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Research Article

Effect of Diabetes Mellitus Educational Video on Knowledge Improvement among Adolescents in Indonesia

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Abstract

Diabetes Mellitus is a health problem that can be prevented by increasing knowledge during adolescence. However, the lack of understanding about this disease among adolescents hinders early prevention efforts. This study aims to examine the effect of educational video media about Diabetes Mellitus on improving adolescents' knowledge. A pre-experimental design with a one-group pretest-posttest approach was used. The research sample consisted of 42 students from Bina Cipta Senior High School (SMA) Palembang, selected using purposive sampling. The intervention involved showing an educational video on Diabetes Mellitus after the pretest, followed by a posttest to measure knowledge changes. The T-test results showed a significant value of 0.000 ($p<0.05$), indicating a significant increase in knowledge after the video intervention. The findings imply that educational videos are an effective tool to enhance adolescent knowledge about Diabetes Mellitus and can be used as an alternative method in health promotion strategies within schools to address knowledge gaps and support early disease prevention.

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Introduction

Adolescence is a critical period in individual development, with many physical, emotional, and social changes. In the adolescent phase, psychological wellbeing is very important in influencing the personal, academic, and social development of adolescents [1]. Adolescence is a transition process that occurs in adolescents, aiming to prepare adolescents for the next life. Adolescents are also required to have the ability to overcome difficulties [2]. According to the World Health Organization WHO, adolescents are defined in context, adolescents are characterized by three aspects, namely biological, namely sexual characteristics, breast enlargement, waist development in women, while in men the growth of a mustache, beard and voice changes are getting deeper [3].

Adolescents are very susceptible to Diabetes Mellitus (DM) due to an unhealthy lifestyle. because adolescents currently consume excessive fat such as junk food and carbonated drinks, lack of physical activity, smoking, high calorie intake. This lifestyle, starting in adolescence and continuing into adulthood, can increase the likelihood that adolescents will develop Diabetes Mellitus [4]. Diabetes

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mellitus is often known as a sweet disease, which is a chronic disease that can affect people of all ages [5]. Diabetes mellitus is a health problem that has an impact on productivity that can reduce human resources [6]. This is reflected in the eating habits of modern society that prioritize comfort over health. such as foods, salt, high in fat [7].

According to the World Health Organization (WHO), Diabetes is a chronic metabolic disease characterized by increased blood glucose levels (also known as blood sugar), causing serious complications in the eyes, kidneys, spleen, heart, and intestines [8]. Type 2 Diabetes Mellitus (T2DM) is the most common diabetes in the world, with 90% of all types of diabetes. DMT2 is a metabolic disorder with a prevalence of 9.65% in men and 9% in women. Based on the prevalence of seven world regions, Southeast Asia ranks third at 11.3% [9]. Diabetes Mellitus (DM) based on the American Diabetes Association SKI 2023 results, the prevalence of diabetes based on doctor's diagnosis and blood sugar level examination in 2023 was higher than the prevalence in 2018 [10]. The prevalence of diabetes mellitus at age≥15 years reached 10.9%, central obesity was found at age ≥15 years at 31.0% where previously it reached 26.6% and increased in women by 12.7% [11].

According to the International Diabetes Federation (IDF), in 2021, the number of people with type II diabetes mellitus reached 536,600 people, people with type II diabetes mellitus aged 20-79 years, it is predicted that this number will continue to increase to reach 642,800, in 2030-2045 with several 783,700 people. Diabetes mellitus currently ranks 7th out of 10 leading causes of death in the world, 90%–95% of cases are Type II Diabetes (DMT2) [12]. Based on Prevalence, Indonesia is ranked fifth in the world with the highest prevalence of Diabetes Mellitus after China, India, Pakistan, and the United States (19.5 million) in the age group 20 to 79 years. Based on data from the South Sumatra Provincial Health Office, the highest cases of Diabetes Mellitus for 3 years were high starting from 2020-2022. In 2020, the number of cases of Diabetes Mellitus was 172,044 cases, while in 2021 the number of cases of Non-Implicit Diabetes was 279,345 cases. The prevalence of Diabetes Mellitus is estimated to reach 435,512 in 2022. According to a national food survey worldwide, an estimated 184,000 deaths per year are caused by consuming sweet drinks and foods, 133,000 of which are from diabetes mellitus, 45,000 due to cardiovascular disease, and 6,450 due to cancer [13]. In adolescents, it is often marked by changes in lifestyle and eating habits that tend to be less healthy. Consuming a lot of sweet, instant, and fast food and drinks, this habit has the potential to cause obesity, various diseases, including the risk of increasing blood glucose levels in adolescents [14].

