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The Effectiveness of Mindfulness Training on Blood Sugar and Psychological Well-Being in Patients with Type 2 Diabetes

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ABSTRACT

This study examined the effectiveness of mindfulness training on blood sugar and psychological well-being in patients with type 2 diabetes. This applied research employed a quasi-experimental methodology with a pretest-posttest design with a control group and involved a three-month follow-up. The study population comprised all patients with type 2 diabetes attending the Diabetes and Endocrinology Treatment Center in Dubai in summer 2023. Forty patients with type 2 diabetes were purposively selected and randomly assigned to two groups: 1) The experimental group, undergoing mindfulness training, and 2) The control group. After the intervention period, both groups took part in free counseling sessions. Participants initially completed Ryff's Psychological Well-Being Questionnaire. The serum level of glycosylated hemoglobin (HbA1c) was measured in the pretest, posttest, and three-month follow-up phases by a laboratory kit. All participants recompleted the questionnaire following the intervention with the experimental group. Data were analyzed by the SPSS 29 software through descriptive statistics (mean and standard deviation) and repeated measures analysis of variance. The results indicated that mindfulness training significantly lowered blood sugar and enhanced psychological well-being in patients with type 2 diabetes at posttest compared to the control group. Therefore, it can be concluded that mindfulness can serve as an effective and sustainable approach to managing and improving diabetic patients' conditions.

Key words: Mindfulness Training, Blood Sugar, Psychological Well-being, Type 2 Diabetes

INTRODUCTION

Diabetes is a chronic disease that affects the way the body converts food into energy. By definition, diabetes is a metabolic disorder characterized by hyperglycemia, which means high blood sugar, resulting from impaired insulin secretion, insulin dysfunction, or both. Type 2 diabetes is the most common form of this disease and arises from the body's resistance to insulin and, occasionally, a relative insulin deficiency (1). In this type of diabetes, the pancreas produces insulin; however, the quantity is insufficient or, alternatively, the patient's body exhibits resistance to the produced insulin and fails to use it properly (2). The cause of type 2 diabetes still remains unknown due to the multiple mechanisms that can lead to the development of this

disease. Numerous factors, including genetic predispositions and various environmental parameters, can contribute to its incidence. Some of these factors include reduced physical activity, unhealthy dietary habits, and obesity (3, 4). According to the International Diabetes Federation (2021), approximately 540 million people (10.5% of the global adult population aged 20 to 79) were living with diabetes, and this number is predicted to rise to 783 million by 2045. Diabetes is a major concern worldwide due to its association with increased premature mortality (5).

According to previous research, type 2 diabetes requires lifelong therapeutic interventions and can be managed effectively by maintaining blood sugar levels within the normal range (6). Awareness of factors influencing glycemic control, including age, gender, weight, duration of diabetes, treatment methods, smoking, and patients' knowledge and education, facilitates better management of this disease (7). However, due to inconsistencies in the findings of previous studies, it remains unclear which of these factors has the greatest influence on blood sugar control.

Psychological well-being, as a broad and dynamic concept within health and wellness domains, emphasizes personal characteristics and values in human life. This concept encompasses positive dimensions of life such as life satisfaction, progress, effective interaction with the world, fostering positive life processes, feeling emotional well-being, and general life satisfaction. Psychological well-being highlights the importance of developing and enhancing positive human traits and capacities and focuses on personal growth and human development. It underscores the relationship between individuals' goals and the outcomes of their life performance (8). A new perspective in mental health centers on psychological well-being as the primary focus and emphasizes human development and personal growth. This perspective considers individuals' evolutionary process against life challenges and their progression toward realizing their potential capabilities. Psychological well-being is a broad concept encompassing mental and physical health, success, and tranquility (9). Numerous studies have demonstrated that psychological well-being can be experienced despite illness and even under the most adverse conditions (38). A diagnosis of type 2 diabetes with severe reliance on self-management introduces new lifelong daily challenges. Consequently, adverse psychological issues may lead to inadequate self-care, poor dietary adherence, reduced physical activity, non-compliance with medication, and insufficient blood sugar monitoring, ultimately resulting in poorer long-term health outcomes (10). It has been estimated that up to 80% of coping efforts employed by diabetic individuals are active coping strategies, which, however, may enfeeble psychological well-being (11). Recent studies conducted during the COVID-19 pandemic indicate that the psychological well-being of individuals with diabetes may be disproportionately affected by specific COVID-related concerns, as diabetic patients are considered at higher risk for severe infections (12). Adherence to medications and healthy behaviors significantly decreased due to drastic lifestyle changes caused by quarantine measures, indicating the considerable impact of environmental conditions on the psychological well-being of patients (13).

