10	primary school	Canada	46	27	phone
Espinosa-Curiel, IE et al. [27]	uncontrolled clinical trial	60	6 weeks	10–11	primary school	Mexico	63	41	PC
Wang, JJ et al. [28]	nonrandomized trial	179	10 weeks	8–12	primary school	Hong Kong	103	76	PC
Gan, FR et al. [29]	Randomized Controlled Trial	360	1 week	7–10	primary school	Philippines	173	1877	PC
Baranowski, T et al. [30]	Randomized Controlled Trial	153	4 days	10–12	middle school	USA	86	67	PC
Majumdar, D et al. [31]	pre–post intervention-control design	531	4 weeks	11–13	middle school	USA	173	168	PC
Spook, J et al. [32]	Pilot Study	453	4 weeks	15–21	secondary vocational education	Netherlands	86	145	phone
Blackburne, T et al. [33]	cluster randomized trial	58	2 weeks	19–61	Not reported	Australia	11	47	phone

Abbreviations: PC Personal computer.

Table 2
Training completion of GDTx for managing obesity.

Study	Size	Control lost	Reason	Intervention lost	Reason
Mack, I et al. [24]	82	2 %	illness	5 %	illness
Froome, HM et al. [26]	95	24 %	absence, dropout	22 %	absence, dropout
Wang, JJ et al. [28]	179	11 %	absence, lost interest, transferred, illness	7 %	absence, lost interest, illness, busy
Baranowski, T et al. [30]	153	20 %	lost interest, monitor, drop, lost interest	10 %	lost interest, dropout, busy, involved in game
Majumdar, D et al. [31]	531	6 %	Absence	8 %	Absent
Spook, J et al. [32]	453	41 %	Not reported	51 %	Not reported
Blackburne, T et al. [33]	58	10 %	illness	10 %	Not reported

the game to their friends. The participants described feeling good and relaxed while playing the game.

2.3. GDTx enhanced the effectiveness of obesity management

2.3.1. GDTx enhanced knowledge of diet and physical activity

The GDTx showed a significant improvement in the knowledge of the participants regarding scientific nutrition and physical activity during the study. In Table 4, most researchers assessed the effectiveness of GDTx in obesity management by incorporating tests to assess the knowledge of the participants regarding diet and physical activity during the study or by incorporating scale assessments at the end of the study. Most studies found that GDTx interventions can improve the nutritional knowledge of participants more effectively than traditional intervention methods. Nutrition knowledge primarily involves distinguishing between healthy foods, such as vegetables, fruits, and junk foods, such as chocolates, cakes, and beverages, to promote greater consumption of healthy foods while reducing or even avoiding the consumption of junk foods.

Wang found that children with higher immersion scores (above the median) had higher motivation to consume fruits and water. In addition to improvement, knowledge maintenance was also evaluated. Mack [24] conducted a 4-week follow-up on the maintenance of nutritional knowledge and found that serious games positively affected the retention of nutritional knowledge.

2.3.2. GDTx promoted health behavior

For evaluating behaviors, most studies implemented self-reporting or questionnaire assessments; however, a few assessments relied on supplementary reports from parents. In Table 5, most studies reported that the GDTx intervention groups reduced their intake of unhealthy foods such as chocolates, candies, and ice cream and reported a significant increase in the consumption of vegetables and fruits. The use of active transport (motor vehicle, walking, cycling and public transport) was reported by Spook [32], the promotion of self-efficacy for physical activity was reported by Wang [28], and an increase in the willingness to engage in physical activity was reported by Espinosa [25]. However, the studies by Mack and Gan [24,29] showed that the effect on physical

Table 3
Experiential Satisfaction of GDTx for managing obesity.

Study	Design	Size	Duration	Education	Region	Platform	Rate
Chang, I-C et al. [23]	Nonrandomized Controlled Trial	104	4 weeks	preschool	Taiwan	PC	Approximately 75 %
Mack, I et al. [24]	Cluster Randomized Controlled Trial	82	6 weeks	primary school	Germany	PC	92 %
Espinosa-Curiel, IE et al. [25]	Design and Pilot Study	27	4 weeks	primary school	Mexico	PC	100 %
Baranowski, T et al. [30]	Randomized Controlled Trial	153	4 days	middle school	USA	PC	80%–90 %
Spook, J et al. [32]	Pilot Study	453	4 weeks	secondary vocational education	Netherlands	phone	on average, neutral to positive

Abbreviations: *PC* Personal computer.

