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Effectiveness of Digital Book-Based Discussions on Type 2 Diabetes Prevention in Obese-Risk Adolescents

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Abstract

Type 2 diabetes mellitus is a chronic disease characterized by elevated blood glucose levels due to insulin resistance. It is increasingly prevalent among adolescents as a result of unhealthy lifestyles and obesity. The prevalence of adolescent obesity in Bengkulu Province continues to rise, particularly in the service area of Lingkar Barat Public Health Center, which includes Public High School (SMAN) 7 Bengkulu City. This study aimed to determine the effectiveness of the discussion method using digital book media on type 2 diabetes mellitus prevention behaviors among adolescents at risk of obesity at SMAN 7, Bengkulu City. This quantitative research employed a quasi-experimental design with a pre-test and post-test with a control group approach. The sample comprised 37 respondents in the intervention group and 37 in the control group. Data were collected using questionnaires and analyzed using the Shapiro–Wilk test for normality, the Wilcoxon signed-rank test, and the Mann-Whitney U test. The study was conducted from March to April 2025. The Wilcoxon signed-rank test results in the intervention group showed a p-value of 0.000 (<0.05), indicating a significant change in the mean prevention behavior score before and after the intervention. Similar results were observed in the control group; however, the improvement in the intervention group was greater. The discussion method using digital book media effectively improved type 2 diabetes mellitus prevention behaviors among adolescents at risk of obesity.

Keywords: Digital book, Discussion, Type 2 Diabetes Mellitus, Obese Adolescents

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1. BACKGROUND

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and/or impaired insulin secretion, leading to the body's inability to effectively regulate blood glucose levels (Sanjana et al., 2022). Traditionally considered a disease of adulthood, T2DM is increasingly being diagnosed in younger populations, particularly adolescents, due to the rising prevalence of obesity,

sedentary lifestyles, and poor dietary habits (Aisyah et al., 2024). This epidemiological shift poses a significant public health challenge, as early-onset T2DM is associated with prolonged exposure to hyperglycemia and a higher risk of developing severe microvascular and macrovascular complications later in life.

Globally, the burden of diabetes remains substantial. According to the International Diabetes Federation (IDF, 2021), an estimated 537 million adults (20–79 years) were living with diabetes in 2021, representing 10.5% of the global adult population. Of these cases, approximately 85–90% are attributed to type 2 diabetes (Magliano & Boyko, 2021). In Indonesia, the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia, SKI) reported regional disparities in diabetes prevalence, with Bengkulu Province ranking 30th nationally at 1.1%. Within the province, Bengkulu City recorded a lower prevalence of 0.29%. However, these figures may underestimate the actual burden, particularly among youth, as prediabetes and obesity are not fully captured in routine surveillance.

Obesity and physical inactivity are well-established modifiable risk factors for T2DM. In Bengkulu City, 27.12% of individuals aged 10 years and older report low levels of physical activity (Badan Pusat Statistik Provinsi Bengkulu, 2021). Alarmingly, data from the Bengkulu City Health Office (2023) indicate that the Puskesmas Lingkar Barat working area has the highest prevalence of adolescent obesity, at 11.35%. SMAN 7 Bengkulu, located within this service area, serves a student population at elevated risk for developing T2DM.

If left unaddressed, T2DM can lead to debilitating complications, including cardiovascular disease, diabetic nephropathy, neuropathy, retinopathy, and increased mortality (Wulandari et al., 2023; Widagdo et al., 2024). Given the long asymptomatic phase of insulin resistance and prediabetes, early prevention and health promotion during adolescence are critical windows for intervention. Adolescence is a formative period when health behaviors are established, making it an ideal stage for implementing sustainable lifestyle changes.

Despite the potential of school-based health education in preventing chronic diseases, diabetes prevention programs in Bengkulu City remain limited, particularly those leveraging digital technologies. Meanwhile, adolescents are among the most active users of digital platforms, demonstrating high engagement with

mobile devices and online content (Panades et al., 2022). This digital affinity presents a strategic opportunity to deliver health education through innovative, accessible, and youth-friendly modalities.

