

The Effectiveness of Yoga on Fatigue, Chronic Pain, Sleep Quality, and Psychological Well-Being in Patients with Type 2 Diabetes

Babak. SaebDoost¹, Shahab. Moradi^{1*}, Parvin. Rafieinia², Maryam. Izadi Mazidi³

¹ Department of Psychology, Se.C., Islamic Azad University, Semnan, Iran

² Associate Professor, Department of Psychology and Educational Sciences, Semnan University, Semnan, Iran

³ Assistant Professor, Department of Psychology, Faculty of Literature and Humanities, University of Yasouj, Yasouj, Iran

* Corresponding author email address: Shahab.moradi@iau.ac.ir

Article Info

Article type:

Original Research

Section:

Clinical Psychology

How to cite this article:

SaebDoost, B., Moradi, S., Rafieinia, P., & Izadi Mazidi, M. (2027). The Effectiveness of Yoga on Fatigue, Chronic Pain, Sleep Quality, and Psychological Well-Being in Patients with Type 2 Diabetes. *KMAN Counseling and Psychology Nexus*, 5, 1-14.
<http://doi.org/10.61838/kman.psyrnexus.6446>



© 2027 the authors. Published by KMAN Publication Inc. (KMANPUB), Ontario, Canada. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) License.

ABSTRACT

Type 2 diabetes is one of the most prevalent chronic metabolic diseases and, in addition to its physical complications, has profound effects on patients' mental health and quality of life. The present study aimed to investigate the effectiveness of yoga exercises in improving fatigue, sleep quality, and psychological well-being among patients with type 2 diabetes. This study employed a quasi-experimental pretest-posttest design with a control group. The statistical population consisted of patients with type 2 diabetes who attended the Tehran Diabetes Association and comprehensive health service centers affiliated with Tehran University of Medical Sciences during 2025–2026. Participants were selected through random sampling and assigned to a yoga group (n = 16) and a control group (n = 16). Participants in the yoga group attended 16 sessions of yoga training, each lasting 60 minutes. Data were collected using standardized measures of fatigue, sleep quality, the McGill Pain Questionnaire, and Ryff's Psychological Well-Being Scales and were analyzed using analysis of covariance (ANCOVA). The results indicated that the yoga intervention significantly reduced fatigue and chronic pain and improved sleep quality and psychological well-being among patients with type 2 diabetes. The greatest improvements were observed in the reduction of chronic pain and enhancement of sleep quality. The findings demonstrate the effectiveness of yoga exercises in managing symptoms associated with type 2 diabetes. Given the specific benefits of this approach, it is recommended that pharmacological treatment programs be complemented by yoga exercises tailored to patients' individual needs.

Keywords: Type 2 diabetes, yoga, fatigue, sleep quality, psychological well-being.

1. Introduction

Type 2 diabetes mellitus is one of the most prevalent chronic metabolic disorders worldwide and represents a major challenge for contemporary healthcare systems because of its progressive nature, high burden of complications, and extensive effects on physical, psychological, and social functioning. The disease is characterized by persistent disturbances in glucose metabolism resulting primarily from insulin resistance, impaired insulin secretion, and complex interactions among genetic, behavioral, metabolic, and environmental factors (Lu et al., 2024). Its burden has increased substantially across different regions of the world, with population aging, sedentary lifestyles, obesity, unhealthy dietary patterns, and socioeconomic transitions contributing to the expansion of the disease across both developed and developing societies (International Diabetes, 2021). Although contemporary diabetes management increasingly emphasizes individualized pharmacotherapy, glycemic monitoring, cardiovascular risk reduction, weight management, and prevention of microvascular and macrovascular complications, patients commonly experience symptoms and functional problems that are not fully captured by glycemic indices alone (Galindo et al., 2023). Contemporary conceptualizations therefore recognize type 2 diabetes as a multidimensional chronic condition in which metabolic dysfunction interacts with physical discomfort, sleep problems, emotional distress, fatigue, psychological vulnerability, and impaired quality of life. The clinical complexity of diabetes may be further intensified by overlap with other metabolic and autoimmune characteristics, emphasizing the heterogeneous nature of diabetic phenotypes and the need for multidimensional assessment and intervention strategies (Bielka et al., 2024). Consequently, treatment approaches that focus exclusively on biochemical control may be insufficient to address the broader symptom burden experienced by patients, particularly when persistent fatigue, pain, sleep disturbance, and impaired psychological well-being coexist and negatively influence self-management, treatment adherence, physical activity, and everyday functioning.

Fatigue is among the most common yet frequently underestimated complaints reported by individuals with diabetes. Unlike ordinary transient tiredness, diabetes-related fatigue may involve persistent physical exhaustion, reduced motivation, cognitive weariness, and diminished capacity to sustain everyday activities. Evidence from

systematic review and meta-analytic research has shown that fatigue is prevalent across both type 1 and type 2 diabetes and is associated with several clinical, behavioral, and psychosocial risk factors (Romadlon et al., 2022). In patients with type 2 diabetes, fatigue may emerge from fluctuating glucose levels, chronic hyperglycemia, inflammatory pathways, sleep disruption, obesity, physical inactivity, depressive symptoms, medication-related factors, and the cumulative demands of long-term disease management. Real-time monitoring studies have demonstrated temporal associations between glucose variations and subjective fatigue, suggesting that metabolic conditions may directly contribute to day-to-day changes in perceived energy and functional capacity (Fritschi et al., 2020). Fatigue also interacts with attentional and emotional processes, and experimental evidence indicates that fatigue can alter emotional processing, whereas mindfulness-related processes may modify how emotional stimuli are perceived and regulated (Fan et al., 2023). From a clinical perspective, fatigue is important because it may reduce willingness to engage in exercise, dietary planning, glucose monitoring, and other self-care behaviors required for successful diabetes management. Its evaluation therefore requires more than a single global question and may benefit from multidimensional measurement encompassing physical, cognitive, motivational, and activity-related aspects. Research on the assessment of fatigue has similarly emphasized the importance of objective and subjective approaches to understanding mental and physical exhaustion (Fouladi Dehaghi et al., 2019). Because fatigue is both a symptom and a potential behavioral barrier, interventions capable of simultaneously improving physiological regulation, physical functioning, relaxation, and psychological self-regulation may be particularly appropriate for patients with type 2 diabetes.