One of the important roles in maintaining and improving health is the role of Education. Health education is an essential component that will be directed at activities to improve health, prevent disease, and help improve new behavior [15]. Education is a planned teaching and learning process, can influence the attitudes and actions of individuals or groups to improve individual welfare through teaching [16].

The importance of early prevention in adolescents and education. Early screening can help identify adolescents at high risk of developing type 2 diabetes, so that intervention can be carried out earlier [17]. The role of health workers in improving health is the role of Education. Health education is an essential

component to be directed at activities to improve health, prevent disease, help improve new behavior. Education is an interactive process to encourage learning which is an effort to add new knowledge, through skills to increase the strengthening of certain practices and experiences [18].

Video media is a medium that is easy to understand, modern and interesting every day, this media is easy to accept. Video educational media has its own advantages, is able to display moving images so that it attracts attention, has its own uniqueness that is not possessed by other learning media [19]. The duration of providing Educational Videos used varies. The time range for providing Educational Videos is between 1-30 seconds to 9 minutes [20].

Based on the background described above, this study aims to examine the effect of providing education on increasing adolescents' knowledge about Diabetes Mellitus at SMA Bina Cipta Palembang. The results of this research are expected to have important implications for developing effective health education strategies for adolescents, thereby enhancing awareness and early prevention of Diabetes Mellitus. Additionally, the findings can serve as a reference for schools and healthcare providers in designing appropriate educational programs to reduce the increasing incidence of Diabetes Mellitus among adolescents and support the establishment of sustainable healthy lifestyles among students.

Research Methods

This research method uses a pre-experimental design with a one-group pretest-posttest design. In this study, the sample was given a pretest (initial observation) before the intervention was administered. After the intervention, a posttest (final observation) was conducted. At the initial stage of this study, field observations were conducted at Bina Cipta Senior High School in Palembang. Then, the sample was selected using a random sampling technique. The respondents were first given an explanation about the purpose of the educational video on Diabetes Mellitus. Next, an intervention was administered in the form of a questionnaire related to the educational video, aiming to assess the improvement of adolescents' knowledge about Diabetes Mellitus. In the third stage, a post-test was conducted by giving the same questionnaire again to evaluate the effectiveness of the video in enhancing adolescents' knowledge.

The research will be conducted at Bina Cipta Senior High School in Palembang and is scheduled to take place on January 9, 2025. The population in this study consists of 42 adolescents enrolled at the school. The sample will be selected using a purposive sampling method, which involves choosing participants based on specific criteria considered appropriate by the researcher. The inclusion criteria include: being a student at Bina Cipta Senior High School, aged between 14 and 17 years, owning a smartphone, and having a low or moderate knowledge level based on the pretest. The exclusion criteria include students who are visually impaired or have hearing impairments.

Results and Discussion

The results of the study on the effect of an educational video about Diabetes Mellitus on improving adolescents' knowledge in 2025 were obtained through a pre-test and post-test questionnaire.

A. Research Results

The research was conducted on January 9, 2025, involving 42 respondents who met the inclusion criteria. The collected data were processed and analyzed using univariate and bivariate analysis. Prior to conducting the study, the researcher obtained ethical approval from the Ethics Committee of STIKES Mitra Adiguna with approval number No.166/EC/STIKES-MAG/I/2025. During the study, the researcher was assisted by a research assistant. Before the data collection began, the researcher and assistant aligned their understanding to ensure the research objectives could be achieved effectively. Table 1 presents the frequency distribution based on respondents' age at Bina Cipta Senior High School in 2025.

