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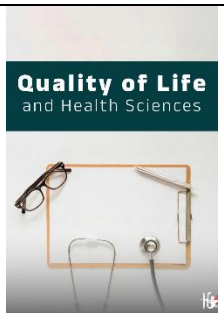

The Effectiveness of Mindfulness-Based Stress Reduction on Perceived Stress, Sleep Quality, and Health-Related Quality of Life Among Patients With Type 2 Diabetes

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A B S T R A C T

Objective: This study aimed to determine the effectiveness of mindfulness-based stress reduction on perceived stress, sleep quality, and health-related quality of life among patients with type 2 diabetes.

Methods and Materials: This quasi-experimental study was conducted using a pretest–posttest control group design with a one-month follow-up. The study population consisted of patients with type 2 diabetes receiving outpatient care in Tehran, Iran. A total of 50 eligible patients were selected through purposive sampling and assigned to an intervention group and a control group, with 25 participants in each group. The intervention group received an eight-session mindfulness-based stress reduction program, while the control group received routine medical care. Data were collected using the Perceived Stress Scale, Pittsburgh Sleep Quality Index, Short Form Health Survey, and a demographic-clinical information form. Data were analyzed using descriptive statistics, assumption tests, repeated-measures analysis of variance, and Bonferroni post hoc comparisons.

Findings: The results of repeated-measures analysis of variance showed significant time, group, and time × group interaction effects for perceived stress, sleep quality, and health-related quality of life. For perceived stress, the time × group interaction was significant ($F = 38.94$, $p < .001$, $\eta^2 = .448$). For sleep quality, the time × group interaction was also significant ($F = 24.63$, $p < .001$, $\eta^2 = .339$). For health-related quality of life, a significant time × group interaction was found as well ($F = 36.52$, $p < .001$, $\eta^2 = .432$). Bonferroni comparisons indicated significant improvement from pretest to posttest and from pretest to follow-up in the intervention group, while posttest–follow-up differences were not significant, showing maintenance of intervention effects. No significant changes were observed in the control group.

Conclusion: Mindfulness-based stress reduction was effective in reducing perceived stress, improving sleep quality, and enhancing health-related quality of life among patients with type 2 diabetes. The stability of findings at follow-up suggests that mindfulness-based stress reduction can be used as a complementary psychological intervention in diabetes care.

Keywords: *Mindfulness-based stress reduction; type 2 diabetes; perceived stress; sleep quality; health-related quality of life; psychological intervention.*

1. Introduction

Type 2 diabetes mellitus is a chronic metabolic condition that requires continuous self-management, long-term behavioral regulation, sustained adherence to treatment, and ongoing psychological adjustment. Although the biomedical management of type 2 diabetes is commonly centered on glycemic control, medication adherence, nutritional regulation, physical activity, and prevention of complications, the lived experience of diabetes extends far beyond metabolic indicators. Patients must repeatedly cope with concerns about disease progression, dietary restrictions, fear of hypoglycemia or hyperglycemia, medication burden, financial and family pressures, reduced physical vitality, and uncertainty about future health. These demands can create a persistent psychological load that affects emotional functioning, sleep, interpersonal life, self-care behavior, and overall health-related quality of life. Contemporary approaches to noncommunicable disease management increasingly emphasize that chronic illnesses should be addressed through integrated models that consider biological, psychological, behavioral, and social dimensions of health, rather than through purely disease-centered frameworks (Carlson et al., 2025; Naveen et al., 2025). Within this perspective, type 2 diabetes is not only a metabolic disorder but also a long-term self-regulatory condition in which stress, sleep, mood, coping style, bodily awareness, and perceived quality of life interact with daily disease management.

Perceived stress is one of the most important psychological factors in the experience of type 2 diabetes because it influences both subjective well-being and the practical capacity to engage in self-care behaviors. Patients who perceive their lives as unpredictable, uncontrollable, or overwhelming may experience greater difficulty maintaining dietary discipline, regular physical activity, medication adherence, glucose monitoring, and attendance at medical appointments. Stress may also intensify emotional eating, fatigue, irritability, hopelessness, and avoidance of health-related responsibilities. In patients with type 2 diabetes, psychological distress is particularly important because diabetes management requires frequent decision-making and continuous behavioral engagement. Interventions designed to improve coping with depression and emotional burden in type 2 diabetes have therefore become a relevant component of chronic disease care (Urrutia & Tufiño, 2024). Evidence from diabetes-focused reviews also suggests that mindfulness-based stress reduction and mindfulness-based cognitive therapy may improve psychological outcomes among people with diabetes, indicating that mindfulness may be especially suitable for patients whose self-management is disrupted by emotional distress and stress reactivity (Ni et al., 2020). Moreover, mind–body interventions have been discussed in relation to diabetes through mechanisms involving stress regulation, biological adaptation, behavioral change, and even possible epigenetic pathways, which strengthens the rationale for examining mindfulness as a complementary psychological intervention for this population (Yang et al., 2021).