Table 4
Findings of GDTx for knowledge of diet & physical activity.

Study	Size	Duration	Education	Region	Platform	Main findings
Chang, I-C et al. [23]	104	4 weeks	preschool	Taiwan	PC	higher nutritional knowledge scores; higher percentage refused to eat junk food.
Mack, I et al. [24]	82	6 weeks	primary school	Germany	PC	The knowledge score increased and remained.
Espinosa-Curiel, IE et al. [25]	27	4 weeks	primary school	Mexico	PC	Knowledge scores increased (PA, healthy eating, and socioemotional wellness).
Froome, HM et al. [26]	95	5 days	primary school	Canada	phone	increases in overall nutrition knowledge
Espinosa-Curiel, I E et al. [27]	60	6 weeks	primary school	Mexico	PC	increased food knowledge. greater frequency in the consumption of cauliflower and broccoli and corn quesadillas and lower intake of unhealthy foods.
Wang, JJ et al. [28]	179	10 weeks	primary school	Hong Kong	PC	increased intrinsic motivation for fruit and water, and autonomous and controlled motivation for PA.
Gan, FR et al. [29]	360	1 week	primary school	Philippines	PC	higher score in Knowledge scores.
Blackburne, T et al. [33]	58	2 weeks	Not reported	Australia	phone	Inhibitory control ability improved. Cognitive restraint was enhanced

Abbreviations: PC Personal computer.

Table 5
Findings of GDTx for health behavior.

Study	Design	Size	Duration	Education	Region	Platform	Main findings
Chang, I-C et al. [23]	Nonrandomized Controlled Trial	104	4 weeks	preschool	Taiwan	PC	higher percentage refused to eat junk food. reduced the frequency of consumption of chocolate, candies, and ice cream.
Mack, I et al. [24]	Cluster Randomized Controlled Trial	82	6 weeks	primary school	Germany	PC	No group changes were observed at the behavioral level.
Espinosa-Curiel, IE et al. [25]	Design and Pilot Study	27	4 weeks	primary school	Mexico	PC	improved their intention to perform PA, healthy eating, and socioemotional wellness; reduction intake of unhealthy foods.
Froome, HM et al. [26]	single-blinded, parallel, randomized controlled pilot study	95	5 days	primary school	Canada	phone	Not reported
Espinosa-Curiel, IE et al. [27]	uncontrolled clinical trial	60	6 weeks	primary school	Mexico	PC	greater frequency in the consumption of cauliflower and broccoli and corn quesadillas. lower intake of unhealthy foods
Wang, JJ et al. [28]	nonrandomized trial	179	10 weeks	primary school	Hong Kong	PC	increased intrinsic motivation for fruit and water, self-efficacy for PA.
Gan, FR et al. [29]	Randomized Controlled Trial	360	1 week	primary school	Philippines	PC	Not reported
Baranowski, T et al. [30]	Randomized Controlled Trial	153	4 days	middle school	USA	PC	increased fruit and vegetable consumption, but not water, moderate-to-vigorous PA, or body composition.
Majumdar, D et al. [31]	pre–post intervention-control design	531	4 weeks	middle school	USA	PC	decreases in frequency and amount of consumption of sweetened beverages and processed snacks.
Spook, J et al. [32]	Pilot Study	453	4 weeks	secondary vocational education	Netherlands	phone	snack consumption decreased more strongly, increase use of active transport
Blackburne, T et al. [33]	cluster randomized trial	58	2 weeks	Not reported	Australia	phone	Cognitive restraint was enhanced after training

Abbreviations: PC Personal computer.

activity was not significant. Other studies did not provide a detailed description of physical activity.

3. Discussion

Based on the abovementioned studies, we concluded that GDTx can improve patient compliance, facilitate knowledge dissemination, and foster a healthy lifestyle. Studies on the application of GDTx for managing obesity are relatively limited; thus, the research process needs to be further improved.

3.1. Improvement in intervention

3.1.1. Increase in the research population

Research on the application of GDTx in obesity management predominantly focuses on children and adolescents, probably because this demographic can be easily accessed in schools. In contrast, the adult population has a wider age range and inconsistent participation in research. The obesity rate among adults is significantly higher than that among children [35]. Therefore, researchers need to focus on the application of GDTx to manage adult obesity.