Table 1. Frequency Distribution Based on Age of Respondents

No	Age	Frequency	Percentage (%)
1	14-17 years	42	100
Total		42	100

Based on Table 1, it is known that the frequency distribution of respondents aged 14–17 years is 42 individuals (100%). The frequency distribution of respondent characteristics based on gender can be seen in the Table 2 below.

Table 2. Frequency Distribution Based on Respondents' Gender at Bina Cipta Senior High School in 2025

No	Gender	Frequency	Percentage (%)
1	Male	20	47
2	Female	22	53
Total		42	100

Based on Table 2, it is known that the frequency distribution of male respondents is 20 individuals (47%), while female respondents are 22 individuals (53%). Table 3 presents the frequency distribution based on adolescents' knowledge level about diabetes mellitus before and after watching the educational video at Bina Cipta Senior High School, Palembang, 2025.

Table 3. Frequency Distribution Based on Adolescents' Knowledge Level About Diabetes Mellitus Before and After Watching Educational Video

No	Knowledge	Pre-test		Post-test	
		Frequency	Percentage (%)	Frequency	Percentage (%)
1	Low	32	76	0	0
2	Moderate	10	24	13	31
3	High	0	0	29	69
Total		42	100	42	100

The analysis results above show that the number of respondents who were given the pre-test questionnaire on the educational video about Diabetes Mellitus with low scores was 32 individuals (76%), moderate scores were 10 individuals (24%). For the post-test of the educational video on Diabetes Mellitus, there were 0 individuals (0%) with low scores, 13 individuals (31%) with moderate scores, and 29 individuals (69%) with high scores. Table 4

presents the shapiro-wilk normality test of adolescents' knowledge level about diabetes mellitus before and after receiving health education via educational video at Bina Cipta Senior High School, Palembang, 2025

Table 4. Shapiro-Wilk Normality Test

No	Knowledge Variable	Shapiro-wilk		
		Statistic	p-value	Status
1	Pre-test	0.896	0.001	Normal
2	Post-test	0.807	0.000	Normal

After observing the results of the normality test from the Shapiro-Wilk table, it is found that the knowledge data before receiving health education via the Diabetes Mellitus educational video is 0.001 < 0.05, and after receiving health education via the educational video, it is 0.000 < 0.05. Therefore, the data is normally distributed. A bivariate analysis was conducted to determine the effect of health education via the educational video on adolescents' knowledge about Diabetes Mellitus using the Shapiro-Wilk test. Table 5 presents the paired t-test on adolescents' knowledge level about diabetes mellitus before and after receiving health education via educational video at Bina Cipta Senior High School, Palembang, 2025

Table 5. Paired T-Test

No	Knowledge	N	Mean	sid	*p-value*
1	Pre-test and Post-test	42	-40.238	12.394	0,000

From Table 5, it is known that the significance value of the parametric statistical test (T-Test) is 0.000 (p-value 0.00 < 0.05), which indicates that there is an effect of health education through the Diabetes Mellitus educational video on improving adolescents' knowledge.

B. Discussion

The purpose of this study was to determine the effect of diabetes mellitus health education using video media on increasing adolescents' knowledge. Based on the characteristics of the respondents, it was found that all participants (100%) were in the age range of 14–17 years. This group represents the transitional period from early to late adolescence, a stage where individuals are developing cognitive maturity and starting to make more independent decisions, including decisions related to health [21].

The results of the study showed a statistically significant effect of the intervention. The pre-test average knowledge score was 0%, which increased to 69% after the video-based health education was delivered. The Shapiro-Wilk test showed a significance value of 0.001 (p-value < 0.05), indicating that the null hypothesis (Ho) was rejected and the alternative hypothesis (Ha) was accepted. This confirms that diabetes mellitus health education using video media significantly improves adolescent knowledge.