Chronic pain constitutes another important and often interrelated problem in people with diabetes. Pain may arise through diabetic neuropathy, musculoskeletal dysfunction, obesity-related mechanical stress, inflammatory processes, vascular complications, reduced physical fitness, or coexisting chronic disorders, and its persistence can substantially compromise mobility, mood, sleep, and quality of life. Chronic pain and diabetes may also influence one another bidirectionally. Longitudinal evidence suggests that chronic widespread pain, particularly when combined with unfavorable lifestyle factors, may be associated with an elevated risk of developing type 2 diabetes, highlighting the broader interaction between pain, physical inactivity,

adiposity, and metabolic dysfunction (Marcuzzi et al., 2023). Once diabetes is established, persistent pain may interfere with exercise and other health-promoting behaviors, thereby creating a cycle in which reduced movement contributes to declining functional capacity and poorer metabolic health. Psychological responses to pain are equally important. Catastrophizing, stress, avoidance, and low perceived control can increase pain-related disability and undermine treatment adherence, whereas psychological flexibility and acceptance-based coping may improve adaptation to chronic symptoms. In this regard, acceptance- and commitment-based interventions have demonstrated beneficial effects on perceived stress, chronic pain, and treatment adherence among older adults with diabetes (Rahimi et al., 2023). These findings support the broader view that pain in diabetes should not be treated solely as a peripheral physical symptom but as a biopsychosocial experience influenced by emotional, cognitive, and behavioral mechanisms. Interventions that integrate controlled physical movement, breathing regulation, attentional training, relaxation, and acceptance may therefore have the potential to reduce both the sensory and psychological burden of chronic pain.

Sleep disturbance is another highly prevalent concern among individuals with type 2 diabetes and may contribute to a mutually reinforcing relationship between poor sleep and metabolic dysregulation. People with diabetes commonly experience insomnia symptoms, fragmented sleep, sleep-disordered breathing, restless sleep, nocturia, pain-related awakenings, and daytime sleepiness, all of which may reduce restorative sleep and impair daytime functioning. Reviews of the literature indicate that sleep disorders are common in people with type 2 diabetes and are associated with adverse health outcomes, including poorer glycemic regulation, obesity, cardiovascular risk, psychological distress, and reduced quality of life (Schipper et al., 2021). Hyperglycemia itself may contribute to impaired sleep quality through nocturia, thirst, autonomic symptoms, discomfort, and alterations in physiological regulation, and recent clinical evidence has demonstrated an association between hyperglycemic status and poorer sleep quality among patients with type 2 diabetes (Elahi et al., 2024). Sleep disturbance may, in turn, exacerbate insulin resistance through neuroendocrine and inflammatory mechanisms and may increase appetite, fatigue, stress reactivity, and reduced engagement in physical activity. Consequently, poor sleep may function both as an outcome of diabetes and as a factor that complicates diabetes management. Sleep is also closely connected with chronic

pain and fatigue: pain can disrupt sleep continuity, poor sleep can heighten pain sensitivity, and inadequate restorative sleep can amplify daytime fatigue. This interconnected symptom cluster indicates that interventions capable of influencing autonomic balance, muscular relaxation, breathing patterns, stress regulation, and emotional arousal may offer particular value in the management of type 2 diabetes.

The psychological consequences of type 2 diabetes are equally important. Living with a chronic disease requires continuous monitoring, behavioral adaptation, dietary control, medication use, concern about complications, and repeated healthcare contact, all of which may generate considerable psychological strain. Depression, anxiety, diabetes-related distress, perceived burden, and reduced health-related quality of life are frequently reported among adults with type 2 diabetes, and these psychological difficulties may adversely affect glycemic control, treatment engagement, and functional outcomes (Alwhaibi, 2024). Umbrella-level evidence further indicates that multiple demographic, clinical, social, and behavioral factors increase the risk of mental health problems in this population (Busili et al., 2024). The relationship between diabetes and mental health is also bidirectional, as psychiatric disorders themselves have been identified as risk factors for the later development of type 2 diabetes through pathways involving medication exposure, altered health behavior, chronic stress, inflammatory activity, and metabolic dysregulation (Lindekilde et al., 2021). Psychosocial factors therefore occupy a central position in comprehensive diabetes care, and recommendations increasingly recognize the need to assess emotional adjustment, diabetes distress, social support, coping, and quality of life in addition to metabolic outcomes (Kulzer et al., 2021). Psychological well-being is broader than the absence of depression or anxiety and includes positive functioning, self-acceptance, purpose in life, personal growth, autonomy, environmental mastery, and positive interpersonal relationships. Enhancing these dimensions may improve patients' ability to manage chronic illness, maintain health behaviors, tolerate treatment demands, and preserve meaningful functioning. Evidence that intensive lifestyle modification can reduce symptoms of anxiety and depression in people with type 2 diabetes further supports the value of behavioral approaches that integrate physical and psychological components (Tripathi et al., 2024). Similarly, cognitive behavioral interventions have shown beneficial short- and long-term effects on glycemic control in diabetes, reinforcing the relevance of

psychological mechanisms to physical disease outcomes (Dong & Yang, 2023).

Among non-pharmacological approaches, mindfulness-based interventions have received increasing attention because of their potential effects on stress regulation, emotional processing, self-awareness, and health behavior. Mindfulness involves purposeful, nonjudgmental attention to present-moment experiences and may reduce repetitive negative thinking, emotional reactivity, and physiological stress responses. Brief mindfulness practice has been shown to influence emotional processing and improve regulation of affective responses (Wu et al., 2019), while systematic evaluation of mindfulness-based interventions in adults with type 2 diabetes suggests potential benefits for psychological outcomes and self-management-related processes, although the strength of evidence varies across outcomes and intervention formats (Ee et al., 2021). These mechanisms are especially relevant because fatigue, pain, sleep disruption, and psychological distress may share common pathways involving autonomic dysregulation, heightened stress responses, maladaptive attention to symptoms, and reduced behavioral activation. Mindfulness is also increasingly incorporated into broader wellness programs alongside breathing exercises and movement-based practices, reflecting an integrative approach to mental and physical health promotion (Brahmbhatt & Kumavat, 2024). Within this context, yoga is particularly relevant because it combines structured physical postures, breathing regulation, attentional focus, relaxation, and contemplative awareness in a single intervention, potentially enabling simultaneous modification of multiple physiological and psychological mechanisms.

Yoga has increasingly been investigated as a complementary health intervention in chronic disease because it integrates physical activity with breath control and mind-body regulation. Its potential benefits include improvements in flexibility, muscular strength, balance, autonomic regulation, perceived stress, sleep, mood, and overall health-related quality of life. Reviews have suggested that yoga may improve health-related quality of life across different clinical populations, although effects may depend on intervention intensity, duration, population characteristics, and methodological quality (Cramer, 2019). Research outside diabetes also provides mechanistic support for yoga as a complementary intervention, with clinical and biochemical studies in cancer populations suggesting potential influences on stress physiology, inflammation, symptom burden, and psychological adaptation (Blockhuys

& Wittung-Stafshede, 2024). Similarly, yoga-based programs have been associated with improvements in body mass index and blood pressure in populations with obesity and endocrine disorders, supporting their potential cardiometabolic relevance (Nilakantham et al., 2024). Pilot evidence also indicates that regular yoga practice may contribute to favorable changes in lipid profiles and insulin resistance among overweight and obese individuals (Shelke et al., 2024). These findings are clinically important because excess adiposity, hypertension, dyslipidemia, insulin resistance, and cardiovascular risk frequently coexist with type 2 diabetes. Broader evaluations have also emphasized the combined cardiovascular and weight-related benefits of yoga and its potential role in holistic lifestyle management (Singh & Shah, 2025). Accordingly, yoga may have advantages over conventional exercise alone for some patients because it can be individually adapted, performed at different levels of intensity, and combined with breathing and relaxation practices that directly target psychological as well as physical symptoms.