On the other hand, health psychologists have turned to third-wave therapies to improve the condition of individuals with chronic illnesses. One of these approaches is mindfulness-based therapy, which teaches individuals to observe life's matters with focus on the present moment and without judgment (14). When individuals become aware of the present, they no longer attend to the past or future. Many psychological problems are usually associated with events that happened in the past or may occur in the future. For example, depressed people often feel regret and guilt about the past, while stressed ones worry about future problems. Mindfulness helps individuals moderate negative behavioral patterns and automatic thoughts and regulate positive and healthy behaviors. In other words, mindfulness, through the combination of vitality and clear perception of experiences, can bring about positive changes in happiness and well-being. This therapeutic approach can improve mood, and its short-term training reduces fatigue and anxiety. Through mindfulness-based exercises and techniques, individuals become aware of their daily activities and gain insight into the

mind's automatic functioning in past and future worlds. By moment-to-moment awareness of thoughts, feelings, and physical states, they control them and are freed from the automatic, everyday mind focused on the past and future (15). These therapies can influence the mental and physical health of patients with type 2 diabetes to manage diabetes and delay the incidence of physical and psychological complications (16). Therefore, the present study sought to answer the following question: Does mindfulness therapy affect blood sugar and psychological well-being in patients with type 2 diabetes? Based on the aforementioned points, the present research aimed to investigate the effectiveness of mindfulness-based training on blood sugar and psychological well-being in patients with type 2 diabetes.

1. Research Method

In the present study, the samples were purposively selected and then randomly assigned to an experimental and a control group. They were assessed at three stages: Pre-test, post-test, and three-month follow-up. Accordingly, the research pursued a quasi-experimental methodology with a pre-test, post-test, and (3-month) follow-up design with a control group.

Table 1: General Research Design

Group	Random Assignment	Pre-test	Intervention	Post-test	Follow-up
Mindfulness Training	RE	T1	X2	T2	T3
Control	RE	T1	--	T2	T3

The population of the present study included all patients with type 2 diabetes who had visited the Diabetes and Endocrinology Treatment Center in Dubai, United Arab Emirates, in summer 2023. Among this statistical population, 40 diabetic patients with type who visited the center and volunteered to participate in the study in response to the researcher's call were purposively selected based on the inclusion and exclusion criteria. Subsequently, they were randomly assigned into two equal groups, i.e., 20 in the experimental and 20 in the control group. In this study, no attrition occurred in either group.

➢ **Inclusion Criteria**

- Definitive diagnosis of type 2 diabetes by an endocrinologist
- An elapse of at least two years since the diagnosis of type 2 diabetes
- No history of severe psychological disorders
- No use of psychiatric medications during the intervention period
- Aging between 45 and 65 years
- A minimum educational level of a high school diploma
- Tending to participate in the study voluntarily and signing the informed consent form

➢ **Exclusion Criteria**

- Absence from mindfulness training sessions for more than two sessions
- Withdrawal from continuing the treatment or participating in the study

To control confounding variables, the researcher instructed all three groups not to discontinue their diabetes medications during the study period. They were also informed that any lifestyle changes, such as

exercising, following a specific diet, increasing medication dosage, using different medications (chemical or herbal), or using complementary medicine, could affect the study outcomes. Therefore, participants were asked to notify the researcher if they decided to make such changes, so that they could be excluded from the study if necessary.

The mindfulness training program was implemented in eight 90-minute sessions over eight weeks. Additionally, to assess the longer-term effects of the intervention, the researcher administered a follow-up test three months after the intervention for the experimental and control groups.

- **Intervention Methods**

Content of Mindfulness Training Sessions

The mindfulness training program in this study was based on the model developed by Kabat-Zinn (2013) (17). The program was conducted over eight weeks, with participants attending one 90-minute therapeutic session each week.

Table 2: Mindfulness Training Program Based on Kabat-Zinn's 2013 Book "Full Catastrophe Living"

Sessions	Topic	Content
First	Introduction and teachings on raisin eating and body scan	After participant introductions, a brief overview of the upcoming eight-week program was provided. This session included the practice of eating raisins and 30 minutes of body scan training, along with homework.
Second	Barriers to Practice and their Solutions Meditation in a sitting position	The previous session's homework and body scan were reviewed. Practicing barriers and the mindfulness program's solutions for these problems were discussed. Training on sitting meditation was provided, and homework was assigned for the next session.
Third	Practicing seeing and Hearing Practicing 3-minute breathing	Homework from the previous session was reviewed. Exercises on seeing and hearing commenced simultaneous with teaching a three-minute breathing exercise. Homework was assigned for the next session.
Fourth	Awareness of body Sounds and thoughts Practicing mindful walking	After the review of the previous session's homework, training body sounds and thoughts initiated alongside breathing. Discussion centered on stress responses and individuals' reactions to difficult situations, particularly relating to diabetes. The session ended with training on mindful walking and assigning homework.