Mindfulness-based stress reduction is a structured psychological intervention that trains individuals to intentionally attend to present-moment experience with openness, curiosity, and nonjudgmental awareness. Rather than attempting to eliminate unpleasant thoughts, emotions, or bodily sensations, MBSR teaches patients to relate to them differently, observe internal experiences without automatic reaction, and cultivate more flexible responses to stress. For patients with chronic illness, this orientation is clinically meaningful because symptoms, uncertainty, pain, fatigue, and treatment burden cannot always be fully removed. Mindfulness may help patients reduce secondary suffering by decreasing rumination, catastrophic interpretation, emotional avoidance, and habitual stress reactivity. The theoretical role of mindfulness in stress among cancer patients has been described as a process through which awareness, acceptance, and decentering may reduce the intensity of stress responses and improve psychological adaptation (Maryam, 2023). Similarly, studies of mindfulness after breast cancer diagnosis have suggested that mindfulness is associated with psycho-behavioral improvement, highlighting its potential role in supporting adjustment after a serious health-related life event (Janusek et al., 2020). Although cancer and diabetes differ clinically, both require patients to adapt to uncertainty, bodily vulnerability, long-term health monitoring, and emotional burden, making the broader mindfulness literature relevant for understanding how stress-related mechanisms may operate in chronic disease contexts.

Sleep quality is another key outcome for patients with type 2 diabetes because sleep problems may worsen fatigue, emotional regulation, appetite control, daytime functioning, and motivation for self-care. Poor sleep can also amplify perceived stress, reduce resilience, and diminish quality of life. In patients with diabetes, sleep difficulties may arise from nocturia, pain, neuropathic symptoms, worries about

disease control, medication effects, lifestyle irregularities, or psychological distress. Therefore, interventions that improve sleep without adding medication burden are clinically valuable. An updated systematic review and meta-analysis on mindfulness-based stress reduction in adults with sleep disturbance concluded that MBSR has beneficial effects on sleep-related outcomes, supporting its relevance as a nonpharmacological strategy for improving sleep quality (Kim et al., 2022). Evidence from broader physical health populations also indicates that mindfulness-based interventions can support children, adolescents, adults, and families coping with chronic physical conditions, suggesting that mindfulness may operate across different illness groups by improving emotional regulation, acceptance, and coping capacity (Hughes et al., 2023). In chronic pain and fibromyalgia populations, mindfulness and other mind–body interventions have also been examined as approaches for symptom coping and functional improvement, which is relevant because pain, fatigue, and bodily discomfort often disrupt sleep in chronic illness (Gascón et al., 2021; Leça & Tavares, 2022; Steen et al., 2024). Psychologically based interventions for chronic neuropathic pain further reinforce the importance of targeting cognitive, emotional, and behavioral responses to persistent symptoms, a concern that is highly relevant to diabetes-related discomfort and sleep disruption (Oguchi et al., 2024). In addition, research on self-initiated strategies for pain and sensory disturbances associated with peripheral neuropathy emphasizes the need for patient-centered coping approaches that can be used alongside medical care (Ogle et al., 2020).

Health-related quality of life is a multidimensional construct that reflects the extent to which physical health, emotional well-being, social functioning, vitality, role performance, and perceived general health are affected by disease and treatment. In type 2 diabetes, quality of life may decline as a result of symptom burden, dietary and medication demands, fear of complications, reduced energy, sleep impairment, stress, and limitations in daily activities. Therefore, evaluating the effectiveness of psychological interventions in diabetes should not be limited to stress reduction alone; it should also include sleep and quality of life as patient-centered outcomes. Research in cardiovascular disease has shown that mindfulness therapy may be beneficial for patients with coronary heart disease, suggesting that mindfulness-based approaches have relevance for chronic cardiometabolic conditions in which emotional distress, lifestyle regulation, and physical health are closely intertwined (Li et al., 2024). Integrative psychological support has also been emphasized in cardiac surgical nursing, particularly in relation to recovery, emotional adjustment, and evidence gaps in perioperative and rehabilitation contexts (Li et al., 2025). Interventions promoting self-management in cardiovascular disease similarly indicate that chronic illness care benefits from approaches that strengthen engagement, coping, and social functioning, rather than focusing only on biomedical indicators (Korenhof et al., 2022). Surgical patient literature further suggests that mindfulness-based interventions may influence postoperative outcomes, patient well-being, and satisfaction, supporting the broader clinical value of mindfulness for people facing bodily vulnerability and health-related stress (Hymowitz et al., 2022).

A substantial part of the evidence base for mindfulness-based interventions comes from oncology, where patients often experience stress, fear of recurrence, fatigue, sleep disturbance, cognitive complaints, pain, and quality-of-life impairment. Although oncology populations are clinically different from patients with type 2 diabetes, the oncology literature is important because it provides strong evidence that mindfulness can be adapted to serious chronic health contexts and evaluated using psychological, physical, and quality-of-life outcomes. Randomized and systematic studies of mindfulness-based stress reduction among breast cancer survivors have reported psychological and physical benefits and have examined mediators of intervention-related improvement (Lengacher et al., 2021; Lengacher et al., 2020). More recent randomized clinical trial evidence has also evaluated mediators of cognitive improvement following MBSR among breast cancer survivors, showing continued refinement of the evidence base regarding how mindfulness may produce changes in functioning (Lengacher et al., 2025). Short-term randomized mindfulness-based interventions in female breast cancer survivors have similarly supported the usefulness of mindfulness for improving adjustment in post-treatment survivorship (Chang et al., 2021). Studies and reviews of online MBSR and web-based mindfulness interventions among cancer patients further suggest that mindfulness can be delivered in flexible formats and may improve psychological and quality-of-life outcomes, which is important for chronic disease populations that may face barriers to frequent in-person care (Hydeman et al., 2022; Wang et al., 2023, 2024). Systematic reviews of mindfulness-based interventions for lung cancer survivors and their partners, adolescents and young adults with cancer, and women living with breast cancer also highlight the

increasing emphasis on integrative, accessible, and survivorship-oriented psychological care (McDonnell et al., 2022; Vitale, 2025; Yusuf et al., 2024).