The discussion-based learning method is an interactive pedagogical approach that promotes critical thinking, enhances understanding, and encourages behavioral reflection by engaging students in dialogue and collaborative problem-solving (Putri et al., 2024). This method can increase student motivation, knowledge retention, and behavioral intention when integrated with digital books- interactive, multimedia-rich educational tools. Digital books offer a practical, scalable, and engaging medium for delivering health education, particularly in resource-constrained settings.

Given the convergence of rising adolescent obesity, low physical activity, and underutilized digital health opportunities in Bengkulu City, this study aims to evaluate the effectiveness of a digital book-based discussion intervention on type 2 diabetes prevention behaviors among adolescents at risk of obesity at Public High School (SMAN) 7, Bengkulu City. The findings inform the development of scalable, technology-enhanced health education models for chronic disease prevention in adolescent populations.

2. METHODS

This study was conducted from April to June 2025 at SMAN 7 Bengkulu City, in Bengkulu Province, Indonesia. The research was approved by the Health Research Ethics Committee of Poltekkes Kemenkes Bengkulu (approval number: KEPK.BKL/199/04/2025), and all procedures adhered to the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants, and parental consent was secured for participants under the age of 18. Participation was voluntary, and respondents were assured of confidentiality and the right to withdraw at any stage without consequence.

A quasi-experimental design with a pretest–posttest control group structure was employed to evaluate the effectiveness of a digital book-based educational intervention on knowledge, attitudes, and practices related to type 2 diabetes mellitus (T2DM) prevention among adolescents at risk of obesity. This design allowed for the assessment of changes within and between groups following the intervention, while accounting for baseline differences through controlled comparison.

The target population comprised all students in grades X and XI at SMAN 7 Bengkulu City who were classified as being at risk of obesity based on Body Mass Index-for-age (BMI/A) ≥ 85th percentile according to World Health Organization (WHO) growth standards for adolescents. A total of 74 participants were included in the study, with 37 assigned to the intervention group (Grade XI) and 37 to the control group (Grade X). Assignment to groups was based on purposive sampling, considering both class availability and eligibility criteria.

Inclusion criteria for participation were as follows: (1) being a student in Grade X or XI at SMAN 7 Bengkulu City, (2) having a BMI ≥ 25 kg/m², (3) for the intervention group, ownership of an internet-enabled digital device, (4) willingness to participate in all educational sessions and complete the required assessments, and (5) functional literacy in reading and writing. Participants were excluded if they had a BMI below 25 kg/m², reported a history of psychiatric disorders, lacked access to a digital device (for the intervention group), were absent during data collection or intervention sessions, declined to participate, or demonstrated an inability to comprehend or complete the questionnaire.

The primary instrument used for data collection was a structured questionnaire assessing three domains: knowledge, attitudes, and practices related to T2DM prevention. The questionnaire was developed based on a comprehensive review of existing literature and adapted to the local context. Before the main study, content validity was established through expert review by three public health and medical professionals, followed by face validity testing. To assess reliability, a pilot study was conducted with 20 students not included in the final sample. Of the initial 15 knowledge items, 10 demonstrated adequate validity, as indicated by a corrected item-total correlation (r-calculated) exceeding the critical value of 0.396 at a significance level of $p < 0.05$. Internal consistency reliability was evaluated using Cronbach's alpha, which yielded a value of 0.848, indicating high reliability. The final instrument consisted of 10 multiple-choice items for knowledge, 10 attitude statements measured on a 4-point Likert scale (ranging from strongly disagree to agree strongly), and 10 practice-related items assessed via a behavioral checklist. Knowledge and attitude scores were transformed into percentages and categorized as good (76–100%), fair (56–75%), and poor (<56%).

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The independent variable was the mode of health education delivery: the intervention group received T2DM prevention education through an interactive digital book accessible via a QR code. In contrast, the control group received identical content in the form of a printed pocket book. The educational material covered key topics, including the pathophysiology of T2DM, risk factors, complications, and preventive strategies such as healthy eating, physical activity, and weight management. The intervention was delivered in four weekly sessions, each lasting approximately 30–40 minutes, facilitated by trained health educators. Both groups received the duplicate core content to ensure comparability, with delivery modality as the only differing factor.

The research procedure began with administering a pretest to both groups to assess baseline levels of knowledge, attitudes, and practices. Following the four-week intervention period, a posttest was administered using the identical questionnaire to evaluate outcome changes. All assessments were conducted in a classroom under supervised conditions to ensure consistency and minimize bias.