Fifth	Mindful Body Movements	Homework from the previous week was discussed. After seated meditation, mindful body movements were introduced and practiced. Homework was assigned for the following session.
Sixth	Practicing the identification of thought content	The session began with a three-minute breathing exercise, followed by a discussion of homework in pairs. Training on identifying thought content was provided, and homework was assigned for the next session.
Seventh	Four-Dimensional Meditation on identifying pleasant and unpleasant life events	After homework reviews, four-dimensional meditation was taught, and identifying pleasant and unpleasant life events was practiced. The session ended with a three-minute breathing exercise and an assignment of homework.
Eighth	Solving problems and answering questions	The session opened with a body scan and a three-minute breathing exercise. Participants discussed barriers to meditation and were asked if their expectations from the training sessions had been met. Other related questions were also asked.

Contrary to the experimental group, the control group underwent no intervention and was placed on a waiting list. However, immediately after the therapeutic interventions, the control group received several free counseling sessions. Both the experimental and control groups completed the Ryff Psychological Well-Being Questionnaire at the pre-test, post-test, and follow-up stages. Additionally, to measure serum blood sugar levels as glycosylated hemoglobin (HbA1c), the researcher employed the SIEMENS DCA SYSTEMS laboratory kit in the experimental and control groups at the pre-test, post-test, and follow-up stages.

- **Statistical Analysis**

Descriptive statistics, including measures of central tendency and dispersion (mean, standard deviation), frequency distribution tables, and charts were used. For inferential statistics, given the normality of data distribution and homogeneity of group variances, a multivariate analysis of variance with repeated measures was employed (due to the presence of repeated assessments in the psychological and biological variables across the follow-up period) to test all research hypotheses. The data were analyzed by the SPSS 29 software.

2. Results and Analysis

Table 3 presents the demographic characteristics of the study groups.

Table 3: Demographics of the research samples

		Gender frequency (%)	Marital status frequency (%)	Education frequency (%)	

Group	Mean age (SD)	Male	Female	Single	Married	Diploma	Associate degree	Bachelor's degree	Master's or higher	Mean disease duration (SD)
Mindfulness	51.25 (6.65)	9 (45%)	11 (55%)	2 (10%)	18 (90%)	6 (30%)	-	8 (40%)	6 (30%)	18.70 (6.25%)
Control	52.40 (6.44)	11 (55%)	9 (45%)	3 (15%)	17 (85%)	4 (20%)	1 (5%)	8 (40%)	7 (35%)	15.55 (6.42%)

- **Comparing Demographic Variables Between Two Groups**

The Chi-square test was used to compare gender and education levels between the two groups. The results of this test are reported in the table below.

Table 4: Comparing gender and education across three groups

			Group		Chi-2 square test	
			Mindfulness training	Control	Test static	Sig.
Gender	Male	Frequency	9	11	0.400	0.819
		(%)	45%	55%		
	Female	Frequency	11	9		
		(%)	55%	45%		
Education	Diploma	Frequency	6	4	0.604	0.604
		(%)	30%	20%		
	Associate degree	Frequency	0	1		
		(%)	0%	5%		
	Bachelor's degree	Frequency	8	8		
		(%)	40%	40%		
	Master's or higher	Frequency	6	7		
		(%)	30%	35%		

Given the significance levels for both gender and education variables, it can be concluded that the distribution of these indices is similar between the mindfulness training group and the control group, and there are no statistically significant differences between the groups regarding gender and education.

- **Comparing baseline values between the two groups before the intervention**

Analysis of variance (ANOVA) was used to compare the research variables between the two groups at the pre-test stage. The results of this test are reported in the table below.

Table 5: Comparing research variables across three groups at the pre-test stage

Variable	Group	Mean	Standard Deviation	Test Statistic	Significance Level
Blood Sugar	Mindfulness Training	9.871	0.907	1.171	0.317
	Control	10.281	0.897		
Psychological Well-being	Mindfulness Training	274.550	114.842	0.214	0.808
	Control	254.400	100.807		

Based on the table above, the significance levels for the tests are greater than 0.05, indicating that the examined variables do not significantly differ between the two groups (mindfulness training and control) in the pre-intervention phase. Therefore, it can be concluded that before applying the intervention, the blood sugar level and psychological well-being were similar in both groups.

According to the results of the group comparisons, the two groups are entirely similar and comparable, which reflects proper participant selection and effective randomization. Hence, any differences observed between the groups after the intervention are more attributable to the effects of the interventions rather than confounding or background differences.

- **Descriptive Statistics of Research Indicators**

- **Mean and Standard Deviation of Research Variables**

To better understand the study population and become more familiar with the research variables, it is necessary to describe these data before performing the statistical analyses. Therefore, the descriptive statistics of the variables used in the study were examined before testing the research hypotheses. The mean, as one of the measures of central tendency, represents the central point of the population, meaning that if all the observations in the population were replaced by the mean, the data sum would not change. The results of the descriptive statistics are presented in the table below.