The potential role of yoga in diabetes management has consequently become an important area of investigation. Yoga-based approaches may affect diabetes through multiple pathways, including enhanced muscular glucose utilization, improved insulin sensitivity, reduction of stress-related neuroendocrine activation, modulation of autonomic function, improvements in body composition, and increased adherence to healthy lifestyle behaviors. Contemporary reviews and practice-oriented analyses describe yoga as a potentially useful adjunct to conventional diabetes management, particularly when incorporated into broader behavioral and lifestyle modification programs (Datti, 2025). Recent discussions similarly emphasize yoga as a preventive and therapeutic lifestyle strategy that may complement standard medical treatment through its combined effects on metabolic and psychological functioning (Sharma et al., 2025). Empirical research on specific yogic practices has reported reductions in random blood glucose levels, suggesting that structured yoga interventions may influence glycemic outcomes among adults with elevated metabolic risk (Saini & Das, 2024). The value of such practices may extend beyond biochemical control, however, because the defining components of yoga—postural exercise, breathing, relaxation, and focused attention—correspond directly to several mechanisms implicated in fatigue, pain, sleep disturbance, and psychological distress. Regular movement may improve muscular endurance and reduce deconditioning; stretching

and controlled postures may alleviate musculoskeletal tension and pain; breathing and relaxation may reduce physiological hyperarousal; and mindfulness-oriented attention may enhance emotional regulation and body awareness. This multidimensional structure differentiates yoga from interventions targeting only one symptom domain and may make it especially suitable for chronic illnesses in which physical and psychological symptoms occur simultaneously.

Despite the growing body of literature, several limitations remain. Much of the available research on yoga and diabetes has focused predominantly on glycemic indices, body weight, cardiovascular parameters, or general quality of life, whereas fewer controlled studies have simultaneously investigated fatigue, chronic pain, sleep quality, and positive psychological functioning as distinct but interrelated outcomes. This gap is important because these symptoms frequently coexist and can reinforce one another. Fatigue may decrease physical activity, pain may impair sleep, sleep disturbance may intensify both fatigue and pain sensitivity, and persistent symptom burden may reduce psychological well-being and treatment motivation. Conversely, a multimodal intervention capable of addressing several of these domains at once may produce broader functional benefits than symptom-specific approaches. Moreover, although yoga is increasingly used within health-promotion settings, variations in protocols, session frequency, intervention duration, and participant characteristics limit the generalizability of previous findings. Carefully structured randomized interventions using standardized outcome measures are therefore needed to clarify whether yoga provides clinically meaningful benefits beyond routine diabetes care. Such evidence is especially relevant for patients who require safe, low-cost, adaptable, and non-pharmacological adjunctive interventions that can be integrated into conventional treatment without replacing necessary medical management.

Therefore, the aim of the present study was to determine the effectiveness of a structured yoga intervention in reducing fatigue and chronic pain and improving sleep quality and psychological well-being among patients with type 2 diabetes mellitus.

2. Methods and Materials

2.1. Study Design and Participants

The study was conducted among patients with type 2 diabetes who attended the Tehran Diabetes Association and

comprehensive health service centers affiliated with Tehran University of Medical Sciences between March and June 2025. These centers were selected to provide access to a demographically heterogeneous patient population encompassing a broad range of ages, socioeconomic backgrounds, and patterns of healthcare utilization. Participants were initially recruited through convenience sampling based on the predefined eligibility criteria and their willingness to participate in the study. Given the interventional nature of the research, the general objectives and procedures of the study were explained to all potentially eligible individuals before enrollment, and volunteers were asked to complete a 10-point Visual Analog Scale for chronic pain and fatigue (Fouladi Dehaghi et al., 2019) as well as the Pittsburgh Sleep Quality Index. Following eligibility screening, 33 participants were invited to enter the trial and were subsequently allocated to the intervention and control groups using simple random allocation. Randomization was performed using a computer-generated random-number sequence, and allocation concealment procedures were applied to minimize the possibility that either participants or investigators could predict group assignment. Of the 33 initially enrolled patients, data from 32 participants were ultimately included in the final analysis, with 16 participants in the yoga group and 16 participants in the control group. Data from one participant assigned to the yoga group were excluded because of insufficient and irregular attendance at the intervention sessions.

Eligibility criteria included an age range of 30 to 65 years, a confirmed diagnosis of type 2 diabetes mellitus for at least one year, absence of severe psychiatric disorders, and no concurrent participation in other pharmacological or non-pharmacological treatment programs apart from the routine medical treatment prescribed by the attending physician. Participants were also required to have experienced chronic pain and fatigue during the two months preceding the study, to obtain a minimum score of 4 out of 10 on the Visual Analog Scale for both pain and fatigue, and to obtain a score of 6 or higher on the Pittsburgh Sleep Quality Index, indicating impaired sleep quality. Regular attendance at a minimum of 80% of the intervention sessions was established as a criterion for remaining in the study. Primary and secondary outcomes were assessed at baseline and again immediately after completion of the intervention at week 8.

2.2. Data Collection Tools

Fatigue was assessed using the Multidimensional Fatigue Inventory (MFI), a standardized self-report instrument developed by Smets and colleagues for the multidimensional assessment of fatigue in both clinical and healthy populations (Smets et al., 1995). The MFI consists of 20 items rated on a five-point Likert-type scale and measures five distinct dimensions of fatigue: general fatigue, physical fatigue, mental fatigue, reduced activity, and reduced motivation. Each dimension is represented by four items, thereby enabling a comprehensive assessment of both physical and psychological manifestations of fatigue. The total score ranges from 20 to 100, with higher scores indicating greater levels of fatigue. In the Iranian validation study conducted by Nouri Azari et al. (2018), the instrument demonstrated satisfactory internal consistency, with a Cronbach's alpha coefficient of .88. In the present study, the Cronbach's alpha coefficient for the total MFI score was .87, indicating acceptable internal consistency for the study sample.

Chronic pain was assessed using the McGill Pain Questionnaire, originally developed by Melzack in 1975, together with its subsequently developed short-form version. The instrument is designed to assess the multidimensional experience of pain and includes components addressing pain intensity and qualitative characteristics. In the version used in the present study, scoring consisted of three sections. The first section employed a four-point Likert-type scale ranging from 0, representing no pain, to 3, representing severe pain. The second section used an 11-point numerical rating scale ranging from 0 to 10, whereas the third section used a six-point Likert-type scale ranging from 0 to 5. Item scores were summed to obtain an overall pain score, with higher scores indicating greater pain intensity and lower scores reflecting less severe perceived pain. Melzack (1987) provided evidence supporting the validity of the instrument and reported a Cronbach's alpha coefficient of .80. More recently, Rahimi et al. (2023) reported a Cronbach's alpha coefficient of .79 for the instrument among Iranian patients with diabetes, supporting its reliability for use in this population.

Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI), a widely used standardized instrument designed to evaluate subjective sleep quality over a specified period. The PSQI comprises seven components assessing subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of

sleep medication, and daytime dysfunction. The fifth item of the questionnaire includes several subitems related to specific causes of sleep disturbance. Each component is scored on a four-point Likert-type scale ranging from 0 to 3, and the component scores are summed to generate a global score ranging from 0 to 21. Higher scores indicate poorer sleep quality, and a total score of 6 or higher was considered indicative of clinically relevant sleep disturbance in the present study. The Persian version of the PSQI has demonstrated acceptable psychometric properties. Farhi Moghadam et al. (2012) reported Cronbach's alpha coefficients ranging from .71 to .98 across the different subscales, indicating satisfactory to excellent internal consistency.

Psychological well-being was assessed using the short form of Ryff's Psychological Well-Being Scale. Ryff originally introduced the multidimensional conceptualization of psychological well-being in the late 1980s, and several forms of the scale have subsequently been developed, including 120-item, 84-item, 54-item, and 18-item versions. The 18-item version used in the present study assesses six dimensions of psychological well-being: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance. Each dimension is represented by three items. Responses are rated on a six-point Likert-type scale ranging from 1, strongly disagree, to 6, strongly agree. Higher scores indicate higher levels of psychological well-being. In an Iranian psychometric study conducted by Khanjani et al. (2014), confirmatory factor analysis supported the six-factor structure of the instrument in the total sample and across both sexes. Cronbach's alpha coefficients for the six dimensions were reported as .51, .76, .75, .52, .73, and .72, respectively, while the reliability coefficient for the total scale was .71. In the present study, Cronbach's alpha for the total psychological well-being score was .81, indicating good internal consistency.

2.3. Intervention

The intervention protocol was designed according to the principles of classical yoga and adapted to contemporary rehabilitation and therapeutic movement approaches. The program consisted of 16 sessions conducted twice weekly over an eight-week period, with each session lasting 90 minutes. The intervention was structured around three core components of yoga, namely asanas or physical postures, pranayama or breathing exercises, and mindfulness-based

practices aimed at improving physical functioning, movement control, body awareness, and psychophysiological balance (Cramer et al., 2019). The sessions followed a progressive sequence in which the intensity and complexity of the exercises were gradually increased according to participants' physical capacity and adaptation to the program. During sessions 1 and 2, the introductory phase focused primarily on foundational asanas designed to strengthen the muscles of the upper extremities, particularly the shoulders and arms, enhance core stability, and improve proprioceptive and bodily awareness through controlled body-weight exercises (Iyengar, 2005). Sessions 3 through 7 constituted the strengthening and flexibility phase and focused on the pelvic region, lower extremities, and spinal musculature, with particular emphasis on forward bends and lateral twisting movements. These exercises were intended to increase hip range of motion, improve hamstring flexibility, reduce musculoskeletal tension, and enhance functional mobility of the spine (Sherman et al., 2017). Sessions 8 through 12 represented the stabilization and balance phase and emphasized dynamic balance, spinal stability during rotational movements, neuromuscular activation, and carefully controlled backward-bending exercises. Sessions 13 through 16 comprised the advanced integrative phase and involved combinations of dynamic movement sequences intended to consolidate previously acquired skills, improve cardiorespiratory endurance, enhance neuromuscular coordination, and introduce controlled jumping movements when physically appropriate. Each session included approximately 10 minutes of warm-up exercises and 10 minutes of relaxation at the end of the session. The execution of individual asanas was modified when necessary according to each participant's physical condition, functional limitations, pain level, and tolerance. To promote adherence to both yoga and mindfulness components, reminder messages were sent to participants on the evening before each scheduled session.

Throughout the intervention period, participants in the control group continued to receive routine diabetes care in accordance with standard clinical guidelines, including periodic medical visits and access to usual healthcare services, but they did not receive any additional structured physical, yoga-based, or psychological intervention.

2.4. Data Analysis

Data were analyzed using IBM SPSS Statistics, version 25. Descriptive statistics, including means and standard deviations, were calculated to summarize the study variables at baseline and post-intervention assessments. Inferential analyses were conducted using analysis of covariance (ANCOVA) to evaluate between-group differences in post-intervention fatigue, chronic pain, sleep quality, and psychological well-being while statistically controlling for the corresponding baseline scores. Prior to conducting ANCOVA, the relevant statistical assumptions were examined, including normality of the dependent variables, homogeneity of variances, linearity between the covariate and dependent variable, and homogeneity of regression slopes across groups. Statistical significance was determined based on the conventional alpha level of .05.

3. Findings and Results

The final sample consisted of 32 patients with type 2 diabetes mellitus, including 16 participants in the yoga intervention group and 16 participants in the control group. The mean age of the participants was 44.09 years ($SD = 5.78$). All participants included in the final analysis completed the pretest and posttest assessments, whereas one initially enrolled participant from the yoga group was excluded because of insufficient attendance at the intervention sessions. Thus, the analyses were conducted using data from the 32 participants who satisfied the study retention criteria.

Table 1

Descriptive Statistics for the Study Variables at Pretest and Posttest in the Yoga and Control Groups

Group	Variable	Pretest M	Pretest SD	Posttest M	Posttest SD
Yoga	Fatigue	63.50	4.92	44.65	4.02
	Chronic pain	72.05	8.64	60.64	6.02
	Sleep quality	7.81	3.27	3.66	1.65
	Psychological well-being	65.26	9.85	77.35	7.85
Control	Fatigue	54.98	4.77	52.15	6.24
	Chronic pain	70.69	7.52	67.74	6.71
	Sleep quality	6.59	2.50	7.99	3.23
	Psychological well-being	69.66	6.19	67.04	4.98

As shown in Table 1, participants in the yoga group demonstrated improvements across all four outcome variables from pretest to posttest. Mean fatigue decreased from 63.50 (SD = 4.92) at pretest to 44.65 (SD = 4.02) at posttest, while mean chronic pain decreased from 72.05 (SD = 8.64) to 60.64 (SD = 6.02). Sleep quality scores decreased from 7.81 (SD = 3.27) to 3.66 (SD = 1.65); because higher scores on the Pittsburgh Sleep Quality Index indicate poorer sleep quality, this reduction represents a substantial improvement in sleep quality. Psychological well-being increased from 65.26 (SD = 9.85) to 77.35 (SD = 7.85). In contrast, changes in the control group were comparatively limited. Fatigue decreased from 54.98 (SD = 4.77) to 52.15 (SD = 6.24), and chronic pain decreased from 70.69 (SD = 7.52) to 67.74 (SD = 6.71). Sleep quality scores increased from 6.59 (SD = 2.50) to 7.99 (SD = 3.23), indicating deterioration in sleep quality, while psychological well-being decreased from 69.66 (SD = 6.19) to 67.04 (SD = 4.98). Overall, the descriptive findings indicate a more

favorable pattern of change in the yoga group compared with the control group.