The growing literature on mindfulness and related third-wave interventions also shows that mindfulness is no longer confined to one disease category or one clinical setting. Scoping reviews in oncology have mapped a wide range of outcomes and applications for mindfulness-based interventions, including emotional symptoms, coping, quality of life, fatigue, and supportive care needs (Chen et al., 2025). Reviews of mindfulness-based cognitive behavioral therapy for anxiety in women with breast cancer further indicate that mindfulness-oriented methods are increasingly used to address anxiety and emotional burden in vulnerable patient groups (Yalico & Chinchilla-Fonseca, 2024). Multidisciplinary programs that combine diet, exercise, and mindfulness have also been examined in relation to quality of life among breast cancer survivors, suggesting that mindfulness may be particularly useful when embedded in broader lifestyle and self-management frameworks (Ruiz-Vozmediano et al., 2020). Educational programs for post-treatment breast cancer survivors have emphasized the value of structured supportive interventions for long-term adjustment and health behavior, which parallels the need for structured psychological support in diabetes care (Lin et al., 2022). Mindfulness-related approaches have also been extended to caregivers of cancer patients and caregivers of persons with dementia and neurodegenerative diseases, showing that mindfulness is relevant not only for patients but also for individuals facing chronic caregiving stress and sustained emotional demands (Hong et al., 2023; Mallya, 2023). In addition, the interrelationships between mindfulness-based interventions, depression, inflammation, and cancer survival have been discussed, indicating growing interest in both psychological and biological pathways of mindfulness-related change (Marinovic & Hunter, 2022).

Despite this expanding evidence base, important gaps remain in the application of mindfulness-based stress reduction to patients with type 2 diabetes, especially when perceived stress, sleep quality, and health-related quality of life are examined together in a controlled intervention design. Many studies have focused on cancer, pain, surgical recovery, cardiovascular disease, or caregiver populations, while diabetes-specific evidence remains comparatively more limited and requires further empirical support in different sociocultural and healthcare contexts. This gap is important because patients with type 2 diabetes face a distinctive combination of metabolic self-management, lifestyle regulation, psychological stress, sleep disturbance, and long-term risk of complications. In settings such as Tehran, where patients may encounter urban stressors, healthcare access challenges, family responsibilities, and culturally specific patterns of coping and self-care, examining the effectiveness of MBSR can provide practical evidence for integrating psychological interventions into diabetes care. Furthermore, studying stress, sleep, and quality of life simultaneously allows a more comprehensive understanding of whether MBSR produces isolated psychological improvement or broader functional benefits relevant to daily life and disease management.

The aim of this study was to determine the effectiveness of mindfulness-based stress reduction on perceived stress, sleep quality, and health-related quality of life among patients with type 2 diabetes in Tehran.

2. Methods and Materials

2.1. Study Design and Participants

This study was conducted using a quasi-experimental design with a pretest–posttest control group and follow-up assessment. The statistical population consisted of adult patients with type 2 diabetes who were receiving outpatient medical care at diabetes clinics and endocrinology centers in Tehran, Iran. A total of 50 patients with type 2 diabetes were selected through purposive sampling based on the study eligibility criteria and were then assigned to two equal groups, including 25 participants in the intervention group and 25 participants in the control group. The inclusion criteria were a confirmed medical diagnosis of type 2 diabetes by an endocrinologist, age between 35 and 65 years, at least one year having passed since diagnosis, ability to read and understand Persian, willingness to participate in the study, and absence of participation in any concurrent psychological or mindfulness-based intervention during the study period. The exclusion criteria included diagnosis of severe psychiatric disorders, serious diabetes-related complications requiring hospitalization, use of sedative or hypnotic medications in a manner that could substantially affect sleep assessment, absence from more than two intervention sessions, and withdrawal of consent at any stage of the study. Before the beginning of the intervention, all participants completed the pretest measures. The intervention group received the mindfulness-based stress reduction program, while the control group received routine medical care and did not participate in any structured

psychological intervention during the same period. Immediately after completion of the intervention, both groups completed the posttest measures, and a follow-up assessment was conducted after one month to evaluate the stability of the intervention effects. Ethical considerations were observed throughout the study, including voluntary participation, confidentiality of personal information, explanation of the study objectives, and obtaining written informed consent from all participants.

2.2. Measures

Data were collected using standardized self-report questionnaires assessing perceived stress, sleep quality, and health-related quality of life. Perceived stress was measured using the Perceived Stress Scale, which evaluates the degree to which individuals appraise situations in their lives as stressful, unpredictable, uncontrollable, and overwhelming. This instrument includes items rated on a Likert-type scale, with higher scores indicating greater perceived stress. Sleep quality was assessed using the Pittsburgh Sleep Quality Index, which measures subjective sleep quality over the previous month and evaluates different dimensions of sleep, including sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, daytime dysfunction, and overall perceived sleep quality. Higher scores on this instrument indicate poorer sleep quality. Health-related quality of life was measured using the Short Form Health Survey, which assesses physical and psychological dimensions of quality of life, including physical functioning, role limitations due to physical problems, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems, and mental health. Higher scores indicate better perceived health-related quality of life. In addition to the main questionnaires, a demographic and clinical information form was used to collect data on age, gender, marital status, educational level, duration of diabetes, type of treatment, and presence of common diabetes-related complications. The intervention consisted of an eight-session mindfulness-based stress reduction program delivered once weekly, with each session lasting approximately 90 minutes. The sessions included training in mindful breathing, body scan, sitting meditation, mindful movement, awareness of thoughts and emotions, stress reactivity, acceptance of unpleasant experiences, and application of mindfulness skills in daily diabetes self-care. Participants in the intervention group were also encouraged to practice mindfulness exercises at home between sessions.