Table 6: Mean and standard deviation of research variables for the experimental group

Variable	Time	N	Mean	SD	Skewness	Kurtosis
Blood Sugar	Pre-test	20	9.871	0.907	-1.164	0.198

Variable	Time	N	Mean	SD	Skewness	Kurtosis
	Post-test	20	7.203	1.156	-1.631	0.133
	Follow-up	20	6.861	1.003	-0.849	-0.502
Psychological Well-being	Pre-test	20	274.550	114.842	-1.454	-0.426
	Post-test	20	392.050	101.475	0.533	-1.466
	Follow-up	20	397.750	88.106	1.200	-1.834

Table 7: Mean and Standard Deviation of Research Variables for the control Group

Variable	Time	N	Mean	SD	Skewness	Kurtosis
Blood Sugar	Pre-test	20	10.281	0.897	-1.236	-0.420
	Post-test	20	9.984	0.986	-1.605	0.330
	Follow-up	20	10.163	0.797	-0.917	-0.256
Psychological Well-being	Pre-test	20	254.400	100.807	-0.643	0.759
	Post-test	20	285.200	147.620	-1.048	-0.111
	Follow-up	20	284.650	129.678	-1.737	0.196

Since the skewness and kurtosis values fall within the range of -2 to +2 for all variables in both examined groups, it can be concluded that the data follow a normal distribution. Therefore, parametric tests can be appropriately used to examine the research hypotheses.

- **Inferential Findings**

- **Examining the effect of mindfulness training on blood sugar in patients with type 2 Diabetes**

To test this hypothesis, repeated measures analysis of variance (ANOVA) was used to examine the differences in mean blood sugar levels at three different periods (pre-test, post-test, and follow-up) between the mindfulness training group and the control group. This test was run to analyze both intra-group and inter-group changes over time.

Initially, the results of Levene's test were used to assess the homogeneity of variances and check whether the error variances of the dependent variable (blood sugar at different times) were equal across groups. Table 8 presents the results of this test.

Table 8: Levene's test for blood sugar

Variable	Time	Test Static	Significance Level
Blood Sugar	Pre-test	0.010	0.923
	Post-test	1.490	0.230
	Follow-up	1.782	0.190

The significance level of the above test ($p > 0.05$) indicates the equality of error variances for blood sugar in both groups (mindfulness training and control groups) and confirms the homogeneity of variances assumption. The results of Box's M test are used to examine the equality of covariance matrices between groups. The null hypothesis of this test states that the covariance matrices of the dependent variables are equal between the two groups. The results of this test are presented in the table below.

Table 9: Box's M Test for Blood Sugar

Variable	Box's M	Test static	Sig. (p)
Blood Sugar	5.885	0.896	0.496

Given the results of the above table, the significance level of this test ($p = 0.496$) is greater than 0.05, suggesting the equality of covariance matrices between the two groups and confirming the assumption of covariance homogeneity. These results indicate that the covariance matrices of the post-test variables in the two groups are equal and do not differ significantly.

Mauchly's Test of Sphericity is a statistical test used to examine the hypothesis that the covariance matrices of the dependent variable errors are equal across all levels of the independent variable, i.e., the sphericity assumption holds.

Table 10: Mauchly's test for blood sugar

Variable	Mauchly's W	Sig.
Blood Sugar	0.953	0.408

Based on the test results, the significance level equals 0.408, indicating that the sphericity assumption is not rejected ($p > 0.05$). This means that the error covariance matrix is proportional to an identity matrix, and the results of the tests can be interpreted without any correction to the degrees of freedom.

Table 11: Inter-Groups Test for Assessing the Effect of Intervention on Blood Sugar

Source	Type III Sum of Squares	df	Mean Square	F Statistic	p-value	Effect Size (Eta)
Intercept	9850.757	1	9850.757	13882.080	p < 0.001	0.997
Group	140.530	1	140.530	198.041	p < 0.001	0.839
Error	26.965	38	0.710			

Based on the significance level for the group ($p < 0.001$) in the above table, which is below 0.05, it can be concluded that the measured blood sugar values after the intervention differ significantly between the two groups by comparing baseline measurements, time of measurement, and the interaction effect between grouping and each of the covariates. Additionally, 83.9% of the variance is attributed to differences between groups. These findings indicate the effectiveness of the mindfulness-based training on blood sugar control.

The following table reports means, standard deviations, and ANOVA test statistics in the mindfulness training group and control group at the post-test and follow-up phases for the blood sugar variable.

