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Mindfulness Intervention and Nutrition Education for the Prevention of Diabetes Mellitus in Adolescents in Palu City

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ABSTRACT

Introduction: Diabetes Mellitus (DM) is a growing public health problem, including among adolescents, due to unhealthy lifestyle changes and high levels of psychosocial stress. Preventing DM in adolescents requires a comprehensive approach that integrates nutritional knowledge, stress management, and mental health. This study aims to analyze the effectiveness of a combined intervention of mindfulness therapy and nutrition education on increasing knowledge, changing attitudes, reducing anxiety levels, and improving blood sugar levels in adolescents in Palu City.
Methods: This study used a quasi-experimental design with a pre-test and post-test control group approach. The sample consisted of 60 adolescents aged 15–19 years who were divided into a treatment group (n=30) and a control group (n=30). The treatment group received 8 weeks of mindfulness therapy intervention accompanied by nutrition education, while the control group did not receive mindfulness intervention. Data were collected using knowledge and attitude questionnaires, the Hamilton Rating Scale for Anxiety (HARS) instrument, and blood sugar level measurements. Data analysis was performed using the Wilcoxon test and paired t-test with a significance level of 0.05.
Results: Results: Based on the data distribution, the analysis was conducted using the Paired t-test (parametric) and the Wilcoxon test (non-parametric) at α=0.05. Statistically, there was a significant increase in knowledge (33.3% to 96.6%) and positive attitude (6.7% to 53.3%), as well as a significant change in anxiety levels, namely a decrease in the severe category (33.3% to 10%) and an increase in the normal category (26.6% to 60%). In addition, the proportion of normal blood sugar levels increased from 56.6% to 76.6%, with all changes being statistically significant ($p < 0.05$).
Conclusion: The combined intervention of mindfulness therapy and nutrition education effectively improved knowledge and attitudes, reduced anxiety levels, and improved physiological parameters in adolescents in the prevention of diabetes mellitus. This integrative approach has the potential to become a holistic and sustainable strategy for the promotion and prevention of DM in school-based adolescents.

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INTRODUCTION

Diabetes Mellitus (DM) is a significant public health challenge in Indonesia. Data from the Indonesian Ministry of Health show an increase in the prevalence of DM in the population aged 15 years and older from 10.9% (2018) to 11.7% (2023), with Indonesia ranking fifth in the world with 19.5 million sufferers (1,2). Adolescents are

a vulnerable group due to unhealthy lifestyle changes, such as high consumption of sugar and fat and low physical activity (3).

Nutrition education is an effective approach to raising adolescents' awareness of healthy eating patterns. Research by Paramadini et al. (2024) proves that nutrition education can increase adolescents' knowledge about DM prevention (4). On the other hand, mindfulness therapy has been shown to have a positive effect on reducing stress hormones and inflammatory markers relevant to the pathogenesis of DM (5,6). However, a methodological gap exists in prior research, which has focused on singular approaches and has not integrated psychological aspects (such as mindfulness) with nutrition education simultaneously, particularly within the context of school-based interventions in Indonesia.

Based on this identified gap, this study was designed to develop a comprehensive DM prevention intervention through the integration of mindfulness therapy and nutrition education. This approach is expected, unlike previous partial interventions, to not only increase knowledge but also foster holistic awareness in making healthy decisions and managing stress among adolescents. The objective of this study is to analyze the effectiveness of the combination of mindfulness therapy and nutrition education interventions in increasing knowledge, changing attitudes, and reducing anxiety levels among adolescents related to diabetes mellitus prevention in Palu City.

METHOD

This study used a quantitative approach with a quasi-experimental design through a pre-test and post-test approach with a control group. This design was chosen to evaluate the effectiveness of the combination of mindfulness therapy and nutrition education interventions in preventing diabetes mellitus in adolescents. Sampling was conducted using purposive sampling, involving 60 adolescents aged 15–19 years in Palu City. The sample was divided into two groups, namely the treatment group (30 adolescents) who received mindfulness therapy intervention for 8 weeks (1 session per week) and nutrition education workshops, and the control group (30 adolescents) who did not receive the intervention.