2.3. Intervention

The intervention protocol consisted of an eight-session mindfulness-based stress reduction program delivered to the experimental group over eight consecutive weeks, with one 90-minute session held each week. The program was designed to help patients with type 2 diabetes develop present-moment awareness, reduce automatic stress reactions, improve emotional regulation, and apply mindfulness skills to daily disease management. In the first session, participants were introduced to the goals and principles of mindfulness, the relationship between stress and diabetes management, and basic mindful breathing exercises. The second session focused on body scan meditation and awareness of bodily sensations without judgment, helping participants observe physical tension and diabetes-related bodily concerns more calmly. The third session emphasized sitting meditation, awareness of thoughts and emotions, and recognition of habitual stress responses. The fourth session trained participants in mindful movement and gentle stretching appropriate for their physical condition, with attention to breathing and bodily limits. The fifth session focused on stress reactivity, acceptance of unpleasant experiences, and nonjudgmental observation of worry, fear, and frustration related to diabetes. The sixth session addressed mindful communication, emotional awareness, and coping with interpersonal and family-related stressors that may affect self-care behaviors. The seventh session emphasized the integration of mindfulness into diabetes self-management activities, including medication adherence, eating behavior, glucose monitoring, sleep preparation, and response to fatigue or discomfort. The final session reviewed the skills learned throughout the program, discussed barriers to continued practice, and developed individualized plans for maintaining mindfulness exercises after the intervention. Participants were encouraged to practice mindfulness exercises at home between sessions, including mindful breathing, body scan, and brief daily awareness practices, and the control group received only routine medical care during the same period.

2.4. Data Analysis

Data analysis was performed using SPSS software. Descriptive statistics, including mean, standard deviation,

frequency, and percentage, were used to describe the demographic and clinical characteristics of the participants and the main study variables. Before conducting inferential analyses, the assumptions of parametric testing were examined, including normality of distribution, homogeneity of variances, homogeneity of covariance matrices, and sphericity where applicable. The Shapiro–Wilk test was used to examine normality, Levene's test was used to assess equality of variances, and Mauchly's test was used to examine the assumption of sphericity. To evaluate the effectiveness of mindfulness-based stress reduction on perceived stress, sleep quality, and health-related quality of life across the pretest, posttest, and follow-up stages, repeated-measures analysis of variance was used with group as the between-subjects factor and time as the within-subjects factor. When significant interaction effects between time and group were observed, Bonferroni post hoc comparisons were applied to determine the specific differences between measurement stages. The level of statistical significance was set at $p < .05$ for all analyses. The results were interpreted based on changes in the intervention group compared with the control group, with particular attention to whether reductions in perceived stress and sleep problems and improvements in health-related quality of life were maintained at the follow-up assessment.

3. Findings and Results

The study included 50 patients with type 2 diabetes who were assigned to the mindfulness-based stress reduction group and the control group, with 25 participants in each group. The demographic and clinical characteristics of the participants indicated that the two groups were comparable before the intervention. In the intervention group, the mean age of participants was 54.18 years with a standard deviation of 7.06, while in the control group the mean age was 53.64 years with a standard deviation of 6.89. Overall, 29 participants were women and 21 were men. In the intervention group, 15 participants were women and 10 were men, and in the control group, 14 participants were women and 11 were men. Most participants were married, with 20 married participants in the intervention group and 19 married participants in the control group. Regarding educational status, the majority of participants had completed secondary school or held a diploma-level education, while a smaller proportion had university education. The mean duration of type 2 diabetes was 8.72 years with a standard deviation of 3.84 in the intervention group and 8.39 years with a standard deviation of 3.67 in the control group. In terms of treatment pattern, most participants were receiving oral antidiabetic medication, while some were receiving insulin or combined medication regimens. Preliminary comparisons showed no statistically significant differences between the intervention and control groups in age, gender distribution, marital status, educational level, duration of diabetes, or treatment type. Therefore, the two groups were considered demographically and clinically homogeneous at baseline, and subsequent differences observed after the intervention could be interpreted in relation to the mindfulness-based stress reduction program rather than pre-existing group differences.

Table 1

Descriptive Statistics of Perceived Stress, Sleep Quality, and Health-Related Quality of Life Across the Three Measurement Stages

Variable	Group	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Follow-up Mean	Follow-up SD
Perceived stress	Mindfulness-based stress reduction	27.84	5.11	19.36	4.72	19.92	4.89
Perceived stress	Control	27.12	5.36	26.48	5.27	26.84	5.42
Sleep quality	Mindfulness-based stress reduction	10.76	2.64	6.68	2.18	6.96	2.24
Sleep quality	Control	10.44	2.51	10.08	2.57	10.20	2.62
Health-related quality of life	Mindfulness-based stress reduction	48.72	10.46	63.88	9.71	62.96	9.84
Health-related quality of life	Control	49.56	10.31	50.24	10.18	50.08	10.37