Before conducting the analysis of covariance, the relevant statistical assumptions were examined. Comparisons of the two groups at the pretest stage indicated that there were no statistically significant baseline differences between the yoga and control groups in any of the study variables, supporting initial comparability between the groups. The Kolmogorov–Smirnov test indicated that the distributions of fatigue, chronic pain, sleep quality, and psychological well-being did not significantly deviate from normality, thereby supporting the normality assumption required for parametric analysis. In addition, the results of Box’s M test supported the homogeneity of the covariance matrices across the two groups. The assumptions required for covariance analysis were therefore considered adequately satisfied, permitting the use of ANCOVA to compare posttest scores between the yoga and control groups while controlling for corresponding pretest scores.

Table 2

Analysis of Covariance for Comparison of Study Outcomes Between the Yoga and Control Groups

Source	Variable	Sum of Squares	df	Mean Square	F	p	Effect Size
Group	Fatigue	196.88	1	196.88	6.84	.010	.71
Group	Chronic pain	208.72	1	208.72	4.64	.040	.54
Group	Sleep quality	124.16	1	124.16	18.27	.001	.98
Group	Psychological well-being	500.86	1	500.86	12.06	.002	.91

As presented in Table 2, after controlling for pretest scores, statistically significant differences were observed between the yoga and control groups in all four study outcomes. The adjusted between-group difference in fatigue was statistically significant, $F = 6.84$, $p = .010$, with an effect size of .71, indicating that participation in the yoga program was associated with a significant reduction in fatigue relative to routine care alone. A statistically significant group effect was also found for chronic pain, $F = 4.64$, $p = .040$, with an effect size of .54, demonstrating lower post-intervention pain among participants who received the yoga intervention. The strongest statistical effect was observed for sleep quality, $F = 18.27$, $p = .001$, with an effect size of .98, indicating a substantial improvement in sleep quality among participants in the yoga group compared with those in the control group. Psychological well-being also differed significantly between the two groups, $F = 12.06$, $p = .002$, with an effect size of .91, with participants receiving yoga demonstrating higher psychological well-being at posttest.

Taken together, these findings indicate that incorporating yoga exercises alongside routine diabetes care was significantly associated with reduced fatigue and chronic pain and with improved sleep quality and psychological well-being in patients with type 2 diabetes mellitus.

4. Discussion

The present study examined the effectiveness of a structured yoga intervention on fatigue, chronic pain, sleep quality, and psychological well-being among patients with type 2 diabetes mellitus. The findings showed that, after controlling for pretest scores, participants in the yoga group demonstrated significantly greater improvement than those in the control group across all four outcomes. Specifically, yoga was associated with significant reductions in fatigue and chronic pain, a marked improvement in sleep quality, and a significant increase in psychological well-being. The descriptive findings also supported this pattern, as

participants in the intervention group showed substantial favorable changes from pretest to posttest, whereas the control group demonstrated comparatively minor changes and, in some outcomes such as sleep quality and psychological well-being, a tendency toward deterioration. The largest statistical effects were observed for sleep quality and psychological well-being, followed by fatigue and chronic pain. These findings suggest that yoga may function as a multidimensional complementary intervention in type 2 diabetes by simultaneously targeting physical symptoms, psychophysiological arousal, emotional regulation, and positive psychological functioning. This pattern is consistent with the growing recognition that successful diabetes management should extend beyond glycemic regulation to include symptom burden, mental health, sleep, functional status, and quality of life (Galindo et al., 2023; Kulzer et al., 2021).

One of the principal findings was the significant reduction in fatigue among participants who completed the yoga program. Fatigue is a common and clinically important symptom in type 2 diabetes and may arise from a combination of metabolic dysregulation, glucose fluctuations, reduced physical fitness, sleep disturbance, psychological stress, and the sustained behavioral demands associated with diabetes self-management. Previous evidence has shown that fatigue is prevalent in individuals with both type 1 and type 2 diabetes and is influenced by multiple clinical and behavioral factors (Romadlon et al., 2022). Fritschi et al. further demonstrated that fatigue may fluctuate in relation to real-time glucose levels in individuals with type 2 diabetes, indicating that subjective exhaustion can be closely connected with metabolic processes (Fritschi et al., 2020). The reduction in fatigue observed in the present study may therefore reflect several interconnected mechanisms. The physical components of yoga may improve muscular endurance, circulation, flexibility, and movement efficiency, thereby reducing the perceived effort required for daily activities. At the same time, breathing and relaxation exercises may reduce autonomic overactivation and stress-related physiological expenditure. Mindfulness-oriented elements may further decrease cognitive fatigue by reducing excessive attention to distressing bodily sensations, worry, and repetitive negative thinking. Research on fatigue and emotional processing suggests that fatigue can influence attentional and emotional responses, whereas mindfulness may modify these effects through improved regulation of cognitive and affective processing (Fan et al., 2023). The present findings therefore support the possibility that yoga

reduces fatigue not through a single pathway but through coordinated physical, cognitive, and emotional mechanisms.

The improvement in fatigue is also compatible with the broader literature concerning the role of yoga in health-related functioning and chronic disease management. Yoga has been associated with improvements in health-related quality of life across a range of clinical conditions, partly because it integrates graded physical activity with relaxation and attentional control (Cramer, 2019). More recent accounts of yoga in diabetes management similarly emphasize its capacity to complement standard care through improvements in physical conditioning, stress regulation, autonomic balance, and metabolic functioning (Datti, 2025; Sharma et al., 2025). The potential metabolic effects of yoga may also be relevant to diabetes-related fatigue. Studies have reported improvements in blood glucose indices following yogic practices (Saini & Das, 2024), while pilot evidence suggests beneficial effects on insulin resistance and lipid parameters in individuals with overweight and obesity (Shelke et al., 2024). Because impaired glucose utilization and insulin resistance may contribute to reduced energy availability and perceptions of exhaustion, improvements in metabolic efficiency could indirectly contribute to lower fatigue. Moreover, evidence for favorable effects of yoga on body mass index, blood pressure, and cardiometabolic functioning supports the hypothesis that regular yoga practice may improve general physiological resilience (Nilakantham et al., 2024; Singh & Shah, 2025). Although the present study did not directly measure metabolic biomarkers, these mechanisms provide a plausible context for understanding the observed decrease in multidimensional fatigue.