Table 12: Comparing Mean Blood Sugar Levels in Mindfulness Training and Control Groups at Post-Test and Follow-Up

Time	Group	Mean Blood Glucose	Standard Deviation	F Statistic	p-value
Post-Test	Mindfulness Training	7.203	1.156	66.965	p < 0.001
	Control	9.984	0.986		
Follow-Up	Mindfulness Training	6.861	1.003	132.857	p < 0.001
	Control	10.163	0.797		

The above test results indicate that mindfulness training effectively reduces blood sugar in patients with type 2 diabetes at the post-test stage.

- **Examining the Effect of Mindfulness Training on Psychological Well-Being in Patients with Type 2 Diabetes**

Repeated measures ANOVA was used to test this hypothesis and examine the differences between the two groups in their mean psychological well-being scores across three periods (pre-test, post-test, and follow-up). This test analyzed intra-group and inter-group changes over time.

Levene's test was first used to assess the homogeneity of variances and determine whether the error variances of the dependent variable (psychological well-being at different times) were equal across groups. The results of this test are presented in Table 13.

Table 13: Levene's Test for Psychological Well-being

Variable	Time	Test Statistic	Significance Level (p-value)
Psychological Well-being	Pre-Test	1.425	0.240
	Post-Test	1.058	0.128
	Follow-Up	1.112	0.127

The significance level of the above test ($p > 0.05$) indicates equality of error variances between the groups, i.e., mindfulness training and control group for psychological well-being, confirming the assumption of homogeneity of variances. To assess the equality of covariance matrices between groups, Box's M test is used. The null hypothesis of this test states that the covariance matrices of the dependent variables are equal across the two groups. Table 14 presents the results of this test.

Table 14: Box's M Test for Psychological Well-Being

Variable	Box's M	Test static	Sig.
Psychological Well-being	10.142	1.545	0.159

Based on the results in the above table, the significance level of this test ($p = 0.159$) exceeds 0.05, indicating equality of the covariance matrices between the two groups and satisfying the assumption of the homogeneity of covariances. These results imply that the covariances of the post-test variables are equal across the two groups and do not differ significantly.

Mauchly's Test of Sphericity is used to examine the hypothesis that the covariance matrices of the dependent variable errors are equal across all levels of the independent variable, i.e., the sphericity assumption holds.

Table 15: Mauchly's Test for Psychological Well-Being

Variable	Mauchly's W	Sig.
Psychological well-being	0.903	0.152

According to the test results, the significance level equals 0.152, indicating that the sphericity assumption is not rejected ($p > 0.05$). This means that the error covariance matrix is proportional to an identity matrix, and the test results can be used without any corrections to the degrees of freedom.

Table 16: Inter-Groups Test for the Effect of Intervention on Psychological Well-Being

	Type III Sum of Squares	df	Sum of Square	F Static	Sig.	Effect Size (Eta)
Intercept	11,889,367	1	11,889,367	1225.424	p < 0.001	0.970
Group	192,160.033	1	192,160.033	19.806	p < 0.001	0.343
Error	368,685.433	38	9,702.248			

Given the significant level of group ($p < 0.001$) in the above table, which is less than 0.05, it can be concluded that the measured values of psychological well-being are significantly different between the two groups in the post-intervention phase by comparing baseline measurements, time of measurement, and the interaction effects between grouping and each covariate. Additionally, 34.3% of the variance is attributed to the differences between groups. These findings indicate the effectiveness of the mindfulness training intervention in enhancing psychological well-being.

The following table reports the means, standard deviations, and ANOVA test statistics in the mindfulness training and control groups at post-test and follow-up periods regarding the psychological well-being variable.

Table 17: Comparing Mean Psychological Well-Being in Mindfulness Training and Control Groups at Post-Test and Follow-Up

Time	Group	Mean Psychological Well-Being	Standard Deviation	F Statistic	p-value
Post-Test	Mindfulness Training	392.050	101.475	7.116	p = 0.011
	Control	285.200	147.620		
Follow-Up	Mindfulness Training	397.750	88.106	10.408	p = 0.

Time	Group	Mean Psychological Well-Being	Standard Deviation	F Statistic	p-value
	g				003
	Control	284.650	129.678		

The results of the above test also show that mindfulness training effectively increases psychological well-being in patients with type 2 diabetes at the post-test stage.

3. Results and Discussion

Repeated measures Analysis of variance (ANOVA) was employed to test the hypotheses of the present study. The results of this test demonstrated that mindfulness training effectively reduced blood sugar and enhanced psychological well-being in patients with type 2 diabetes at the post-test stage. These effects remained significant at the follow-up stage.