As shown in Table 1, the descriptive findings indicated that patients in the mindfulness-based stress reduction group experienced meaningful improvement from pretest to posttest in all three outcome variables. The mean score of perceived stress in the intervention group decreased from 27.84 at pretest to 19.36 at posttest and remained relatively stable at 19.92 during the follow-up stage. This pattern suggests that participation in the mindfulness-based stress

reduction program was associated with a substantial reduction in perceived stress and that this reduction was largely maintained one month after the completion of the intervention. In contrast, the control group showed only a very small decrease in perceived stress from pretest to posttest, followed by a slight increase at follow-up, indicating no meaningful change over time. Sleep quality also improved in the intervention group, as reflected by a decrease in mean sleep quality scores from 10.76 at pretest to 6.68 at posttest and 6.96 at follow-up. Because higher scores on the sleep quality index indicate poorer sleep quality, this reduction demonstrates improvement in subjective sleep quality among patients who received mindfulness-based stress reduction. The control group again showed minimal change across the three stages. Health-related quality of life improved markedly in the intervention group, increasing from 48.72 at pretest to 63.88 at posttest and remaining high at 62.96 during follow-up. However, the control group showed only negligible changes in health-related quality of life scores. Overall, the descriptive pattern indicates that mindfulness-based stress reduction was associated with reduced perceived stress, improved sleep quality, and enhanced health-related quality of life among patients with type 2 diabetes, while routine care alone was not associated with comparable improvement.

Before conducting the main inferential analysis, the assumptions required for repeated-measures analysis of variance were examined. The results of the Shapiro–Wilk test indicated that the distributions of perceived stress, sleep quality, and health-related quality of life scores were not significantly different from normal distribution across the measurement stages in either group, with all significance values greater than .05. Levene's test also confirmed the homogeneity of error variances for the dependent variables at the pretest, posttest, and follow-up stages. In addition, the assumption of equality of covariance matrices was examined and supported. Mauchly's test of sphericity was not significant for perceived stress, sleep quality, or health-related quality of life, indicating that the assumption of sphericity was met for the repeated-measures comparisons. Accordingly, repeated-measures analysis of variance was used to examine the main effect of time, the main effect of group, and the interaction effect of time and group.

Table 2

Repeated-Measures Analysis of Variance for the Effects of Time, Group, and Time × Group Interaction

Variable	Effect	df	F	p	Partial Eta Squared
Perceived stress	Time	2, 96	54.27	< .001	.531
Perceived stress	Group	1, 48	9.86	.003	.170
Perceived stress	Time × Group	2, 96	38.94	< .001	.448
Sleep quality	Time	2, 96	32.18	< .001	.401
Sleep quality	Group	1, 48	7.92	.007	.142
Sleep quality	Time × Group	2, 96	24.63	< .001	.339
Health-related quality of life	Time	2, 96	49.76	< .001	.509
Health-related quality of life	Group	1, 48	10.41	.002	.178
Health-related quality of life	Time × Group	2, 96	36.52	< .001	.432

As presented in Table 2, the repeated-measures analysis of variance demonstrated statistically significant effects for all three study variables. For perceived stress, the main effect of time was significant, indicating that perceived stress scores changed significantly across the pretest, posttest, and follow-up stages. The main effect of group was also significant, showing an overall difference between the mindfulness-based stress reduction group and the control group. More importantly, the interaction effect of time and group was statistically significant, indicating that the pattern of change in perceived stress over time differed significantly between the two groups. This finding shows that the reduction in perceived stress was not merely the result of repeated measurement or passage of time, but was specifically associated with participation in the mindfulness-based stress reduction intervention. For sleep quality, the main effect of time, the main effect of group, and the time × group interaction were also significant. Since lower scores on the sleep quality index indicate better sleep quality, these results suggest that the intervention group experienced a significantly greater improvement in sleep quality compared with the control group. For health-related quality of life, the significant main effect of time showed that quality of life scores changed across the three stages, while the significant group effect indicated overall differences between the intervention and control groups. The significant interaction

effect further confirmed that improvement in health-related quality of life was substantially greater among participants who received mindfulness-based stress reduction. The partial eta squared values indicated moderate to large effect sizes, particularly for the time × group interactions, suggesting that mindfulness-based stress reduction had a meaningful and clinically relevant effect on psychological stress, sleep quality, and health-related quality of life in patients with type 2 diabetes.

Table 3

Bonferroni Post Hoc Comparisons of Outcome Variables Across Measurement Stages

Variable	Group	Comparison	Mean Difference	Standard Error	p	95% Confidence Interval
Perceived stress	Mindfulness-based stress reduction	Posttest – Pretest	-8.48	1.03	< .001	-10.91 to -6.05
Perceived stress	Mindfulness-based stress reduction	Follow-up – Pretest	-7.92	1.08	< .001	-10.46 to -5.38
Perceived stress	Mindfulness-based stress reduction	Follow-up – Posttest	0.56	0.71	.742	-1.12 to 2.24
Perceived stress	Control	Posttest – Pretest	-0.64	0.88	.612	-2.72 to 1.44
Perceived stress	Control	Follow-up – Pretest	-0.28	0.91	.887	-2.43 to 1.87
Perceived stress	Control	Follow-up – Posttest	0.36	0.69	.815	-1.27 to 1.99
Sleep quality	Mindfulness-based stress reduction	Posttest – Pretest	-4.08	0.54	< .001	-5.35 to -2.81
Sleep quality	Mindfulness-based stress reduction	Follow-up – Pretest	-3.80	0.58	< .001	-5.17 to -2.43
Sleep quality	Mindfulness-based stress reduction	Follow-up – Posttest	0.28	0.37	.846	-0.59 to 1.15
Sleep quality	Control	Posttest – Pretest	-0.36	0.42	.705	-1.35 to 0.63
Sleep quality	Control	Follow-up – Pretest	-0.24	0.45	.819	-1.30 to 0.82
Sleep quality	Control	Follow-up – Posttest	0.12	0.31	.913	-0.61 to 0.85
Health-related quality of life	Mindfulness-based stress reduction	Posttest – Pretest	15.16	1.86	< .001	10.77 to 19.55
Health-related quality of life	Mindfulness-based stress reduction	Follow-up – Pretest	14.24	1.91	< .001	9.73 to 18.75
Health-related quality of life	Mindfulness-based stress reduction	Follow-up – Posttest	-0.92	1.24	.613	-3.85 to 2.01
Health-related quality of life	Control	Posttest – Pretest	0.68	1.43	.842	-2.70 to 4.06
Health-related quality of life	Control	Follow-up – Pretest	0.52	1.49	.901	-3.00 to 4.04
Health-related quality of life	Control	Follow-up – Posttest	-0.16	0.97	.974	-2.45 to 2.13