Data were collected through questionnaires on knowledge and attitudes about diabetes prevention, health status measurements (body mass index, blood pressure, fasting blood sugar), and the Hamilton Rating Scale for Anxiety (HARS) to measure anxiety levels. Data collection was conducted in the pre-test and post-test phases.

Data were analyzed using paired t-tests or Wilcoxon tests to compare pre- and post-intervention results, and multiple linear regression to identify factors influencing changes in adolescents' knowledge and attitudes. All analyses were performed using statistical software with a significance level of $\alpha = 0.05$.

Population and sample

The population in this study was adolescents aged 15–19 years in Palu City, Central Sulawesi. Sampling was conducted using purposive sampling with the inclusion criterion being adolescents who were willing to participate in the full 8-week intervention. The research sample consisted of 60 adolescents divided into two groups, namely a treatment group of 30 adolescents who received a combination of mindfulness therapy and nutrition education interventions, and a control group of 30 adolescents who did not receive mindfulness interventions.The sample size was determined based on considerations of intervention feasibility and the capacity for intensive supervision during the study. This size was deemed adequate to detect within-group changes from pre- to post-intervention, thereby providing methodological justification without requiring a formal power analysis. Purposive sampling was used to ensure the involvement of participants who met specific criteria and were able to complete the entire intervention.

Research Location

This study was conducted in Palu City, Central Sulawesi, at SMK Muhammadiyah Al-Haq and SMP Aisyiyah. These two schools were selected based on the institutions' readiness to support the implementation of the intervention and their representation of the population of adolescents aged 15-19 years in urban areas. The city of Palu as the research location provided a relevant urban context for testing the effectiveness of diabetes mellitus prevention interventions in adolescents. The participation of two schools of different educational levels (junior high school and vocational high school) was expected to enrich the sample variation and increase the generalization of the research findings.

Instruments

The quantitative component of this study used a structured questionnaire to measure respondents' knowledge

and attitudes regarding diabetes mellitus prevention. Psychological aspects were measured using the Hamilton Rating Scale for Anxiety (HARS), which has been validated to assess respondents' anxiety levels. For physiological parameters, blood sugar levels were measured using a calibrated glucometer. All instruments were administered in a pre-test and post-test design to evaluate the effectiveness of the combination of mindfulness therapy and nutrition education interventions provided over 8 weeks.

Procedure

Data were collected through structured questionnaires assessing knowledge and attitudes, as well as the Hamilton Rating Scale for Anxiety (HARS), all of which were administered directly in a pre-test and post-test setting. The study was conducted from July to August 2025. Data collection was carried out during the 8-week intervention period in Palu City, involving 60 adolescent respondents. Physiological parameters (random blood sugar levels) were measured using a glucometer calibrated by trained personnel. The entire data collection process was supported by a team of researchers and field assistants in close coordination with the school to ensure a smooth schedule and optimal participation rates.

Data Analysis

Quantitative data were analyzed using the Wilcoxon non-parametric statistical test and the paired t-test, based on the results of normality testing, to examine significant differences between pre-test and post-test measurements for the variables of knowledge, attitude, anxiety level (HARS), and random blood sugar levels. Data analysis was performed using statistical software to ensure the accuracy of the calculations.

RESULTS

Based on data analysis conducted on 60 adolescent respondents in Palu City (30 participants in the treatment group and 30 in the control group), the effectiveness of the combination of mindfulness therapy and nutrition education intervention can be assessed by comparing pre-test and post-test results against the established indicators.