The results of this study confirmed the effectiveness of mindfulness-based stress reduction programs in lowering blood sugar in patients with type 2 diabetes. This finding is consistent with the results of studies by Huey et al. (2023), Hamasaki (2023), Guo et al. (2022), Dalpatadu (2022), Ngan et al. (2021), and Ni et al. (2021), demonstrating that mindfulness-based stress reduction therapy significantly reduced blood sugar in diabetic patients (18–23). However, Shojaei et al. (2022) examined the effects of two therapeutic approaches—self-healing therapy and cognitive-behavioral therapy integrated with mindfulness—on blood sugar in patients with type 2 diabetes. They found that only self-healing significantly reduced glycated hemoglobin (HbA1c), whereas mindfulness therapy did not yield a significant effect (39). Furthermore, Fisher et al. (2023) discovered that mindfulness-based stress reduction programs did not impact glycated hemoglobin significantly. Therefore, these studies are not consistent with the findings of the present study (24).

Mindfulness-based stress reduction programs can affect blood sugar in patients with type 2 diabetes through multiple mechanisms. Stress reduction, a key component of this approach, plays a crucial role in blood sugar control. Chronic stress elevates hormones, such as cortisol and adrenaline, which increase blood sugar. Mindfulness helps regulate biological pathways associated with the secretion of these hormones by reducing stress and improving an individual's perception of stressful situations. This biological modulation contributes to improved HbA1c levels (25). Moreover, mindfulness training enhances emotional regulation abilities. Diabetes patients frequently experience anxiety and depression, which can complicate disease management. Better emotion regulation fosters motivation to adhere to diabetes management plans, including regular medication intake, proper diet, and physical activity (26). Finally, mindfulness influences health-related behaviors. Participants in mindfulness programs usually tend to adopt healthier lifestyles, such as improved dietary choices and engagement in self-care activities. These behavioral changes, alongside the psychological benefits of mindfulness, contribute significantly to reducing HbA1c levels. Therefore, mindfulness approaches, by emphasizing the connection between mental and physical health, can be

considered an effective complementary method for managing type 2 diabetes (27).

The results of this study confirmed the effectiveness of mindfulness-based interventions in enhancing psychological well-being in patients with type 2 diabetes. This finding aligns with the study by Amin Kazemi et al. (2024) on women with epilepsy, revealing that mindfulness-based stress reduction programs significantly improved psychological well-being (35). Similarly, Mahmoudi et al. (2024) reported the effectiveness of mindfulness training in improving psychological well-being among female heads of households (40). Hatami et al. (2023) demonstrated that mindfulness-based approaches improved psychological well-being in hospitalized and recovered COVID-19 patients (37). Pasiar et al. (2023) found that mindfulness-based stress reduction increased psychological well-being in women with breast cancer (36). Özdemir (2022) confirmed the effectiveness of mindfulness-based stress reduction in enhancing psychological well-being of patients with schizophrenia (28). Liu (2023) showed that mindfulness-based stress reduction improved psychological well-being among nurses after the COVID-19 pandemic (29). Norhidayyah and Zuhara (2021) observed that mindfulness-based stress reduction enhanced psychological well-being in mothers of children with intellectual disabilities (30).

The effectiveness of mindfulness-based approaches is mediated through multiple processes, including stress reduction, neurological and physiological changes, increased self-compassion, improved sleep quality, and enhanced coping mechanisms, making it a multifaceted strategy to improve psychological well-being in patients with type 2 diabetes. According to previous studies, chronic stress exacerbates diabetes symptoms and complicates disease management, which in turn may lead to unhealthy choices and impaired glycemic control. Since mindfulness-based stress reduction programs reduce stress, they equip patients with tools to manage stress more effectively. Furthermore, mindfulness practices induce significant structural and functional changes in the brain. Studies have demonstrated that such programs can improve brain regions associated with emotional regulation, such as the prefrontal cortex, while decreasing activity in the amygdala, a region involved in stress responses. These neurological changes contribute to mood improvement and relief of anxiety and depression symptoms commonly seen in diabetic patients (31). Additionally, mindfulness-based stress reduction programs foster self-compassion, which is beneficial for patients experiencing self-criticism related to diabetes management. Self-compassion reduces distress and increases psychological flexibly, thereby improving general well-being. Research indicates that increased self-compassion among diabetic patients correlates with better emotional health and fewer diabetes-related complications (32). Moreover, mindfulness improves sleep quality and mitigates insomnia, which is particularly advantageous for patients with type 2 diabetes, as poor sleep is linked to increased stress, anxiety, and depressive symptoms. By enhancing sleep quality, mindfulness supports psychological well-being and strengthens resilience against diabetes management challenges (33). Finally, mindfulness-based stress reduction programs equip patients with effective coping strategies to tackle diabetes-related life challenges. Through cultivating mindfulness, patients learn to respond to stressors and emotional stimuli non-reactively. This facilitates healthier choices regarding diet, physical activity, and medication adherence, ultimately improving both mental and physical health (34).