The Bonferroni post hoc comparisons presented in Table 3 provide a more detailed explanation of the observed changes across time. In the mindfulness-based stress reduction group, perceived stress decreased significantly from pretest to posttest and from pretest to follow-up. However, the difference between posttest and follow-up was not statistically significant, indicating that the reduction in perceived stress achieved after the intervention was maintained during the follow-up period. In the control group, none of the pairwise comparisons for perceived stress were statistically significant, showing that routine care alone did not produce meaningful change in perceived stress. A similar pattern was observed for sleep quality. The mindfulness-based stress reduction group showed significant improvement from pretest to posttest and from pretest to follow-up, while the non-significant difference between posttest and follow-up indicated stability of the intervention effect. The control group did not show significant changes in sleep quality across any of the measurement stages. For health-related quality of life, the intervention group showed a significant increase from pretest to posttest and from pretest to follow-up, while the small difference between posttest and follow-up was not significant. This pattern demonstrates that the improvement

in health-related quality of life was sustained after the intervention. In contrast, the control group showed no significant improvement in health-related quality of life across time. Taken together, the post hoc findings confirm that mindfulness-based stress reduction produced significant and stable improvements in perceived stress, sleep quality, and health-related quality of life among patients with type 2 diabetes, whereas the control condition was associated with no statistically meaningful changes.

4. Discussion

The present study examined the effectiveness of mindfulness-based stress reduction on perceived stress, sleep quality, and health-related quality of life among patients with type 2 diabetes. The findings showed that patients who participated in the mindfulness-based stress reduction program experienced a significant reduction in perceived stress from pretest to posttest, and this reduction remained stable at the follow-up stage. In contrast, the control group did not show a meaningful change in perceived stress across the three measurement stages. This result indicates that mindfulness-based stress reduction was effective in decreasing the subjective appraisal of stress among patients with type 2 diabetes. This finding is theoretically meaningful because diabetes is a chronic condition that exposes patients to continuous self-management demands, uncertainty about disease progression, dietary restrictions, medication adherence, fear of complications, and repeated monitoring of bodily symptoms. Mindfulness-based stress reduction may reduce perceived stress by helping patients observe stressful thoughts and bodily sensations without immediate emotional reactivity, reinterpret daily diabetes-related demands with greater acceptance, and shift from automatic worry-based responses to more deliberate coping responses. This interpretation is consistent with diabetes-focused evidence showing that mindfulness-based stress reduction and mindfulness-based cognitive therapy can improve psychological outcomes among people with diabetes (Ni et al., 2020). It is also aligned with studies emphasizing the relevance of mind–body interventions in diabetes, including their potential effects on stress regulation, biological adaptation, and behavioral self-management (Yang et al., 2021). The result is further supported by broader literature on noncommunicable disease management, which suggests that meditation and mindfulness-based approaches can be useful complementary strategies for improving coping in chronic diseases (Naveen et al., 2025).

The reduction in perceived stress observed in the intervention group may be explained by the core mechanisms of mindfulness-based stress reduction. Patients with type 2 diabetes often experience stress not only because of objective disease demands but also because of how those demands are appraised and emotionally processed. Mindfulness training encourages individuals to become aware of thoughts, emotions, and bodily sensations as transient experiences rather than fixed realities or threats. Through practices such as mindful breathing, body scan, sitting meditation, and nonjudgmental awareness, patients may learn to identify early signs of emotional tension and respond to them with acceptance rather than avoidance or catastrophizing. This mechanism is consistent with theoretical explanations of mindfulness in stress among patients with serious physical illnesses, where mindfulness is understood to reduce stress by increasing awareness, acceptance, emotional regulation, and cognitive decentering (Maryam, 2023). Similar patterns have been reported in cancer-related research, where mindfulness has been associated with psycho-behavioral improvement following diagnosis and treatment (Janusek et al., 2020). Randomized trials and mediator analyses among breast cancer survivors have also shown that mindfulness-based stress reduction can influence psychological and physical outcomes through pathways related to emotional regulation, symptom awareness, and coping processes (Lengacher et al., 2021; Lengacher et al., 2020; Lengacher et al., 2025). Although the present study was conducted among patients with type 2 diabetes rather than cancer survivors, the psychological mechanisms of chronic illness adaptation are comparable in several respects, particularly regarding uncertainty, health-related worry, bodily monitoring, and long-term adjustment.