Data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics were used to summarize sociodemographic characteristics and outcome variables. The Shapiro–Wilk test was applied to assess data normality. Given the non-normal distribution of the data, non-parametric tests were employed. The Wilcoxon signed-rank test examined within-group differences between pretest and posttest scores. In contrast, the Mann–Whitney U test was used to compare the change magnitude between the intervention and control groups. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS

This study involved 74 respondents, divided into two groups: 37 in the intervention group and 37 in the control group. All respondents were adolescents at risk of obesity at Public High School (SMAN) 7 Bengkulu City, aged 15–18 years. Most respondents in the intervention group were male (62.2%), as were those in the control group (64.9%). All respondents had an overweight nutritional status based on the Body Mass Index-for-age (BMI/A) calculation. Most respondents in both groups were non-smokers, 73.0% in the intervention group and 78.4% in the control group. The homogeneity test results showed no significant differences between the two groups ($p > 0.05$), indicating that the groups were homogeneous.

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Table 1. Characteristics of Adolescents at SMAN 7 Bengkulu City

Respondent Characteristics	Intervention		Control		Total	p-value
	n	%	n	%	n	
Gender						
Male	23	62,2	24	64,9	47	0,809
Female	14	37,8	13	35,1	27	
Smoking						
Yes	9	24,32	8	21,62	17	0,782
No	28	75,68	29	78,38	57	
Parental History of Diabetes						
Yes	19	48,7	12	34,3	31	0,099
No	18	51,3	25	65,7	43	

Based on the increase in the mean knowledge score, there was an improvement in the average (mean) knowledge score in the intervention group from 48.38 ± 8.665 before the intervention to 84.05 ± 5.507 after the intervention. Prior to the intervention, the average knowledge level of respondents was in the "poor" category (score range: 30–60), but after the intervention, the score increased to the "good" category (score range: 70–90). Meanwhile, the control group also experienced an increase from 37.84 ± 9.757 to 67.30 ± 9.902; however, this improvement only shifted the category from "poor" to "moderate" (score range: 50–69).

Table 2. Mean Knowledge Before and After in the Intervention and Control Groups

Knowledge		Intervention	Control	p-value[b]
Pretest	Minimum-maximum	30-60	20-60	0,001
	$\bar{X}$±SD	48,38 ± 8,665	37,84 ± 9,757	
Posttest	Minimum-maximum	70-90	50-90	0,001
	$\bar{X}$±SD	84,05 ± 5,507	67,30 ± 9,902	
	p-value[a]	0,001	0,001	
Delta	Minimum-maximum	40-30	30-30	0,001
	$\bar{X}$±SD	35,68 ± 3,158	29,46 ± 0,145	

[a]Wilcoxon Signed-Rank Test, [b]Mann-Whitney

Based on the analysis of the attitude variable, the mean attitude score in the intervention group before the intervention was 55.06 ± 10.76, with a score range of 41–80, which falls into the "moderate" category (56–75%). After the intervention, the score increased to 85.28 ± 7.52, with a range of 70–97, placing it in the "good" category (76–100%). In the control group, the pretest attitude score was 47.55 ± 5.58 (range: 39–56), classified as "poor" (<56%), which then increased to 70.86 ± 10.78 (range: 61–93) in the posttest, thereby falling into the "good" category (76–100%).

Table 3. Mean attitudes Before and After in the Intervention and Control Groups

Attitudes		Intervention	Control	p-value[b]
Pretest	Minimum-maximum	41-80	39-56	0,001
	$\bar{X}$±SD	55,06 ± 10,76	47,55 ± 5,58	
Posttest	Minimum-maximum	70-97	61-93	0,001
	$\bar{X}$±SD	85,28 ± 7,52	70,86 ± 10,78	
	p-value[a]	0,001	0,001	
Delta	Minimum-maximum	15-48	14-45	0,001
	$\bar{X}$±SD	30,22 ± 7,03	23,31 ± 10,84	

[a]Wilcoxon Signed-Rank Test, [b]Mann-Whitney

Based on the analysis of the practice variable, the mean practice score in the intervention group before the intervention was 52.97 ± 9.96, with a score range of 40–70, which falls into the "moderate" category (56–75%). After the intervention, the score increased to 85.14 ± 9.89, with a range of 60–100, placing it in the "good" category (76–100%). In the control group, the pretest practice score was 47.57 ± 10.90 (range: 30–70), classified as "poor" (<56%), which then increased to 72.16 ± 12.93 (range: 50–100) in the posttest, thereby shifting into the "moderate" category (56–75%).

