KMAN PUBLISHING INSTITUTE
Journal Website

Article history:
Received 09 April 2026
Revised 27 June 2026
Accepted 02 July 2026
Initial Publication 13 July 2026
Final Publication 20 July 2026

KMAN Counseling & Psychology Nexus

Volume 4, pp 1-12

E-ISSN: 3041-9026

The Effectiveness of Healthy Lifestyle Education Combined with Yoga Therapy on Self-Care Behaviors and Daily Physical Activity Levels in Overweight Individuals at Risk of Developing Diabetes

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A r t i c l e I n f o

Article type:
Original Research
Section:
Health Psychology

How to cite this article:
Abdolkarimy Nazary, M., Agahheris, M., Kordmirza Nikoozadeh, E., Rahmanian, M., & Abdolhoseini, A. (2026). The Effectiveness of Healthy Lifestyle Education Combined with Yoga Therapy on Self-Care Behaviors and Daily Physical Activity Levels in Overweight Individuals at Risk of Developing Diabetes. *KMAN Conseling and Psychology Nexus*, *4*, 1-12.
http://doi.org/10.61838/kman.hp.psynexus.5742

A B S T R A C T

The present study aimed to examine the effectiveness of healthy lifestyle education combined with yoga therapy on self-care behaviors and daily physical activity levels in overweight individuals at risk of developing diabetes. This study was a quasi-experimental study with a pretest, posttest, and follow-up design with a control group. The statistical population consisted of overweight individuals at risk of developing diabetes. After meeting the inclusion criteria, participants were selected through purposive sampling and randomly assigned to the experimental and control groups. The experimental group received healthy lifestyle education combined with yoga therapy over 10 sessions, while the control group remained on the waiting list. Data were collected using the Diabetes Self-Care Questionnaire and daily physical activity indicators and were analyzed using repeated-measures analysis of variance. The results showed that healthy lifestyle education combined with yoga therapy had a significant effect on improving self-care behaviors and increasing daily physical activity levels in the experimental group compared with the control group ($P < 0.05$). These changes also persisted at the follow-up stage, indicating the stability of the intervention effects. The findings suggest that healthy lifestyle education combined with yoga therapy can improve self-care behaviors and daily physical activity levels in overweight individuals at risk of developing diabetes by enhancing health awareness, increasing individual responsibility, and encouraging regular physical activity. Therefore, the use of this intervention is recommended as a complementary strategy in diabetes prevention programs.

Keywords: *healthy lifestyle, yoga therapy, diabetes self-care, physical activity, prediabetes, overweight.*

1. Introduction

Type 2 diabetes mellitus is one of the most important chronic metabolic disorders worldwide and is strongly associated with lifestyle-related risk factors, including excess body weight, physical inactivity, unhealthy dietary patterns, psychological stress, and inadequate self-care behaviors. The clinical and public health importance of diabetes is not limited to its diagnostic stage, because the prediabetic phase represents a critical window during which preventive interventions can delay or reduce progression to type 2 diabetes. Individuals who are overweight and at risk of diabetes often experience a gradual accumulation of metabolic, behavioral, and psychological vulnerabilities that increase insulin resistance and impair glucose regulation. Therefore, diabetes prevention requires interventions that address not only biological risk but also the behavioral and psychosocial mechanisms that shape daily health practices. The landmark Diabetes Prevention Program showed that structured lifestyle intervention can substantially reduce the incidence of type 2 diabetes among high-risk individuals, thereby establishing lifestyle modification as a central component of diabetes prevention and risk management (Knowler et al., 2002).

Prediabetes and diabetes prevention have particular relevance in contexts where the burden of diabetes is increasing and where preventive care must be integrated into accessible, culturally adaptable, and behaviorally sustainable programs. Evidence from Iran has shown that attention to the diabetes care cascade and compliance with global coverage targets is essential for improving prevention, diagnosis, management, and long-term outcomes (Haghdoost et al., 2023). At the same time, qualitative evidence regarding the national program for diabetes prevention and control in Iran indicates that structural, educational, behavioral, and implementation-related barriers can limit the effectiveness of preventive strategies if interventions do not sufficiently address motivation, adherence, lifestyle barriers, and self-management capacity (Sadeghi et al., 2023). These findings highlight the need for prevention-oriented programs that are practical, low-risk, acceptable to participants, and capable of strengthening daily self-care and physical activity behaviors among individuals who are already overweight or metabolically vulnerable.