The second major finding was a significant reduction in chronic pain in the yoga group compared with the control group. Chronic pain in patients with type 2 diabetes may be associated with neuropathic complications, musculoskeletal dysfunction, excess body weight, inflammatory processes, physical inactivity, or combinations of these conditions. Pain may further restrict movement and reduce engagement in physical activity, thereby exacerbating deconditioning and metabolic risk. Longitudinal evidence has shown that chronic widespread pain and unfavorable lifestyle factors may interact in ways that increase vulnerability to type 2 diabetes, underscoring the close relationship between pain, activity, and metabolic health (Marcuzzi et al., 2023). The observed reduction in pain may be explained by the progressive structure of the yoga program, which emphasized flexibility, postural control, spinal mobility,

muscular strengthening, balance, and controlled movement. Such practices may reduce muscular tension, improve joint mobility, enhance body mechanics, and increase tolerance of movement. Unlike strenuous forms of exercise, yoga can also be adapted to physical limitations and may therefore enable patients with pain to remain active without provoking excessive symptom exacerbation.

Psychological mechanisms are also likely to have contributed to the reduction in chronic pain. Pain perception is influenced not only by nociceptive input but also by attention, emotional state, perceived control, stress, and avoidance behavior. The breathing, relaxation, and mindfulness elements of yoga may reduce hypervigilance toward painful sensations and foster a less reactive relationship with discomfort. This interpretation is consistent with evidence that acceptance- and commitment-based treatment can reduce chronic pain and perceived stress while improving treatment adherence among older adults with diabetes (Rahimi et al., 2023). Mindfulness practices may similarly alter emotional and attentional processing, thereby decreasing amplification of aversive bodily experiences (Wu et al., 2019). Evidence from other chronic illness populations also supports the potential analgesic and symptom-management effects of yoga. For example, yoga has been examined as a complementary treatment in cancer populations, where both clinical and biochemical mechanisms have been proposed to explain improvements in symptom burden, stress regulation, and quality of life (Blockhuys & Wittung-Stafshede, 2024). Taken together, these findings suggest that yoga may affect chronic pain through both biomechanical pathways, such as increased flexibility and reduced muscular tension, and psychological pathways, including reduced stress reactivity, improved acceptance, and altered attention to painful sensations.

A particularly strong effect of yoga was observed for sleep quality. Participants in the yoga group showed a marked decline in Pittsburgh Sleep Quality Index scores, indicating improved sleep, whereas sleep quality in the control group worsened over the study period. This finding is clinically important because sleep disturbances are highly prevalent among people with type 2 diabetes and are associated with adverse metabolic, psychological, and functional outcomes. Reviews have documented frequent insomnia symptoms, fragmented sleep, sleep-disordered breathing, daytime sleepiness, and other sleep problems in individuals with type 2 diabetes, with consequences for glycemic regulation, obesity, cardiovascular health, and quality of life (Schipper et al., 2021). Hyperglycemia may

itself interfere with sleep through nocturia, thirst, discomfort, and physiological arousal, and recent evidence has identified a relationship between poorer glycemic status and impaired sleep quality in patients with type 2 diabetes (Elahi et al., 2024). Yoga may improve sleep by reducing sympathetic nervous system activation, facilitating muscular relaxation, regulating breathing, decreasing pre-sleep cognitive arousal, and improving emotional calmness. The repeated practice of controlled breathing and relaxation may be especially beneficial for patients whose sleep is disrupted by stress, bodily discomfort, or persistent worry about illness.

The sleep-related findings are also consistent with research on mindfulness-based approaches. Mindfulness interventions encourage nonjudgmental attention to present-moment experiences and may reduce rumination and physiological arousal that interfere with sleep initiation and maintenance. Mindfulness-based interventions have been evaluated in adults with type 2 diabetes and may provide benefits for psychological adjustment and self-management-related outcomes (Ee et al., 2021). Experimental evidence has also demonstrated that even brief mindfulness meditation can influence emotional processing and improve regulatory responses (Wu et al., 2019). Because the intervention in the present study combined physical postures, breathing practices, relaxation, and mindfulness, its effect on sleep may have resulted from the cumulative influence of these components. Improved sleep may in turn have contributed to the observed reductions in fatigue and pain, since inadequate sleep can increase daytime exhaustion, lower pain thresholds, intensify emotional reactivity, and reduce coping capacity. Thus, the strong effect on sleep quality may represent not only an independent benefit of yoga but also one of the mechanisms through which other study outcomes improved.

The fourth major finding was a significant increase in psychological well-being among participants in the yoga group. Psychological well-being is particularly relevant in type 2 diabetes because living with a chronic illness requires ongoing behavioral regulation, medication adherence, dietary restraint, monitoring of symptoms and glucose levels, and adaptation to concerns regarding future complications. Depression, anxiety, emotional distress, and reduced health-related quality of life are common among adults with type 2 diabetes (Alwhaibi, 2024). Umbrella evidence has further demonstrated that patients with type 2 diabetes are exposed to multiple clinical, behavioral, and social risk factors for mental health disorders (Busili et al.,

2024). Psychosocial variables therefore constitute an essential component of diabetes management rather than a secondary concern (Kulzer et al., 2021). The improvement in psychological well-being observed in the present study may be explained by the integrated characteristics of yoga. Regular practice can provide experiences of mastery, bodily competence, self-regulation, relaxation, and increased awareness of internal states, all of which may strengthen psychological functioning. Group-based participation may additionally provide routine, social contact, and a sense of active engagement in one's health.

The psychological benefits observed in this study are supported by evidence from both diabetes-specific and broader mind-body intervention research. Intensive lifestyle modification has been associated with improvement in symptoms of anxiety and depression among individuals with type 2 diabetes (Tripathi et al., 2024), while psychological interventions such as cognitive behavioral therapy may also produce favorable effects on diabetes-related outcomes, including glycemic control (Dong & Yang, 2023). These findings indicate that psychological and metabolic processes in diabetes are interdependent. Psychiatric disorders have themselves been identified as risk factors for subsequent development of type 2 diabetes, suggesting a bidirectional relationship between mental health and metabolic dysfunction (Lindekilde et al., 2021). Yoga may be particularly useful within this framework because it combines behavioral activation with stress management and mindfulness rather than targeting psychological symptoms through cognitive strategies alone. Contemporary wellness literature describes yoga and mindfulness as complementary approaches capable of enhancing emotional balance, self-awareness, and general mental well-being (Brahmbhatt & Kumavat, 2024). By reducing fatigue, pain, and sleep disturbance at the same time, yoga may also indirectly promote psychological well-being because persistent physical symptoms are major sources of distress and perceived loss of control.

The findings should also be interpreted within the broader pathophysiological and clinical context of type 2 diabetes. The disease develops through complex interactions among insulin resistance, pancreatic beta-cell dysfunction, adiposity, inflammation, genetic vulnerability, and lifestyle factors (Lu et al., 2024). Its clinical manifestations are heterogeneous, and contemporary research emphasizes that diabetes phenotypes may overlap and become increasingly complex, as demonstrated by emerging discussion of combined characteristics of type 1 and type 2 diabetes

(Bielka et al., 2024). This complexity strengthens the rationale for interventions that can influence multiple domains simultaneously. Yoga should not be regarded as a substitute for pharmacological treatment or standard diabetes care; rather, the present results suggest that it may serve as a useful adjunct to routine treatment. This interpretation is consistent with current approaches to diabetes management, which increasingly incorporate lifestyle modification, patient-centered care, and psychosocial support alongside pharmacotherapy (Galindo et al., 2023). The international burden of diabetes further highlights the importance of accessible and scalable complementary strategies capable of improving functioning and quality of life in addition to metabolic outcomes (International Diabetes, 2021).