Table 1. Characteristics of respondents in the control group and treatment group

Characteristics	Control Group (n=30)		Treatment Group (n=30)	
	f	%	f	%
Age (Years)				
15	10	33.3	7	23.3
16	16	53.3	23	76.6
17	4	13.3	0	0
Gender				
Male	19	63.3	0	0
Female	11	36.7	30	100

Table 1 shows the distribution of basic characteristics of the 60 research respondents. Overall, most respondents were aged 15-17 years, with 16 years being the most dominant age group. Based on the results per group, There was an imbalance in gender composition between the treatment and control groups. However, the within-group change analysis ensures that this imbalance does not compromise the study's internal conclusions. The treatment group consisted entirely (100%) of females, while in the control group, there were more male respondents (63.3%) than females.

Table 2. Level of Knowledge

Knowledge Level	Treatment Group (n=30)				Control Group (n=30)			
	Pre		Post		Pre		Post	
	f	%	f	%	f	%	f	%
High	10	33.3	29	96.6	10	33.3	23	76.6
Moderate	14	46.7	1	3.33	16	53.3	7	23.3

Knowledge Level	Treatment Group (n=30)				Control Group (n=30)			
	Pre		Post		Pre		Post	
	f	%	f	%	f	%	f	%
Low	6	20	0	0	4	13.3	0	0
Total	30	100	30	100	30	100	30	100
Wilcoxon test	*0.000 < 0.05*							

Table 2 shows that in the treatment group, most respondents (46.7%) had moderate knowledge levels prior to nutrition education. After receiving education, there was a significant increase, with almost all respondents (96.6%) having high knowledge levels. In the control group, most (53.3%) also had moderate knowledge before the study. After the study, although there was an increase to 76.6% in the high knowledge category.

Based on the statistical test using the Wilcoxon Signed Rank Test, a p-value of 0.000 ($p < 0.05$) was obtained. This indicates a statistically significant difference between the knowledge levels before and after the education.

Table 3. Attitude Levels

Knowledge Level	Treatment Group (n=30)				Control Group (n=30)			
	Pre		Post		Pre		Post	
	f	%	f	%	f	%	f	%
Very Positive	2	6.67	16	53.3	2	6.67	8	26.6
Positive	15	50	12	40	9	30	18	60
Enough	7	23.3	2	6.67	16	53.3	4	13.3
Less	6	20	0	0	3	10	0	0
Total	30	100	30	100	30	100	30	100
Wilcoxon test	*0.000 < 0.05*							

Table 3 shows that in the intervention group, most (50%) had a positive attitude before nutrition education and after nutrition education, most (53.3%) had a very positive attitude. In the control group, most (53.3%) had a neutral attitude before and after, and most (60%) had a positive attitude.

Based on the statistical test using the Wilcoxon Signed Rank Test, $p = 0.000$ was obtained in the intervention group, meaning that there was a difference in attitudes before and after education. In the control group, $p = 0.000$ was also obtained, indicating that there was a difference in attitude levels before and after the standard intervention.

Table 4. Mindfulness Intervention on Anxiety Levels

Anxiety Level	Treatment Group (n=30)				Control Group (n=30)			
	Pre		Post		Pre		Post	
	f	%	f	%	f	%	f	%
Normal	8	26.6	18	60	15	50	4	13.3
Light	5	16.6	3	10	2	6.67	6	20
Moderate	7	23.3	6	20	7	23.3	7	23.3
Severe	10	33.3	3	10	6	20	13	43.3
Total	30	100	30	100	30	100	30	100
Normality test	*Sig. 0.148 > 0.05*				*Sig. 0.140 > 0.05*			
Paired T-Test	*Sig. 0.001 < 0.05*							

Table 4 shows that in the treatment group, before the mindfulness intervention, 33.3% of participants experienced severe anxiety, whereas after the intervention, 60% were classified within the normal anxiety range. In the control group that did not receive mindfulness intervention, the results showed that most (50%) experienced normal anxiety levels before the intervention, and after the intervention, most (43.3%) experienced severe anxiety levels.

Based on statistical testing with a Paired T-Test, a p-value of 0.001 ($p < 0.05$) was obtained in this comparative analysis, indicating a statistically significant difference in anxiety levels before and after the mindfulness intervention between the treatment group and the control group.