This study supports previous findings that health education is an effective strategy to improve public knowledge and attitudes in disease management. The use of video as an educational medium is particularly beneficial because it can increase interest, reach wider audiences, and make information more accessible and engaging [22]. Animated video, in particular, is recognized for its ability to facilitate efficient learning within a

short time while enhancing retention by stimulating multiple senses [23]. Several respondents in this study showed enthusiasm and active participation during the educational session, which further strengthened the delivery of material. This response indicates that video-based education is well received by adolescents, who are part of the digital-native generation and more responsive to multimedia content.

Despite the promising results, this study has limitations. The study did not include a control group for comparison, which may limit the strength of causal conclusions. Additionally, the assessment was conducted only in the short term, so it is unclear whether the increase in knowledge will be retained over time. The study was also conducted in a limited population, which may affect the generalizability of the findings.

Future research is recommended to involve a control group, broader participant demographics, and follow-up assessments to evaluate long-term knowledge retention. Researchers could also explore the use of interactive media or mobile health (mHealth) applications to further enhance adolescent engagement in health education. The implications of this research for educational development are substantial. It suggests that integrating video-based health education into school curricula can be an effective way to build adolescent health literacy. Educators and school health programs should consider leveraging multimedia tools to deliver critical health content in ways that resonate with students' learning preferences. By doing so, schools can play a more active role in chronic disease prevention and health promotion from an early age.

Conclusion

This study aimed to evaluate the effectiveness of educational videos in increasing adolescents' knowledge about Diabetes Mellitus, and the findings demonstrated a significant positive impact, as shown by a p-value of 0.000 ($p < 0.05$) in the pre-post test analysis. The intervention successfully addressed the research problem by providing an engaging, accessible, and clear medium for delivering health information, which led to improved knowledge and awareness among students. The results suggest that integrating educational videos into school health education programs can be an impactful strategy for early prevention of chronic diseases such as Diabetes Mellitus. However, this study was limited by its short-term measurement and lack of long-term follow-up to assess knowledge retention and behavior change. Future research is recommended to explore the sustained effects of video-based education across diverse populations and settings. The implication of this study for educational development is that innovative, multimedia-based learning methods should be increasingly adopted to enhance students' understanding and participation in health education initiatives.

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Author Contributions

Listya Puspita: conceptualization; formal analysis; data curation; methodology; writing- review and editing. Husna Juma Mlwale: validation; data curation; writing- review and editing. Nurjannah: validation; formal analysis; data curation; writing- review and editing.

Availability of data and materials

All data is available from the authors.

Competing interests

The authors declare no competing interest.

Additional information

No additional information from the authors.

References

[1] Abrar, E. A., Yusuf, S., Sjattar, E. L., & Rachmawaty, R. "Development and evaluation educational videos of diabetic foot care in traditional languages to enhance knowledge of patients diagnosed with diabetes and risk for diabetic foot ulcers," *Primary care diabetes*, vol. 14, no. 2, pp. 104-110, 2020. https://doi.org/10.1016/j.pcd.2019.06.005

[2] Nur'aeni, Y., Fitri, S. Y. R., & Kurniawan. "Resiliensi Remaja Di Wilayah Pesisir: S Scoping Review," *Jurnal Keperawatan,* vol. 16, no. 3, pp. 1063–1072, 2023. https://doi.org/10.32583/keperawatan.v16i3.1788

[3] Bintang, A. Z., & Mandagi, A. M. "Kejadian Depresi Pada Remaja Menurut Dukungan Sosial Di Kabupaten Jember," *Journal Of Community Mental Health and Public Policy,* vol. 3, no. 2, pp. 92–101, 2021. https://doi.org/10.51602/cmhp.v3i2.55

[4] Maharani, A., Ghinan Sholih, M., Studi Farmasi, P., Ilmu Kesehatan, F., & Singaperbangsa Karawang, U. "Literature Review: Faktor Risiko Penyebab Diabetes Melitus Tipe Ii Pada Remaja," *Jurnal Sehat Mandiri,* vol. 19, no. 1, pp.185–197, 2024. https://doi.org/10.33761/jsm.v19i1.1395