Children and adolescents are easily influenced by their families [36–38]. The dietary behavior of parents and the eating habits of families play a crucial role in cultivating healthy eating habits and behaviors in preschool children [39]. If parents consume a large quantity of unhealthy food or frequently provide such foods to their children, the children are likely to adopt these unhealthy dietary habits. Therefore, the dietary habits of parents and family food supply significantly influence the nutrition knowledge and dietary behaviors of preschool children. However, most studies on the application of GDTx for managing obesity often overlook the assessment of obesity in parents and the nutritional education provided to children.

Obesity in preadulthood and adulthood are closely related [40]. Obesity in childhood often persists in adulthood, especially without intervention or changes in unhealthy lifestyle habits, and thus, they have a high risk of developing adult obesity. Long-term studies of GDTx

interventions running through childhood to adulthood are expected in the future.

3.1.2. Popularizing portable devices

The current research tends to be utilized in a centralized setting, conducted using computers, as most studies collected data from primary and secondary schools. Fixed devices might be more convenient for researchers conducting studies on GDTx to monitor the usage of devices by students. However, for managing adult obesity, mobile platforms can increase accessibility and convenience, which may result in greater compliance and benefits [41]. Every year, over 1.3 billion mobile phones are sold; in 2010, smartphones accounted for nearly 20 % of the total mobile phones sold [42]. By 2013, the global population of mobile phone users approached 7 billion [43]. People now use smartphones more frequently in their daily lives, especially for communication, accessing social media, browsing the internet, and performing lightweight office tasks. As smartphones are extremely portable and always available, they have become an indispensable part of daily life. This advantage of smartphones might be used to enhance the effectiveness of GDTx in obesity management. In the future, studies should focus on mobile devices as a platform for managing obesity.

3.1.3. Expanding application scenarios

Most researchers have conducted studies and implemented their treatment strategies in centralized school settings. Most students spend a long time on campus and can receive encouragement from teachers and peers, which can promote effective obesity management. However, GDTx is similar to administering prescribed medicines, i.e., they require timely and regulated use [18]. The application of GDTx is not only based on the diversity of the population but also needs to consider the integration of different real-world scenarios. Primary Care is a medical system used in Europe and America, where primary health care institutions provide continuous and comprehensive medical services to patients [44,45]. Therefore, GDTx can also be incorporated into primary care, leveraging the advantages of community hospitals to enable community residents to receive different types and more professional obesity management services. Moreover, the number of community hospitals is far greater than that of specialized hospitals, which also plays a certain role in promoting and publicizing the application of GDTx in obesity management. The home environment offers a more comfortable and relaxed setting, thus reducing social anxiety that might arise from using GDTx. It also encourages family involvement and interaction, providing additional support and encouragement, making it more suitable for promoting GDTx [46]. Therefore, future studies need to investigate the effectiveness of the application of GDTx for obesity management in different contexts beyond the school environment.

Moreover, in designing a GDTx system that provides personalized feedback, it is essential to incorporate cultural considerations to make the system universally relevant and effective. Firstly, the system should be developed with a deep understanding of cultural competency, ensuring the development team is aware of and respects cultural differences. Collecting voluntary demographic data during the user onboarding process can help tailor feedback and content to reflect the user's cultural background. In addition, adapting the language, graphics, and cultural references in the GDTx system to align with the user's local culture is crucial. Creating content informed by cultural research, including dietary habits, exercise preferences, and health beliefs, is indispensable. By integrating these strategies, the GDTx system can offer a more personalized and culturally sensitive experience, likely enhancing user engagement and the effectiveness of therapeutic interventions across various populations.

3.2. Enhancements in evaluation

3.2.1. Optimizing evaluation scope and metrics

GDTx offers personalization, goal setting and feedback, and social interaction, which can enhance user engagement compared to other digital approaches. GDTx tailors the gaming experience to individual preferences, goals, and progress, making the intervention more relevant and engaging. By setting clear, achievable goals and providing real-time feedback, GDTx helps users stay motivated and focused on their weight loss journey. Social features such as leaderboards, challenges, and community support foster competition and camaraderie, which can be highly motivating. It's important to note that the effectiveness of these strategies can vary depending on the specific implementation of the GDTx program and the target population. Further research and data analysis are required to validate the comparative effectiveness of these strategies against other digital approaches.