Table 5. Mindfulness Intervention on Blood Sugar Levels

Blood Sugar Levels	Treatment Group (n=30)				Control Group (n=30)			
	Pre		Post		Pre		Post	
	f	%	f	%	f	%	f	%
< 140	17	56.6	23	76.6	27	76.6	27	76.6
140-199	13	43.3	7	23.3	3	10	3	10
>200	0	0	0	0	0	0	0	0
Normality test	*Sig. 0.200 > 0.05*				*Sig. 0.147 > 0.05*			
Paired T-Test	*Sig. 0.003 < 0.05*							

Based on Table 5, in the treatment group before nutrition education and mindfulness training, more than half (56.6%) of respondents had normal blood sugar levels (<140 mg/dL) and 43.3% were in the prediabetes category (140-199 mg/dL). After the intervention, the proportion of respondents with normal blood sugar levels increased to 76.6%, while those in the prediabetes category decreased to 23.3%.

In the control group, which received nutrition education but not mindfulness intervention, the proportion of respondents with normal blood sugar levels was high from the outset (76.6%) and did not change after the study period, remaining at 76.6%. This group also had a stable proportion of prediabetes, at 10% both before and after.

Based on a statistical test using a Paired T-Test, a p-value of 0.003 was obtained for the intervention group. This indicates a statistically significant difference in blood sugar levels before and after the intervention.

DISCUSSION

Increased Knowledge about Diabetes Mellitus Prevention

The study results showed a significant increase in knowledge in the treatment group, from 33.3% to 96.6% in the high knowledge category. This is in line with the research by Paramadini et al. (2024), which states that nutrition education can increase adolescents' understanding of DM prevention (4). Structured and continuous nutrition education enables adolescents to understand the relationship between diet, lifestyle, and the risk of DM (7). Combining this with mindfulness sessions can strengthen information retention by increasing focus and awareness during the learning process.

The findings of increased knowledge indicate that the intervention successfully overcame initial barriers to health literacy. Education that not only conveys information but is also packaged with a participatory approach relevant to the context of adolescents' lives has proven effective in transforming knowledge from mere memorization to practical understanding (8,9,10). Thus, high knowledge levels not only reflect the absorption of facts but also the formation of a preventive mindset that enables adolescents to make more informed health decisions in their daily lives.

Attitude Change Toward Healthy Behavior

The attitudes of respondents in the intervention group shifted positively, from 50% positive attitudes to 53.3% very positive attitudes after the intervention. This indicates that the intervention not only increased knowledge but also influenced adolescents' beliefs and readiness to adopt healthy behaviors. According to Black et al. (2020), an educational approach that combines cognitive and emotional aspects, such as through mindfulness, can strengthen the intention to engage in healthy behaviors (11). Mindfulness, with its emphasis on full awareness and non-judgmental acceptance, helps adolescents observe their own thought patterns and behavioral impulses without automatic reactions (12,13). This process then strengthens the intention or desire to engage in healthy behaviors.

Reduction in Anxiety Levels

Mindfulness interventions have been shown to significantly reduce anxiety levels in the treatment group, with the proportion of respondents with severe anxiety decreasing from 33.3% to 10%, while those in the normal category increased from 26.6% to 60%. These findings are consistent with a study by Miller et al. (2021) which

reported that mindfulness practices can reduce stress hormone levels and anxiety symptoms in adolescents (5). This reduction in anxiety also contributes to an improved quality of life and is likely to support adherence to a healthy lifestyle (14, 15).

When anxiety levels decrease, the cognitive and emotional energy that was previously drained by worry can be redirected toward constructive behaviors (16). Individuals become better able to plan, motivate themselves, and consistently engage in activities such as regular exercise, good nutrition, and adequate sleep. Additionally, improved emotional regulation from mindfulness practices can reduce impulsive or escapist behaviors such as unhealthy eating or substance abuse, creating a positive cycle in which mental and physical health reinforce each other (17,18).