[5] Lestari, Zulkarnain, Sijid, & Aisyah, S. " Diabetes Melitus: Review Etiologi, Patofisiologi, Gejala, Penyebab, Cara Pemeriksaan, Cara Pengobatan Dan Cara Pencegahan, " *Prosiding Biologi Achieving the Sustainable Development Goals with Biodiversity in Confronting Climate* Change, vol. 1, no. 2, pp. 237–241, 2021. https://doi.org/10.24252/psb.v7i1.24229

[6] Sinaga, E. B., Safari, F. R. N., Yusnanda, F., & Pratiwi, T. A. "Penyuluhan Diabetes Militus Pada Wus Di Lingkungan Wilayah Kerja Puskesmas Binjai Kota Tahun 2023," *Jurnal Pengabdian Masyarakat Aufa,* vol. 5, no. 3, pp. 139–143, 2023. https://doi.org/10.51933/jpma.v5i3.1196

[7] Ardila, M., Humolungo, D. T. W. S., Amukti, D. P., & Akrom, A. "Promosi Kesehatan Pencegahan Dan Pengendalian Diabetes Melitus Pada Remaja," *Jurnal Abdimas Indonesia,* vol. 4, no. 2, pp. 534–540, 2024. https://doi.org/10.53769/jai.v4i2.729

[8] Ardini, S. D., & Sugiarti, R. "Tinjauan Literatur Sistematis: Pengaruh Lingkungan Sosial Dan Perlakuan Yang Diterima Remaja Dari Lingkungan Sosialnya Terhadap Psychological Well-Being," *Jurnal Syntax Admiration,* vol. 5, no. 8, pp 3147–3156, 2024. https://doi.org/10.46799/jsa.v5i8.1473

[9] Ardika, O. B., Larasati, T., Suharanto, & Kurniati, I. "Gangguan Sekresi Dan Sensitivitas Insulin Pada Remaja Dengan Riwayat Keluarga Diabetes Melitus Tipe 2," *Medical Profession Journal of Lampung,* vol. 14, no. 1, pp. 190–195, 2024. https://doi.org/10.53089/medula.v14i1.943

[10] Maharani, A., Ghinan Sholih, M., Studi Farmasi, P., Ilmu Kesehatan, F., & Singaperbangsa Karawang, U. "Literature Review: Faktor Risiko Penyebab Diabetes Melitus Tipe Ii Pada Remaja," *Jurnal Sehat Mandiri,* vol. 19, no. 1, pp. 185–197, 2024. https://doi.org/10.33761/jsm.v19i1.1395

[11] Nuridah, N., Burhanuddin, Y. E., Tulak, G. T., & Yodang, Y. "Pencegahan Diabetes Melitus Melalui Deteksi Dini Sindroma Metabolik Pada Remaja di Smas It Wihdatul Ummah Kolaka," *Jurnal Pengabdian Masyarakat Medika*, vol. 4, no. 2, pp. 57–65, 2024. https://journals2.ums.ac.id/index.php/jpmmedika/article/view/4301

[12] Aminuddin, A., Sima, Y., Cholifatul Izza, N., Syamsi Norma Lalla, N., & Arda, D. "Edukasi Kesehatan Tentang Penyakit Diabetes Melitus bagi Masyarakat," *Abdimas Polsaka*, vol. 2, no. 1, pp. 7–12, 2023. https://doi.org/10.35816/abdimaspolsaka.v2i1.25

[13] Novianto, D. R., Suryoputro, A., & Widjanarko, B. "The Effectiveness of Media "Remaja Cerdik Mobile" Android-Based Application on Adolescents' Knowledge, Attitude and Self Efficacy on Prediabetes Prevention," *International Journal of Health, Education & Social (IJHES)*, vol. 2, no. 9, pp. 41-55, 2019. https://doi.org/10.1234/ijhes.v2i9.24