Lifestyle education is one of the most widely recommended approaches for diabetes prevention because it directly targets modifiable health behaviors. In individuals at risk of diabetes, education can improve awareness of diet, physical activity, weight control, sleep, stress, and self-monitoring; however, knowledge alone is often insufficient to produce stable behavioral change. Sustainable prevention requires not only information but also self-regulation, motivation, perceived behavioral control, emotional readiness, and repeated practice of health-promoting behaviors. Recent research has therefore emphasized the importance of self-management and self-regulatory processes in diabetes-related interventions. For example, educational interventions based on behavioral theories have been shown to improve self-management behaviors in individuals with type 2 diabetes by targeting the reasons that support or prevent engagement in health behavior (Ranjbar et al., 2024). Similarly, adaptive behavioral trials among adults with prediabetes have shown that the sequence and structure of intervention components may influence self-regulatory and behavioral outcomes, suggesting that the design of lifestyle interventions should be sensitive to how participants initiate, maintain, and consolidate behavior change (Miller et al., 2024).

Self-care behaviors are central to diabetes prevention and management because they represent the daily actions through which individuals regulate health risk. These behaviors include healthy eating, regular physical activity, monitoring health indicators, adherence to recommendations, stress control, and avoidance of harmful sedentary patterns. In diabetes and prediabetes, self-care is especially important because metabolic risk is strongly influenced by repeated daily decisions rather than by single clinical encounters. Evidence from self-care promoting programs among people with type 2 diabetes and diabetic complications indicates that structured interventions can improve engagement in self-care behaviors and produce favorable health-related outcomes (Kim et al., 2022). Although much of the self-care literature has focused on people already diagnosed with diabetes, the same behavioral framework is highly relevant for individuals at high risk, because strengthening self-care before disease onset may reduce progression and support long-term health responsibility.

Physical activity is another core determinant of diabetes prevention. Regular movement improves insulin sensitivity, supports weight management, reduces cardiometabolic risk, and contributes to psychological well-being. However, many individuals with prediabetes or overweight struggle to maintain regular activity because of fatigue, low motivation, time constraints, physical discomfort, low self-efficacy, or

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E-ISSN: 3041-9026

negative emotional experiences associated with exercise. Research on women with prediabetes has shown that physical activity change is a long-term process rather than a short-term task, and that different patterns of change require different behavioral strategies over time (Bean et al., 2020). Similarly, a feasibility study targeting people with prediabetes emphasized that psychological factors such as self-compassion may be relevant for increasing physical activity behavior, particularly when individuals experience difficulty initiating or maintaining lifestyle change (Signore et al., 2022). These findings suggest that interventions for at-risk individuals should combine behavioral guidance with psychological support and should be designed to make physical activity more acceptable, gradual, and sustainable.

Lifestyle interventions for prediabetes are most effective when they are embedded in the lived realities of participants. A meta-synthesis of qualitative studies on lifestyle change among people with prediabetes identified both facilitators and barriers related to knowledge, motivation, social support, emotional responses, practical constraints, and perceptions of risk (Wierdsma et al., 2022). This evidence is important because it indicates that preventive interventions must go beyond advising participants to "exercise more" or "eat better." Instead, programs should help individuals understand risk, translate knowledge into daily routines, regulate stress and emotions, and develop confidence in their ability to sustain new behaviors. Recent studies using both diaries and accelerometers have also shown that combining subjective and objective methods can clarify how physical activity changes during lifestyle interventions for adults with prediabetes, indicating that behavioral change is multidimensional and requires careful monitoring (Klos et al., 2024). Therefore, a comprehensive intervention for overweight individuals at risk of diabetes should address self-care, activity level, sedentary behavior, motivation, and psychological regulation simultaneously.

Yoga therapy has increasingly attracted attention as a complementary lifestyle-based intervention for metabolic and psychological health. Yoga is not merely a form of physical exercise; it is a multidimensional practice that may include postures, breathing exercises, relaxation, mindfulness, body awareness, and stress regulation. This multidimensional structure makes yoga potentially relevant for diabetes prevention because it can address both physical inactivity and psychophysiological stress, two important contributors to metabolic dysfunction. Early reviews of yoga for neuropsychiatric disorders suggested that yoga may influence mental health and stress-related processes through behavioral, neurobiological, and psychological pathways (Balasubramaniam et al., 2013). More recent neurobiological discussions have expanded this perspective by explaining how yoga and mindfulness may affect neuronal function, stress responses, autonomic regulation, and well-being (Bakshi & Srivastava, 2024). These mechanisms are particularly relevant for individuals at risk of diabetes, for whom chronic stress, low self-regulation, and poor adherence to health behaviors can interfere with prevention efforts.