Conclusion

The results of this study demonstrated that mindfulness training significantly reduced blood sugar and improved psychological well-being in patients with type 2 diabetes. These effects, which persisted through both the post-test and follow-up stages, underscore the robustness of this approach in enhancing the physical and psychological health of these patients. Furthermore, the mechanisms underlying the effectiveness of mindfulness training, including stress reduction, enhanced emotional self-regulation, and improved health-related behaviors, could facilitate diabetes management effectively. By reducing psychological stress,

improving emotional regulation, and increasing awareness of daily behaviors, this approach helps patients better manage their disease and improve their quality of life. These findings align with the majority of prior studies, emphasizing the importance of psychological interventions as integral components of treatment programs for chronic disease patients. The results indicate that mindfulness training can serve as a reliable and complementary method alongside conventional medical treatments and play an impactful role in improving general patient health. Therefore, it is recommended that future research explore the applicability of this method across specific populations such as the older adults, adolescents, or individuals with other chronic conditions (e.g., cardiovascular diseases or cancer) to assess the generalizability of these results.

References

1. Latek D, Rutkowska E, Niewieczerzal S, Cielecka-Piontek J. Drug-induced diabetes type 2: In silico study involving class B GPCRs. PLoS One. 2019;14(1):e0208892.
2. American Diabetes Association. Cardiovascular disease and risk management: standards of medical care in diabetes—2018. Diabetes Care. 2018;41(Suppl 1):S86–104.
3. Al Ali T, Ashfaq A, Saheb Sharif-Askari N, Abusnana S, Mussa BM. Investigating the association between diabetic neuropathy and vitamin D in Emirati patients with type 2 diabetes mellitus. Cells. 2023;12(1):198.
4. Haidari F, Zakerkish M, Karandish M, Saki A, Pooraziz S. Association between serum vitamin D level and glycemic and inflammatory markers in non-obese patients with type 2 diabetes. Iran J Med Sci. 2016;41(5):367.
5. Saeedi P, Salpea P, Karuranga S, Petersohn I, Malanda B, Gregg EW, et al. Mortality attributable to diabetes in 20–79 years old adults, 2019 estimates: Results from the International Diabetes Federation Diabetes Atlas. Diabetes Res Clin Pract. 2020;162:108086.
6. Blaslov K, Naranđa FS, Kruljac I, Renar IP. Treatment approach to type 2 diabetes: Past, present and future. World J Diabetes. 2018;9(12):209.
7. Ali MK, McKeever Bullard K, Imperatore G, Barker L, Gregg EW. Characteristics associated with poor glycemic control among adults with self-reported diagnosed diabetes—NHANES, United States, 2007–2010. MMWR Morb Mortal Wkly Rep. 2012;61(2):32–7.
8. Ryff CD, Singer BH, Dienberg Love G. Positive health: connecting well-being with biology. Philos Trans R Soc Lond B Biol Sci. 2004;359(1449):1383–94.
9. Keyes CL, Shmotkin D, Ryff CD. Optimizing well-being: the empirical encounter of two traditions. J Pers Soc Psychol. 2002;82(6):1007.
10. Watson NA, Dyer KA, Buckley JD, Brinkworth GD, Coates AM, Parfitt G, et al. Comparison of two low-fat diets, differing in protein and carbohydrate, on psychological wellbeing in adults with obesity and type 2 diabetes: a randomised clinical trial. Nutr J. 2018;17:1–12.
11. Bennett P. Introduction to Clinical Health Psychology. McGraw-Hill Education (UK); 2000.
12. Joensen LE, Madsen K, Holm L, Nielsen KA, Rod M, Petersen AA, et al. Diabetes and COVID-19: psychosocial consequences in people with diabetes in Denmark. Diabet Med. 2020;37(7):1146–54.
13. Galmiche M, Lucas N, Déchelotte P, Deroissart C, Le Solliec M-A, Rondeaux J, et al. Plasma peptide concentrations and peptide-reactive immunoglobulins in patients with eating disorders at inclusion in the French EDILS cohort. Nutrients. 2020;12(2):522.