[14] Purwaningsih, N. V., Kunsah, B., Maulidiyanti, E. T. S., Widyastuti, R., Saputro, T. A., Rahmawati, R., & Nuzula, F. N. "Edukasi Dan Skrining Diabetes Melitus Pada Remaja Di Rongtengah Sampang Madura," *Jurnal Abdi Masyarakat Kita,* vol. 4, no. 1, pp. 11–21, 2024. https://doi.org/10.33759/asta.v4i1.501

[15] Dewi, Mursidah, Y. "Peningkatan Kapasitas Remaja Perilaku Pencegahan Childhood Diabetes Melalui Pemanfaatan Modul Edukasi Diabetes," *Jurnal Pengabdian Kesehatan,* vol. 4, no. 1, pp. 47–53, 2023. https://doi.org/10.35910/binakes.v3i02.682

[16] Yetti, K., Novieastari, E., & Gayatri, D. "Model Edukasi Yang Digunakan Perawat Untuk Meningkatkan Literasi Kesehatan Pasien Diabetes Melitus Dalam Perspektif Manajemen: Systematic Review," *Jurnal Keperawatan,*

vol. 16, no. 1, pp. 1–16, 2024. https://doi.org/10.32583/keperawatan.v16i1.1421

[17] Ayudia, E. I., Harahap, H., Justitia, B., Imam, M., & Delfira, A. "Diabetes Melitus Pada Remaja Di Kota Jambi," *Seroja Husada. Seroja Husada Jurnal Kesehatan Masyarakat,* vol. 1, no. 5, pp. 372–383, 2024. https://doi.org/10.572349/verba.v2i1.3637–81.

[18] Sarah, N., Haskas, Y., & Restika BN, I. "Perbandingan Efektivitas Intervensi Media Edukasi Kesehatan Berbasis Audio Visual Dan Booklet Terhadap Pengetahuan Dan Sikap Remaja Dalam Pencegahan Diabetes Melitus Tipe 2," *JIMPK: Jurnal Ilmiah Mahasiswa & Penelitian Keperawatan*, vol. 4, no. 5, pp. 71-76, 2024. https://doi.org/10.35892/jimpk.v4i5.1685

[19] Prasetyo, B., & Hasan, M. "The Effectiveness of Motion Graphic Media in Enhancing Adolescents' Knowledge and Attitudes Regarding Diabetes Mellitus," In *Proceeding International Conference Health Polytechnic of Jambi*, Vol. 4, pp. 1-9, Dec. 2024. https://doi.org/10.35910/icohpj.v4i0.918

[20] Jannah, M., Aji, A. S., Sari, P., & Afifah, E. "The Effect of an Educational Video on Physical Activity for Diabetes Prevention among Obese High School Students in Yogyakarta," *Journal of Global Nutrition*, vol. 4, no. 1, pp. 314-322, 2024.https://doi.org/10.53823/jgn.v4i1.84

[21] Rosyida, I., Sulfikar, A., & Mustafa, S. R. "The Effect of Health Education as a Preventive Effort Against Diabetes Mellitus in Adolescents at SMA Negeri 4 Kota Parepare," *Innovative Approaches in Health Science Journal*, vol. 2, no. 1, pp. 33-38, 2025. https://doi.org/10.1234/4zp80r63

[22] Fathoni, A., Sentana, A. D., Emilyani, D., Cembun, C., & Lestari, V. A. "The Effect of Education Through Video on the Knowledge, Attitudes, and Skills about Foot Care in Type 2 Diabetes Mellitus Patients," *Jurnal Keperawatan Terpadu (Integrated Nursing Journal)*, vol. 6, no. 1, pp. 18-26, 2024. https://doi.org/10.32807/jkt.v6i1.545

[23] Agung, F. H., Sekartini, R., Sudarsono, N., Hendarto, A., Werdhani, R. A., Dhamayanti, M., ... & Sawyer, S. M. "Development of an internet-based intervention to improve health professionals' counseling skills around adolescent weight management in Indonesia," *Plos one*, vol. 18, no. 12, pp. e0294986, 2023. https://doi.org/10.1371/journal.pone.0294986