The assessment of compliance and effectiveness in the application of GDTx is a crucial issue for promoting its use in obesity management, affecting not only patient health but also the efficiency and sustainability of obesity management. However, few studies have also incorporated long-term treatment effects into the evaluation system [24]. When optimizing the scope and metrics of evaluation, various factors need consideration to ensure a comprehensive assessment of GDTx application. Relying on questionnaires and quizzes as the primary assessment tools has inherent limitations, which are particularly significant when assessing behavior change, as they are constrained by subjective patient reporting and specific testing conditions. For instance, patients may inaccurately report their daily activity levels due to memory biases or subjective perceptions in surveys. To address this limitation, we recommend incorporating more objective and continuous data sources, such as wearable devices such as smartwatches or health trackers, to monitor daily step counts, exercise heart rates, screen usage time, and dietary intake [47]. Such data can provide more detailed and real-time information [48], offering robust support for a comprehensive evaluation of GDTx application effectiveness and patient compliance.

Furthermore, in evaluating patient compliance, we emphasize the customization of personalized treatment plans by GDTx in obesity management and gain a profound understanding of patients' responses to the treatment plans. We suggest integrating electronic monitoring devices into routine practices and establishing regular communication with patients through methods such as phone calls, text messages, and emails [49,50]. This not only facilitates patient involvement in the management process but also provides timely feedback for the application of GDTx in obesity management, allowing for better adjustments and optimizations of GDTx use.

Regarding the safety of GDTx, it is imperative to recognize the current research's relative lack of in-depth investigation into adverse events. We underscore the need to establish a comprehensive monitoring and feedback system, with future research focusing more on potential risks and side effects. Collecting and analyzing adverse event reports related to GDTx is a necessary step to promptly identify and address any device safety issues. Additionally, attention should be given to user training and education, ensuring that patients and healthcare professionals understand the correct usage, risks, and mitigation measures of GDTx, contributing to reducing human errors and enhancing the overall safety of GDTx.

3.2.2. Improving experimental design

In a comprehensive evaluation of GDTx for conditions such as obesity, it is indeed crucial to employ a multi-dimensional framework that assesses not only physical outcomes but also psychological, physiological, and social behavioral factors. Physical outcomes are typically measured using objective indicators such as weight loss, body mass index (BMI), waist circumference, and improvements in physical fitness. Psychological outcomes encompass aspects like self-efficacy, motivation, and mental health. To increase the accuracy of the findings, a larger sample size and sample stratification are necessary to reduce the effect of recall bias and misreporting caused by self-reporting methods. The effects of gender differences, such as psychological stress [51], menstrual cycles [52], and eating speed [53], also need to be considered.

Additionally, race and socioeconomic status can also influence access to food and obesity rates [54,55], and thus, the economic and racial backgrounds of the participants should be assessed. In the studies reviewed, the follow-up and intervention durations were relatively short, whereas weight loss for managing obesity is a long-term self--regulation process. Therefore, in subsequent studies on GDTx, the duration of interventions and follow-up should be increased.

4. Conclusion

Studies on the application of GDTx for the self-management of obesity have found that it can enhance compliance and effectiveness in managing obesity. GDTx plays a significant role in improving unhealthy dietary and lifestyle habits and increasing health knowledge. However, most studies had some limitations, such as relatively restricted intervention populations, platforms, and settings. The evaluation of intervention effects was constrained by limited indicators and schemes. While designing studies, researchers need to consider various factors and perform further optimization to extend the user population, application scenarios and device type, improving the evaluation tool and study design for better promotion and application of GDTx.

Availability of data and materials

The dataset(s) supporting the conclusions of this article are included within the mian text.

Conflicting interests

The authors have no conflicts of interest to declare.

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Contributorship

All authors contributed to the study design. Xujuan Zhu analyzed and interpreted the patient data regarding obesity and GDTx and was a major contributor in writing the manuscript. Shuneng Gu and Jian Li had main responsibility for revising and reviewing the manuscript. All the authors have read and approved the final manuscript.

CRediT authorship contribution statement

Xuejuan Zhu: Writing – original draft, Conceptualization. **Shuneng Gu:** Writing – original draft, Visualization, Conceptualization. **Jian Li:** Writing – review & editing, Funding acquisition.

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List of abbreviations

GDTx	Gamified Digital Therapeutics
ADHD	Attention Deficit Hyperactivity Disorder
FDA	Food and Drug Administration
DTx	Digital Therapeutics
GLP-1	Glucagon-like Peptide-1
PA	Physical Activity

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