The possible mechanisms of yoga in diabetes prevention and management have been described through psycho-neuro-endocrine-immune pathways. Yoga may influence stress hormones, autonomic balance, inflammatory processes, emotional regulation, and behavioral awareness, thereby creating conditions that support improved metabolic functioning and healthier lifestyle choices (Ranganathan et al., 2022). A narrative review on the mechanisms of yoga in type 2 diabetes prevention and management similarly emphasized that yoga may operate through multiple pathways, including improved insulin sensitivity, reduced stress, enhanced physical activity, improved body composition, and better adherence to self-care routines (Tandon et al., 2021). Recent work has also proposed that yoga may distinctly target modifiable risk factors in type 2 diabetes and improve the immuno-metabolic axis, supporting its role as an integrative intervention that connects physical, psychological, and metabolic health (Joshi et al., 2025). These theoretical and empirical mechanisms provide a strong rationale for integrating yoga therapy into lifestyle education for individuals at elevated diabetes risk.

Systematic reviews and meta-analyses have provided growing support for yoga-based interventions in diabetes-related populations. Evidence on yoga practice in the prediabetic state has suggested beneficial effects on glycemic control and other health parameters, indicating that yoga may be useful before the onset of type 2 diabetes (Jayawardena et al., 2019). A similar meta-analytic report has further supported the effect of yoga practice on glycemic control and health-related outcomes among people in the prediabetic state (Ramamoorthi et al., 2019). In individuals with type 2 diabetes, meta-analytic evidence has shown that yoga may improve blood glucose and lipid profile, suggesting that yoga can contribute to metabolic regulation as part of broader care (Saeed et al., 2022). Another systematic review and meta-analysis comparing yoga and walking for glycemic control in type 2 diabetes showed that

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movement-based lifestyle practices can be clinically relevant for diabetes management (Jyotsna et al., 2023). More recently, a systematic review and meta-analysis indicated that yoga as an adjunct to standard care may improve glycemic control, insulin resistance, oxidative stress, and quality of life among individuals with or at risk of type 2 diabetes mellitus (Popoviciu et al., 2025).

Beyond metabolic outcomes, yoga may also support weight-related and activity-related intervention goals. Since overweight is a key risk factor for type 2 diabetes, interventions that improve movement, reduce stress-related eating, and promote self-regulation may indirectly contribute to diabetes prevention. A randomized trial investigating yoga as an intervention approach for improving long-term weight loss suggested that yoga may have value in weight-related behavioral interventions, particularly when the intervention aims to support long-term maintenance rather than short-term change only (Harrison et al., 2022). The delivery format of yoga interventions is also important. Research on perceived delivery of essential yoga properties within in-person and remote weight loss maintenance interventions indicates that the therapeutic value of yoga depends not only on the physical movements but also on how core properties such as breath regulation, mindfulness, attention, and relaxation are delivered (Sherman et al., 2024). Therefore, yoga therapy may be especially useful when integrated with structured lifestyle education rather than presented as an isolated exercise activity.

Large-scale yoga-based lifestyle interventions also support the preventive potential of this approach. A multicenter cluster-randomized controlled trial of a yoga-based lifestyle protocol in a high-risk Indian cohort showed that structured yoga-based lifestyle programming can be used in diabetes prevention among individuals at elevated risk (Nagarathna et al., 2021). Such findings are important because they suggest that yoga-based lifestyle protocols can be adapted for preventive contexts and may be suitable for community-based populations. However, despite increasing evidence, many studies have focused primarily on glycemic outcomes, diagnosed diabetes, or weight-related variables, while fewer studies have examined the simultaneous effects of healthy lifestyle education combined with yoga therapy on self-care behaviors and daily physical activity indicators among overweight individuals at risk of diabetes. This gap is important because self-care and daily activity are proximal behavioral outcomes that may mediate longer-term metabolic improvement.

Combining healthy lifestyle education with yoga therapy may therefore provide a coherent and theoretically grounded intervention model. Lifestyle education can provide participants with knowledge, behavioral goals, and practical strategies for diabetes prevention, while yoga therapy can enhance body awareness, stress regulation, flexibility, breathing control, relaxation, and gradual engagement in physical activity. This combination may be particularly suitable for overweight individuals because yoga can be adapted to different fitness levels and may reduce psychological resistance to movement. At the same time, the educational component can help participants understand the importance of diet, activity, self-monitoring, and health responsibility. When implemented together, these components may strengthen self-care behaviors, increase daily steps, reduce sedentary tendencies, and support the maintenance of behavioral change after the intervention period.