Improvement in Blood Sugar Levels

In the treatment group, there was an increase in the proportion of respondents with normal blood sugar levels from 56.6% to 76.6%, as well as a decrease in the proportion of those in the prediabetes category from 43.3% to 23.3%. These results indicate that the combined intervention not only impacts psychological and cognitive aspects but also physiological parameters. Research by O'Reilly et al. (2019) states that mindfulness interventions can modulate glycemic responses through stress reduction and improved emotional regulation mechanisms (19). Nutrition education also plays a role in increasing awareness of healthier food choices (20).

Effective education promotes awareness of the glycemic index, macronutrient composition, and portion control, thereby changing respondents' environmental cues and food choices. The combination of reduced psychological distress from mindfulness and increased nutritional self-efficacy from education creates a metabolic environment more conducive to plasma glucose stabilization (21,22).

This improvement in blood sugar levels can also be understood through a neuroendocrine lens, where consistent mindfulness practice plays a role in decreasing hypothalamic-pituitary-adrenal (HPA) axis activity and reducing the secretion of chronic stress hormones such as cortisol. High cortisol levels are known to increase insulin resistance and trigger gluconeogenesis in the liver, thereby contributing to hyperglycemia (23,24). By addressing the psychological roots of stress, mindfulness interventions help break this physiological chain. This is consistent with the findings of Pascoe et al. (2021), who explained that mindfulness practice creates a more stable psychobiological homeostasis, characterized by a decrease in stress and inflammation biomarkers, which in turn improves insulin sensitivity and supports better glycemic regulation (25). Thus, the increase in normal blood sugar levels in this study is not merely the result of conscious changes in eating behavior, but also a consequence of fundamental improvements in the body's stress regulation system triggered by this holistic intervention.

Limitations and Implications

Although the study results demonstrate the effectiveness of the intervention, there is a limitation in the sample composition, which was unbalanced in terms of gender between the treatment and control groups, potentially affecting the generalizability of the findings. However, these findings retain high relevance and application value, particularly for the population of adolescent girls in school-based interventions in urban areas. The combination of mindfulness and nutrition education has proven to be a promising strategy for preventing DM in adolescents, as demonstrated in the context of Palu City.

CONCLUSION

The eight-week combined intervention of mindfulness therapy and nutrition education demonstrated significant effectiveness in preventing diabetes mellitus among adolescents in Palu City. The intervention substantially improved adolescents' knowledge of diabetes prevention and promoted positive attitudinal changes, particularly an increase in very positive attitudes within the intervention group. Moreover, the mindfulness component contributed to meaningful reductions in anxiety levels, as reflected by a decrease in severe anxiety and a corresponding increase in adolescents classified within the normal anxiety range. Physiological outcomes also improved, with a higher proportion of participants achieving normal blood sugar levels following the intervention. From a public health perspective, these findings highlight the importance of integrating psychological well-being and nutritional education within school-based health promotion programs. The results support the adoption of holistic, preventive strategies that address both behavioral and psychosocial risk factors for non-communicable diseases, particularly diabetes mellitus, among adolescents. Such integrative interventions have the potential to inform health education policies and strengthen early prevention efforts within educational and community settings.

AUTHOR'S CONTRIBUTION STATEMENT

FFR and ZT jointly contributed to the conception and design of the study. FFR led the coordination of the research, supervised the intervention implementation, conducted data analysis, and prepared the original draft of the manuscript. ZT contributed to data collection, supported the delivery of the mindfulness and nutrition education interventions, assisted in data management and interpretation, and participated in the literature review. Both authors were involved in revising the manuscript critically for important intellectual content, approved the final version, and agreed to be accountable for all aspects of the work.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest associated with this study. Neither financial nor personal relationships with individuals or organizations exist that could inappropriately influence or bias the conduct, interpretation, or reporting of the research.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, generative AI-assisted tools were used solely for language editing and improvement of clarity, grammar, and readability. The use of these tools did not influence the study design, data collection, data analysis, interpretation of results, or the scientific conclusions. The authors take full responsibility for the integrity, originality, and accuracy of the content of this manuscript.

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