14. Sado M, Ninomiya A, Nagaoka M, Koreki A, Goto N, Sasaki Y, et al. Effectiveness of mindfulness-based cognitive therapy for pharmacotherapy-refractory anxiety disorders: protocol for feasibility RCT. JMIR Res Protoc. 2022;11(1):e33776.
15. Kabat-Zinn J. Mindfulness-based interventions in context: past, present, and future. 2003.
16. Eisazadeh F, Saffarinia M, Alipour A, Dehkordi MA. Comparison of the effectiveness of acceptance, commitment and mindfulness therapy on psychological well-being and weight control in people with type 2 diabetes. Int J Appl Behav Sci. 2022;9(3):42–53.
17. Kabat-Zinn J. Full catastrophe living. Revised edition. Hachette UK; 2013.
18. Heo S, Kang J, Umeakunne E, Lee S, Bertulfo TF, Barbé T, et al. Effects of meditation on self-management in adults with type 2 diabetes: systematic review and meta-analysis. J Cardiovasc Nurs. 2023;38(6):581–92.
19. Hamasaki H. The effects of mindfulness on glycemic control in people with diabetes: an overview of systematic reviews and meta-analyses. Medicines. 2023;10(9):53.
20. Guo J, Wang H, Ge L, Valimaki M, Wiley J, Whittemore R. Effectiveness of nurse-led mindfulness intervention on diabetes distress and HbA1c: pilot RCT. Res Nurs Health. 2022;45(1):46–58.
21. Dalpatadu K, Galappatthy P, Katulanda P, Jayasinghe S. Effects of meditation on physiological and metabolic parameters in patients with type 2 diabetes: RCT protocol. Trials. 2022;23(1):821.
22. Ngan HY, Chong YY, Chien WT. Effects of mindfulness- and acceptance-based interventions on diabetes distress and glycaemic level in type 2 diabetes: systematic review and meta-analysis. Diabet Med. 2021;38(4):e14525.
23. Ni YX, Ma L, Li JP. Effects of mindfulness-based intervention on glycemic control and psychological outcomes in diabetes: systematic review and meta-analysis. J Diabetes Investig. 2021;12(6):1092–103.
24. Fisher V, Li WW, Malabu U. Effectiveness of MBSR on mental health, HbA1c, and mindfulness in diabetes: systematic review and meta-analysis. Appl Psychol Health Well Being. 2023;15(4):1733–49.
25. Sanogo F, Xu K, Cortessis VK, Weigensberg MJ, Watanabe RM. Mind- and body-based interventions improve glycemic control in type 2 diabetes: systematic review and meta-analysis. J Integr Complement Med. 2023;29(2):69–79.
26. Mangoulia P, Milionis C, Vlachou E, Ilias I, editors. The interrelationship between diabetes mellitus and emotional well-being. Healthcare. 2024.
27. Ravari ON, Mousavi SZ, Babak A. Effects of 12-week MBSR on glycemic control and mental health in women with type 2 diabetes. Adv Biomed Res. 2020;9(1):61.
28. Özdemir AA, Kavak Budak F. Effects of MBSR on hope, psychological well-being, and functional recovery in schizophrenia. Clin Nurs Res. 2022;31(2):183–93.
29. Liu L, Tian L, Jiang J, Zhang Y, Chi X, Liu W, et al. Effect of online MBSR on well-being, burnout, and psychological adaptation in nurses post-pandemic. Holist Nurs Pract. 2023;37(5):244–52.
30. Nurhidayah R, Zuhara N. Effect of MBSR therapy on psychological well-being in mothers of mentally retarded children. J Qual Public Health. 2021;4(2):295–300.
31. Guendelman S, Bayer M, Prehn K, Dziobek I. Mechanistic understanding of MBSR using RCT neuroimaging: effects on stress regulation. NeuroImage. 2022;254:119059.
32. Majidzadeh R, Rezaei S, Akbari B. Self-compassion reduces destructive effects of perceived stress on psychological well-being and self-care in T2DM. Iran J Diabetes Obes. 2022;14(4):189–201.

33. Cohen R, Pereira I, Marguilho M, Sousa M, Ferreira B. Mindfulness approach to sleep disorders. Eur Psychiatry. 2023;66(S1):S1104.
34. Ferrara L, Kaufman SR. Perceived usefulness of MBSR in persons with type 2 diabetes. Diabetes. 2022;71(Suppl 1).
35. Amin Kazemi N, Mohammadi F, Asmakhani Akbarinejad H. Effectiveness of MBSR on sleep quality and well-being in women with epilepsy. Med Sci (IAU Tehran). 2024;34(3):274–83.
36. Pasiar S, Baghouli H, Barzegar M, Sohrabi N. Effectiveness of MBSR on well-being, health anxiety, and body image in women with breast cancer. Nurs Educ. 2023;12(2):101–11.
37. Hatami S, Khakpour M, Safarian Tousi M. Comparing effectiveness of MBSR and emotion-focused therapy on well-being in COVID-19 patients. Clin Psychol Couns Res. 2023;13(1):64–86.
38. Sarvestan N. Analyzing psychological well-being concepts. J Adv Psychol Educ Sci Teach. 2019;2(14):80–96.
39. Shojaei F, Jabal Ameli S, Latifi M. Comparing self-healing and CBT integrated with mindfulness on diabetes distress and blood sugar in type 2 diabetes. Diabetes Nurs. 2022;11(1):2039–56.
40. Mahmoudi F, Zarnaghash M, Sohrabi Shegefti N, Barzegar M. Comparing psychological capital and mindfulness training on well-being in female household heads. Psychol Sci. 2024;23(133):197–214.