5. Conclusion

An important feature of the present findings is that yoga produced simultaneous improvements across several interrelated symptom domains. Fatigue, chronic pain, sleep disturbance, and psychological well-being should not be regarded as entirely independent outcomes. Rather, these variables form a dynamic symptom network in which deterioration in one domain can aggravate others. Poor sleep may increase fatigue and pain sensitivity; chronic pain may disrupt sleep and reduce physical activity; fatigue may impair self-management and contribute to psychological distress; and reduced psychological well-being may heighten symptom perception and decrease motivation to engage in health-promoting behaviors. The observed improvements across all four variables therefore suggest that yoga may interrupt this reciprocal cycle at multiple points. Its combination of movement, breathing, mindfulness, and relaxation provides a plausible basis for such multidimensional effects. The present findings are consistent with the broader evidence supporting yoga as an intervention for improving health-related quality of life (Cramer, 2019), and with the increasingly holistic conceptualization of yoga as an approach capable of simultaneously addressing cardiometabolic and psychological health (Singh & Shah, 2025). The magnitude of improvement observed in sleep quality and psychological well-being may indicate that the regulatory and restorative components of yoga are especially relevant for patients with type 2 diabetes whose difficulties extend beyond metabolic symptoms.

Several limitations should be considered when interpreting the findings of the present study. First, the

sample size was relatively small, with only 32 participants included in the final analysis, which limits statistical power and restricts the generalizability of the results to the wider population of patients with type 2 diabetes. Second, participants were recruited from the Tehran Diabetes Association and comprehensive health service centers affiliated with a single medical university, and the sample may therefore not fully represent patients from other geographic, cultural, socioeconomic, or healthcare settings. Third, several outcomes were assessed using self-report questionnaires and were consequently susceptible to recall bias, response tendencies, and participants' expectations regarding the intervention. Fourth, the study evaluated outcomes immediately after completion of the eight-week intervention and did not include medium- or long-term follow-up assessments; therefore, the durability of the observed effects remains unknown. Fifth, blinding of participants to group allocation was not feasible because of the behavioral nature of the yoga intervention, and expectancy effects cannot be completely excluded. Finally, the study did not directly assess potential physiological mediators such as glycemic control, inflammatory markers, autonomic functioning, body composition, or cardiorespiratory fitness, which limits conclusions regarding the biological mechanisms underlying the observed improvements.

Future studies should replicate these findings using larger, multicenter samples and longer follow-up periods to determine the stability and generalizability of the effects of yoga on fatigue, chronic pain, sleep quality, and psychological well-being in patients with type 2 diabetes. Researchers should consider using stratified randomization according to sex, age, duration of diabetes, glycemic status, comorbidities, and baseline symptom severity to clarify whether certain subgroups benefit more strongly from yoga-based interventions. Future trials would also benefit from active comparison conditions, such as conventional aerobic exercise, stretching, relaxation training, or mindfulness-only programs, to determine which components of yoga are responsible for the observed effects. Objective indicators, including glycated hemoglobin, fasting glucose, continuous glucose monitoring, inflammatory biomarkers, heart-rate variability, actigraphy, physical fitness measures, and quantitative pain assessments, should be incorporated alongside self-report instruments. Investigation of possible mediating mechanisms, including changes in sleep, stress, pain acceptance, self-efficacy, physical activity, and autonomic regulation, could further clarify how yoga

produces multidimensional benefits. Dose-response studies examining session frequency, session duration, intervention length, and home practice would also help determine the most efficient and sustainable yoga protocol for clinical populations.

The findings support consideration of structured yoga programs as an adjunct to routine medical management for adults with type 2 diabetes, particularly for patients experiencing clinically meaningful fatigue, chronic pain, poor sleep quality, or reduced psychological well-being. Such programs should be implemented by appropriately trained instructors and adapted to patients' age, physical capacity, diabetic complications, cardiovascular status, musculoskeletal limitations, and previous experience with exercise. A progressive format combining safe postures, controlled breathing, relaxation, and mindfulness may be preferable to intensive or technically demanding yoga practices. Healthcare professionals may consider incorporating yoga into multidisciplinary diabetes education and rehabilitation services while emphasizing that it complements rather than replaces prescribed medication, nutritional management, glucose monitoring, and routine clinical follow-up. Screening for contraindications, individual modification of movements, monitoring of symptoms during sessions, and strategies to improve adherence should be incorporated into clinical implementation. Integrating these programs into diabetes associations, community health centers, and outpatient rehabilitation settings may provide a relatively accessible approach for addressing both physical and psychological dimensions of living with type 2 diabetes.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. This study was conducted as a randomized controlled trial registered under the code IRCT20250718066543N1 to evaluate the effectiveness of yoga exercises in reducing fatigue and chronic pain and improving sleep quality and psychological well-being among patients with type 2 diabetes mellitus.