Table 4. Mean Practice Before and After in the Intervention and Control Groups

Practice		Intervention	Control	p-value[b]
Pretest	Minimum-maximum	40-70	30-70	0,001
	$\bar{X}$±SD	52,97 ± 9,962	47,57 ± 10,905	
Posttest	Minimum-maximum	60-100	50-100	0,001
	$\bar{X}$±SD	85,14 ± 9,894	72,16 ± 12,939	
	p-value[a]	0,001	0,001	
Delta	Minimum-maximum	20-30	20-30	0,001
	$\bar{X}$±SD	32,17 ± 0,068	24,59 ± 2,034	

[a]Wilcoxon Signed-Rank Test, [b]Mann-Whitney

4. DISCUSSION

The findings of this study demonstrate that a digital book-based discussion intervention significantly improves knowledge, attitudes, and preventive practices related to type 2 diabetes mellitus (T2DM) among adolescents at risk of obesity. The observed improvements in knowledge, attitudes, and practices of all three domains underscore the potential of technology-enhanced, interactive health education strategies in promoting early diabetes prevention during adolescence, a critical developmental period for establishing lifelong health behaviors.

The demographic and clinical characteristics of the participants were

relatively homogeneous between the intervention and control groups, particularly in terms of gender distribution, which did not differ significantly. This balance reduces the likelihood of gender-related confounding in the interpretation of outcomes. All respondents were classified as overweight or obese based on BMI-for-age, aligning with established evidence that excess body weight is a primary modifiable risk factor for insulin resistance and T2DM onset (Mansyah, 2021). Notably, a subset of adolescents in the intervention group reported a family history of T2DM and personal smoking habits, both of which are independent risk factors associated with dysglycemia through mechanisms involving chronic inflammation, oxidative stress, and pancreatic beta-cell dysfunction (Fanani, 2022; Banjarnahor et al., 2022). The convergence of genetic predisposition, adverse lifestyle behaviors, and nutritional status among these adolescents highlights the urgency of early, targeted, and multimodal health education to interrupt the trajectory toward metabolic disease. Adolescence represents a pivotal window for intervention, as health beliefs and behaviors formed during this stage often persist into adulthood.

The intervention group exhibited a significantly greater improvement in knowledge compared to the control group, with a mean score increase of 35.68 versus 29.46, respectively. The statistically significant between-group difference ($p < 0.001$) supports the superior efficacy of digital book-based education in enhancing health literacy. This finding is consistent with prior research indicating that digital educational media particularly those incorporating multimedia elements such as text, images, animations, and interactive features facilitate deeper cognitive processing and improved knowledge retention (Putri et al., 2024; Panades et al., 2022). Integrating the discussion method further amplifies learning by promoting active engagement, critical thinking, and peer-to-peer knowledge exchange. From a pedagogical perspective, this approach aligns with Bloom's cognitive domain, where interactive digital content enables learners to progress from basic recall to comprehension, application, and ultimately, synthesis of health information (Anderson & Krathwohl, 2001). The structured discussion sessions provided a platform for clarifying misconceptions, reinforcing key messages, and contextualizing knowledge within real-life scenarios, thereby enhancing the meaningfulness and durability of learning.

Attitudinal change is a crucial intermediary step from knowledge

acquisition to behavioral adoption. In this study, both groups showed significant within-group attitude improvements following the intervention. However, the digital book group demonstrated a significantly greater shift than the control group ($p = 0.001$). This outcome reflects the affective domain of learning, where learners move from passive reception of information to internalizing values and developing a sense of personal responsibility toward health (Pakpahan et al., 2021). Narrative-based digital content such as case scenarios and relatable characters allowed participants to engage emotionally with the material, fostering empathy and self-reflection. Meher et al. (2021) noted that such reflective processes create a "safe space" for adolescents to evaluate their behaviors, confront cognitive dissonance, and reframe health risks in personally relevant terms. This reflective capacity is further strengthened with guided discussion, enabling participants to articulate health values, justify behavioral choices, and commit to preventive actions. This is particularly relevant in dietary self-regulation and smoking avoidance, where social norms and peer influence often outweigh factual knowledge alone.