The findings also demonstrated that mindfulness-based stress reduction significantly improved sleep quality among patients with type 2 diabetes. The mean sleep quality score decreased from pretest to posttest in the intervention group, indicating better sleep, and the improvement was maintained at follow-up. No significant change was observed in the control group. This finding is important because sleep disturbance is a common and clinically relevant problem in chronic metabolic conditions. Patients with type 2 diabetes may experience poor sleep due to nocturia, physical discomfort, neuropathic symptoms, anxiety about glycemic control, daytime fatigue, and persistent stress. Poor sleep can also worsen emotional regulation and reduce the patient's

capacity for self-care. The present findings are consistent with an updated systematic review and meta-analysis showing that mindfulness-based stress reduction has beneficial effects on sleep disturbance among adults (Kim et al., 2022). The result can also be interpreted in light of evidence from chronic pain and fibromyalgia populations, where mindfulness and mind–body therapies have been examined as approaches for reducing symptom burden, improving coping, and supporting sleep-related functioning (Gascón et al., 2021; Leça & Tavares, 2022; Steen et al., 2024). Because sleep problems in diabetes are often linked with stress, discomfort, and cognitive arousal, mindfulness may improve sleep by reducing rumination, relaxing the body, decreasing hyperarousal, and helping patients disengage from repetitive worry before bedtime.

The improvement in sleep quality may also reflect the indirect effect of stress reduction. When perceived stress decreases, patients may experience fewer intrusive thoughts, less physiological arousal, and improved ability to settle into sleep. Mindfulness practices may regulate attention and reduce the tendency to remain mentally engaged with disease-related concerns at night. In addition, body scan exercises may increase bodily awareness without fear-based interpretation of sensations, thereby helping patients relate to discomfort with less tension. This explanation is supported by literature on psychologically based interventions for chronic neuropathic pain, which emphasizes that changing cognitive and emotional responses to persistent symptoms can improve adjustment and daily functioning (Oguchi et al., 2024). It is also compatible with evidence on self-initiated interventions for sensory disturbances and neuropathy-related symptoms, where coping-oriented strategies are considered valuable components of symptom management (Ogle et al., 2020). Furthermore, studies on mindfulness-based interventions among surgical patients and patients with physical health conditions suggest that mindfulness may support well-being, satisfaction, and recovery by reducing distress and enhancing adaptive self-regulation (Hughes et al., 2023; Hymowitz et al., 2022). Therefore, the sleep-related improvement found in the present study can be understood as part of a broader self-regulatory benefit of mindfulness, in which psychological calmness, reduced cognitive arousal, and increased acceptance contribute to better subjective sleep quality.

Another major finding of the present study was that mindfulness-based stress reduction significantly improved health-related quality of life among patients with type 2 diabetes. Participants in the intervention group showed a substantial increase in quality-of-life scores from pretest to posttest, and this improvement was sustained at follow-up. The control group showed only minimal change. This finding indicates that the benefits of mindfulness-based stress reduction were not limited to reducing distress but extended to broader perceptions of physical, emotional, and functional well-being. Health-related quality of life in diabetes is influenced by psychological stress, sleep quality, fatigue, treatment burden, perceived control, social functioning, and confidence in disease management. By reducing stress and improving sleep, mindfulness-based stress reduction may indirectly improve energy, mood, role functioning, and overall health perception. This interpretation is consistent with integrative medicine approaches that emphasize the need to address emotional, behavioral, and quality-of-life dimensions of disease management (Carlson et al., 2025). It is also aligned with evidence from cardiovascular and cardiac populations showing that mindfulness therapy and integrative psychological support can contribute to improved adjustment, well-being, and quality-of-life-related outcomes in chronic physical conditions (Li et al., 2024; Li et al., 2025). Similarly, interventions designed to strengthen self-management in cardiovascular disease support the idea that psychosocial and behavioral interventions can improve chronic disease adaptation beyond symptom control alone (Korenhof et al., 2022).

The improvement in health-related quality of life may be explained by several interrelated pathways. First, mindfulness may increase patients' sense of control over their responses to diabetes-related stress, even when they cannot fully control the disease itself. Second, mindfulness may reduce avoidance and emotional resistance, helping patients engage more consistently with self-care behaviors. Third, improved sleep may enhance vitality and daily functioning. Fourth, acceptance-based awareness may reduce the psychological burden associated with chronic symptoms and future-oriented fears. Evidence from oncology supports these pathways, as mindfulness-based interventions have been associated with improvements in quality of life, psychological adaptation, fatigue, anxiety, and survivorship-related concerns (Chen et al., 2025; Yusuf et al., 2024). Web-based and online mindfulness studies in cancer populations also indicate that mindfulness can improve patient-centered outcomes and may be adaptable to different delivery formats (Hydeman et al., 2022; Wang et al., 2023, 2024). In addition, research on internet-based

interventions for quality-of-life assessment among women with breast cancer highlights the growing role of accessible psychosocial interventions in improving patient-reported outcomes (Vitale, 2025). Although these studies were conducted mainly in oncology, their findings support the broader conclusion that mindfulness-based interventions can enhance quality of life among individuals facing chronic disease burden and long-term health-related uncertainty.

The stability of intervention effects at follow-up is another important aspect of the findings. The Bonferroni comparisons showed significant improvements from pretest to posttest and from pretest to follow-up in perceived stress, sleep quality, and health-related quality of life, while the differences between posttest and follow-up were not significant. This pattern indicates that the improvements achieved after the mindfulness-based stress reduction program were maintained during the follow-up period. The sustained effect may be due to the practical nature of mindfulness skills, which patients can continue using in daily life after formal sessions end. Unlike interventions that depend entirely on the therapist or clinical setting, mindfulness-based stress reduction teaches repeatable self-regulation practices that can be applied during stressful situations, before sleep, while managing symptoms, or during daily diabetes self-care. This finding is consistent with studies of structured mindfulness and educational interventions among breast cancer survivors, which suggest that organized programs can have continuing benefits for adjustment and functioning after treatment (Chang et al., 2021; Lin et al., 2022). It is also supported by multidisciplinary approaches incorporating mindfulness, diet, and exercise, where quality-of-life benefits may emerge through repeated practice and integration into daily routines (Ruiz-Vozmediano et al., 2020). The maintenance of effects is particularly relevant for diabetes care because patients need sustainable strategies that can be used beyond the short-term intervention period.