References

- Alwhaibi, M. (2024). Depression, Anxiety, and Health-Related Quality of Life in Adults with Type 2 Diabetes. *Stomatology*, 13(20), 6028. <https://doi.org/10.3390/jcm13206028>
- Bielka, W., Przekaz, A., Molęda, P., Pius-Sadowska, E., & Machaliński, B. (2024). Double diabetes-when type 1 diabetes meets type 2 diabetes: definition, pathogenesis and recognition. *Cardiovascular diabetology*, 23(1), 62. <https://doi.org/10.1186/s12933-024-02145-x>
- Blockhuys, S., & Wittung-Stafshede, P. (2024). Yoga as a complementary therapy for cancer patients: from clinical observations to biochemical mechanisms. *Complementary Medicine Research*, 31(5), 403-415. <https://doi.org/10.1159/000540213>
- Brahmbhatt, A., & Kumavat, P. P. (2024). Yoga and Mindfulness Practices: Their Role in Modern Mental Health and Wellness Programs. *Research Review Journal of Indian Knowledge Systems*, 1(2), 9-17. <https://doi.org/10.31305/rjiks.2024.v1.n2.002>
- Busili, A., Kumar, K., Kudrna, L., & Busaily, I. (2024). The risk factors for mental health disorders in patients with type 2 diabetes: An umbrella review of systematic reviews with and without meta-analysis. *Heliyon*. <https://doi.org/10.1016/j.heliyon.2024.e28782>
- Cramer, H. (2019). Yoga for improving health-related quality of life. *Cochrane Database of Systematic Reviews*.
- Datti, R. S. (2025). Yoga for the Management of Diabetes. In *Yoga and Meditation* (pp. 315-327). Apple Academic Press. <https://doi.org/10.1201/9781003568308-13>
- Dong, N., & Yang, L. (2023). The short- and long-term effects of cognitive behavioral therapy on the glycemic control of diabetic patients: a systematic review and meta-analysis. *BioPsychoSocial Medicine*, 17(1). <https://doi.org/10.1186/s13030-023-00274-5>
- Ee, C. C., Armour, M., Piya, M. K., McMorrow, R., Al-Kanini, I., & Sabag, A. (2021). Mindfulness-based interventions for adults with type 2 diabetes mellitus. *The Cochrane Database of Systematic Reviews*, 2021(12). <https://doi.org/10.1002/14651858.CD014881>
- Elahi, M. F. E., Islam, M. A., Khan, M. R. U., & Nosib, M. N. U. (2024). Hyperglycemic Impact On Sleep Quality In Patients With Type 2 Diabetes Mellitus-A Cross Sectional Study. <https://doi.org/10.3329/bafmj.v56i1.72736>
- Fan, J., Li, W., Lin, M., Li, X., & Deng, X. (2023). Effects of mindfulness and fatigue on emotional processing: An event-related potentials study. *Frontiers in Behavioral Neuroscience*, 17, 1175067. <https://doi.org/10.3389/fnbeh.2023.1175067>
- Fouladi Dehaghi, B., Mohammadi, A., & Nematpour, L. (2019). Mental Fatigue Assessment using recording Brain Signals: Electroencephalography. *Iranian Journal of Ergonomics*, 7(2), 45-53.
- Fritschi, C., Park, C., Quinn, L., & Collins, E. G. (2020). Real-time associations between glucose levels and fatigue in type 2 diabetes: Sex and time effects. *Biological Research For Nursing*, 22(2), 197-204. <https://doi.org/10.1177/1099800419898002>
- Galindo, R. J., Trujillo, J. M., Low Wang, C. C., & McCoy, R. G. (2023). Advances in the management of type 2 diabetes in adults. *BMJ Medicine*, 2(1), e000372. <https://doi.org/10.1136/bmjmed-2022-000372>
- International Diabetes, F. (2021). *IDF Diabetes Atlas* (10th ed.). IDF. <https://diabetesatlas.org/en/>
- Kulzer, B., Albus, C., Herpertz, S., Kruse, J., Lange, K., Lederbogen, F., & Petrak, F. (2021). Psychosocial factors and diabetes. *Experimental and Clinical Endocrinology & Diabetes*, 129(S 01), S91-S105. <https://doi.org/10.1055/a-1284-6524>
- Lindekilde, N., Rutters, F., Henriksen, J. E., Lasgaard, M., Schram, M. T., Rubin, K. H., & Pouwer, F. (2021). Psychiatric disorders as risk factors for type 2 diabetes: an umbrella review of systematic reviews with and without meta-analyses. *Diabetes Research and Clinical Practice*, 176, 108855. <https://doi.org/10.1016/j.diabres.2021.108855>
- Lu, X., Xie, Q., Pan, X., Zhang, R., Zhang, X., Peng, G., & Tong, N. (2024). Type 2 diabetes mellitus in adults: pathogenesis, prevention and therapy. *Signal Transduction and Targeted Therapy*, 9(1), 262. <https://doi.org/10.1038/s41392-024-01951-9>
- Marcuzzi, A., Caceres-Matos, R., Åsvold, B. O., Gil-Garcia, E., L Nilsen, T. I., & Mork, P. J. (2023). Interplay between chronic widespread pain and lifestyle factors on the risk of type 2 diabetes: Longitudinal data from the Norwegian HUNT Study. *BMJ Open Diabetes Research & Care*, 11(5), e003249. <https://doi.org/10.1136/bmjdr-2022-003249>
- Nilakantham, S., Singh, A., Metri, K. G., & Nagaratna, R. (2024). Effects of residential Yoga therapy on blood pressure and body mass index in women with hypothyroidism and obesity: A retrospective study. *Ayu (An International Quarterly Journal of Research in Ayurveda)*, 45(1), 12-16. https://doi.org/10.4103/ayu.ayu_263_22
- Rahimi, R., Ahadi, H., Tajeri, B., & Khoshlahjeh, S. A. (2023). Effectiveness of Acceptance and Commitment Therapy on Perceived Stress, Chronic Pain, and Treatment Adherence in Older Adults with Diabetes. *Islamic Lifestyle Centered on Health*, 7, 76-85.
- Romadlon, D. S., Hasan, F., Wiratama, B. S., & Chiu, H. Y. (2022). Prevalence and risk factors of fatigue in type 1 and type 2 diabetes: A systematic review and meta-analysis. *Journal of Nursing Scholarship*, 54(5), 546-553. <https://doi.org/10.1111/jnu.12763>
- Saini, M., & Das, P. K. (2024). Efficacy of Different Yogic Practices on Blood Sugar Random Among the Working Men of North Tripura. *Journal of Environmental, Pharmaceutical*

- and *Sustainability Science*, 1(01), 37-44.
<https://doi.org/10.52756/jepss.2024.v01.i01.005>
- Schipper, S. B., Van Veen, M. M., Elders, P. J., van Straten, A., Van Der Werf, Y. D., Knutson, K. L., & Rutters, F. (2021). Sleep disorders in people with type 2 diabetes and associated health outcomes: a review of the literature. *Diabetologia*, 64(11), 2367-2377. <https://doi.org/10.1007/s00125-021-05541-0>
- Sharma, V., Bhambu, S. K., & Rao, A. (2025). Diabetes Mellitus prevention and management with Yoga. *Journal of Ayurveda and Integrated Medical Sciences*, 10(2), 249-255. <https://doi.org/10.21760/jaims.10.2.35>
- Shelke, A., Kawade, R., Bhattacharya, S., Sarkar, V., & Selvaraj, N. (2024). Impact of yoga practice on lipid profile and insulin resistance in overweight and obese individuals-A Pilot Study. *Journal of the Scientific Society*, 51(4), 566-570. https://doi.org/10.4103/jss.jss_346_23
- Singh, V., & Shah, S. R. (2025). Holistic benefits of yoga: A dual approach to cardiovascular health and obesity control. *International Journal of Yoga and Allied Sciences*, 14(1), 118-130.
- Tripathi, P., Sharma, B., Kadam, N., Tiwari, D., Kathrikolly, T., Vyawahare, A., Das Biswas, M., Vijayakumar, V., Kuppusamy, M., Ganla, M., & Saboo, B. (2024). Improvement in symptoms of anxiety and depression in individuals with type 2 diabetes: retrospective analysis of an intensive lifestyle modification program. *BMC psychiatry*, 24(1). <https://doi.org/10.1186/s12888-024-06130-2>
- Wu, R., Liu, L., Zhu, H., Su, W., Cao, Z., Zhong, S., Liu, X., & Jiang, C. (2019). Brief Mindfulness Meditation Improves Emotion Processing. *Frontiers in Neuroscience*, 13, 482990. <https://doi.org/10.3389/fnins.2019.01074>