Perhaps most importantly, the intervention yielded a statistically significant improvement in preventive practices, with the intervention group showing a greater increase in self-reported healthy behaviors than the control group ($p = 0.010$). This finding supports the theoretical foundation of the Knowledge-Attitude-Practice (KAP) model, which posits that sustained behavioral change is most likely when accurate knowledge and positive attitudes converge to motivate action (Iswahyuni et al., 2024; Nisak et al., 2024). The digital book served as an informational tool and a behavioral prompt, presenting actionable strategies such as portion control, increased physical activity, and label reading in a visually engaging and age-appropriate format. The subsequent discussion sessions functioned as a reinforcement mechanism, allowing adolescents to share implementation challenges, receive peer feedback, and develop personalized action plans. This social-cognitive reinforcement is consistent with Bandura's theory of self-efficacy, wherein observational learning and verbal persuasion enhance confidence in one's ability to enact change (Bandura, 1997).

Moreover, the digital book's design, accessible via QR code and optimized for mobile devices, leveraged the high digital literacy and smartphone usage prevalent among adolescents. This modality offers advantages in terms of accessibility,

convenience, and scalability, particularly in low-resource settings where printed materials may be costly or logistically challenging to distribute. The flexibility of digital platforms also allows for timely content updates, interactive assessments, and integration with school curricula, making them a sustainable option for long-term health promotion.

While the results are promising, several limitations should be acknowledged. First, the study relied on self-reported data for attitudes and practices, which may be subject to social desirability bias. Second, the follow-up period was limited to the immediate post-intervention phase, so the long-term sustainability of behavioral changes remains unknown. Third, although randomization was not feasible due to school scheduling constraints, efforts were made to ensure group comparability through purposive sampling and baseline assessment. Future studies should consider longitudinal designs, objective outcome measures (e.g., physical activity tracking, dietary logs), and broader implementation across multiple schools to enhance generalizability.

Nonetheless, this study contributes to the growing evidence supporting integrating digital health tools with active learning strategies in adolescent health education. It demonstrates that a well-designed, theory-informed intervention combining digital books and structured discussions can effectively bridge the gap between knowledge and action in T2DM prevention. Given the rising burden of metabolic diseases globally, particularly in low- and middle-income countries, scalable and engaging educational models are urgently needed. The approach tested in this study offers a replicable, cost-effective, and youth-centered framework that can be adapted to address other non-communicable diseases in school settings.

5. CONCLUSION

This study demonstrates that a digital book-based discussion intervention is an effective strategy for improving knowledge, attitudes, and preventive practices related to type 2 diabetes mellitus among adolescents at risk of obesity. The digital educational tool was found to be both valid and feasible for use in school-based health promotion, offering an engaging, accessible, and pedagogically sound medium for delivering critical health information. Participant characteristics—including nutritional status, family history of diabetes, physical activity levels, and dietary behaviors—were integral to tailoring the intervention and reinforcing its relevance to a high-risk population. The

significant improvements observed in all three domains of the KAP (Knowledge, Attitude, Practice) model following the intervention underscore the potential of integrating digital technology with interactive learning methods to foster meaningful behavioral change.

The findings affirm that the combination of digital books and structured discussions enhances cognitive engagement, promotes affective development, and supports the translation of knowledge into preventive action. This approach aligns with contemporary educational theories and leverages adolescents' familiarity with digital platforms, thereby increasing the acceptability and impact of health education. As such, the intervention represents a scalable and sustainable model for addressing the growing burden of type 2 diabetes in young populations, particularly in resource-limited settings where innovative, low-cost solutions are urgently needed.

AUTHOR CONTRIBUTIONS

Tasya Ingrit Cahyati: Research conceptualization, data collection and analysis, writing the initial draft. Demsa Simbolon: Methodological guidance, instrument validation, data analysis supervision. Linda Sitompul: Discussion strengthening, and reference management.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest in this research.

DATA AVAILABILITY STATEMENT

The data are available from the corresponding author upon reasonable request.

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