The present results are also consistent with the broader expansion of mindfulness and third-wave cognitive-behavioral approaches across patient and caregiver populations. Scoping reviews of third-wave cognitive behavioral therapies for caregivers of cancer patients and mindfulness-based interventions for caregivers of individuals with dementia suggest that mindfulness-based approaches can reduce distress and improve well-being in people exposed to sustained caregiving and health-related burden (Hong et al., 2023; Mallya, 2023). This is relevant because patients with type 2 diabetes similarly live with ongoing responsibility, vigilance, and repeated emotional demands. Reviews of mindfulness-based interventions for lung cancer survivors and their partners further demonstrate that mindfulness may support both patients and close relational systems, emphasizing its value in chronic illness contexts where psychological burden often affects family life as well as individual functioning (McDonnell et al., 2022). Evidence on mindfulness-based cognitive behavioral therapy for anxiety among women with breast cancer also supports the effectiveness of mindfulness-oriented psychological strategies for reducing emotional symptoms in vulnerable clinical groups (Yalico & Chinchilla-Fonseca, 2024). In addition, research exploring links among mindfulness, depression, inflammation, and cancer survival suggests that mindfulness may influence both psychological and biological pathways, although more research is needed to clarify these mechanisms in diabetes (Marinovic & Hunter, 2022). Overall, the present findings add to this growing literature by showing that mindfulness-based stress reduction may be beneficial for patients with type 2 diabetes across stress, sleep, and quality-of-life outcomes.

5. Conclusion

The findings of this study have important clinical implications. Patients with type 2 diabetes frequently receive medical guidance regarding medication, diet, and physical activity, but their psychological needs may be insufficiently addressed in routine care. The present results suggest that mindfulness-based stress reduction can be used as a complementary intervention to reduce perceived stress, improve sleep quality, and enhance quality of life. Because these outcomes are closely related to self-management capacity, emotional well-being, and daily functioning, integrating MBSR into diabetes care may improve the overall effectiveness of chronic disease management. The findings also support the movement toward integrative care models in which psychological interventions are not viewed as secondary or optional, but as essential components of long-term disease care. In practical terms, MBSR may help patients become more aware of stress reactions, reduce emotional overidentification with disease-related worries, improve bedtime relaxation, and approach self-care tasks with greater patience and acceptance. Therefore, the results provide empirical support for the inclusion of mindfulness-based stress reduction in psychosocial programs for patients with type 2 diabetes, particularly for those who experience high stress, poor sleep, and reduced quality of life.

6. Limitations & Suggestions

This study had several limitations that should be considered when interpreting the findings. First, the sample size was relatively small, with 50 participants from Tehran, which may limit the generalizability of the results to broader populations of patients with type 2 diabetes in other regions or healthcare settings. Second, the study used self-report measures for perceived stress, sleep quality, and health-related quality of life, which may be influenced by response bias, social desirability, or individual differences in self-perception. Third, the follow-up period was limited to one month, so the long-term durability of the intervention effects remains unclear. Fourth, the study did not include objective biomedical indicators such as HbA1c, fasting blood glucose, inflammatory markers, or actigraphy-based sleep measures, which could have provided a more comprehensive understanding of the clinical impact of the intervention. Finally, although the control group received routine care, the study did not include an active psychological control condition, and therefore the effects of attention, group support, and expectancy cannot be completely separated from the specific effects of mindfulness practice.

Future studies should replicate this research with larger and more diverse samples of patients with type 2 diabetes across different cities, clinical centers, socioeconomic groups, and age ranges. It is also recommended that future research use randomized controlled trial designs with active comparison groups, such as diabetes education, relaxation training, cognitive-behavioral stress management, or supportive counseling, to clarify the specific effects of mindfulness-based stress reduction. Longer follow-up periods, such as three months, six months, or one year, would help determine whether the improvements in stress, sleep, and quality of life remain stable over time. Future studies should also combine self-report questionnaires with objective clinical and behavioral indicators, including glycemic control, blood pressure, inflammatory markers, physical activity, medication adherence, and objective sleep assessment. In addition, researchers may examine mediating mechanisms such as emotion regulation, mindfulness skills, acceptance, rumination, self-compassion, and diabetes self-efficacy to better explain how mindfulness-based stress reduction produces change in patients with type 2 diabetes.

The findings suggest that mindfulness-based stress reduction can be incorporated into diabetes care as a complementary psychological intervention alongside routine medical treatment. Diabetes clinics and endocrinology centers can offer structured mindfulness programs for patients who report high stress, poor sleep, emotional fatigue, or reduced quality of life. Healthcare professionals should consider screening patients for psychological stress and sleep problems as part of routine diabetes management and refer suitable patients to mindfulness-based or other evidence-based psychosocial interventions. Nurses, psychologists, diabetes educators, and health counselors can be trained to deliver brief mindfulness exercises, breathing practices, body awareness techniques, and stress-management strategies in clinical settings. It is also useful to encourage patients to continue home practice after the formal intervention period, because sustained practice may help maintain improvements in daily coping, sleep regulation, and quality of life. Integrating mindfulness into diabetes care may strengthen patient-centered treatment by addressing not only biological control but also the emotional and functional burden of living with type 2 diabetes.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this article.

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