Accordingly, the present study aimed to examine the effectiveness of healthy lifestyle education combined with yoga therapy on self-care behaviors and daily physical activity levels in overweight individuals at risk of developing diabetes.

2. Methods and Materials

2.1. Study Design and Participants

The present study was applied in terms of its objective and quasi-experimental in terms of its methodological approach, using a pretest, posttest, and follow-up design with a control group. The statistical population consisted of overweight individuals at risk of developing diabetes in Tehran in 2026. After the initial screening process, participants were selected through purposive sampling based on the inclusion and exclusion criteria and were then randomly assigned to the experimental and control groups. The inclusion criteria were being overweight, defined as a body mass index equal to or greater than 25 kg/m²; being in the prediabetes range or having a high risk of developing diabetes based on the Finnish Diabetes Risk Score; being 30 to 65 years old; providing informed consent to participate in the study; and being able to attend the educational and therapeutic sessions. The exclusion criteria included having severe physical or psychiatric disorders, being absent from more than two intervention sessions, and unwillingness to continue participation in the study. The experimental group participated in healthy lifestyle education combined with yoga therapy, whereas the control group received no

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intervention during the study period and remained on the waiting list. Assessments were conducted at three stages: pretest, posttest, and follow-up.

2.2. Measures

Summary of Diabetes Self-Care Activities Measure. The Summary of Diabetes Self-Care Activities Measure was developed by Toobert, Hampson, and Glasgow (2000) to assess diabetes-related self-care behaviors. This instrument is a brief self-report questionnaire that evaluates the frequency of self-care activities performed during the previous seven days. The revised version includes core items related to several domains of diabetes self-management, including general diet, specific diet, physical activity, blood glucose testing, foot care, and smoking behavior. The items are scored based on the number of days, from 0 to 7, on which the respondent performed each self-care behavior during the past week, with higher scores indicating more favorable self-care performance in the relevant domain. Some items related to unhealthy dietary behaviors are reverse scored according to the scoring instructions. The instrument allows both domain-specific interpretation and an overall appraisal of diabetes self-care behavior. Its validity and reliability have been confirmed in previous studies, and it has been widely used in clinical and health psychology research to assess self-management behaviors among individuals with diabetes or those at risk of diabetes.

International Physical Activity Questionnaire–Short Form. Daily physical activity was assessed using the International Physical Activity Questionnaire–Short Form, developed by Craig and colleagues (2003) as part of an international project for the standardized assessment of physical activity across different populations and countries. The short form contains 7 items and measures the frequency and duration of physical activity during the previous seven days in three intensity levels: vigorous-intensity activity, moderate-intensity activity, and walking. It also includes an item assessing sitting time as an indicator of sedentary behavior. Scoring is based on the calculation of metabolic equivalent task minutes per week, commonly expressed as MET-minutes/week, by multiplying the frequency and duration of each activity category by its standard MET value. Total physical activity can be classified into low, moderate, or high activity levels according to the scoring protocol. The validity and reliability of the questionnaire have been confirmed in previous international studies, and the instrument is commonly used in health psychology, preventive medicine, and behavioral intervention research to assess physical activity patterns in adult populations.

2.3. Intervention

The experimental group received healthy lifestyle education combined with yoga therapy over 10 structured sessions. The intervention was designed to improve health-related awareness, strengthen self-care behaviors, increase motivation for regular physical activity, and reduce lifestyle-related risk factors associated with diabetes. The initial sessions focused on introducing the objectives of the program, establishing group rapport, explaining the relationship between overweight, sedentary lifestyle, stress, and diabetes risk, and increasing participants' awareness of the role of lifestyle modification in diabetes prevention. Subsequent sessions addressed healthy nutrition, including balanced dietary patterns, portion control, reduction of simple carbohydrates and saturated fats, increased consumption of fiber-rich foods, and practical strategies for improving eating behaviors in daily life. Participants were also trained in principles of regular physical activity, gradual activity planning, reduction of sedentary behaviors, and self-monitoring of health behaviors. The psychological components of the intervention included stress management, identification of barriers to self-care, modification of maladaptive health beliefs, enhancement of personal responsibility for health, and reinforcement of adherence to behavioral goals. The yoga therapy component included breathing exercises, gentle yoga postures appropriate for overweight adults, flexibility and balance movements, body awareness exercises, and relaxation techniques. These practices were selected to be safe, feasible, and compatible with the physical condition of participants at risk of diabetes. Each session included educational content, practical yoga exercises, guided relaxation, group discussion, review of previous assignments, and home practice recommendations. Participants were encouraged to practice breathing exercises, relaxation, and light physical activity between sessions and to record their self-care behaviors. The control group did not receive any educational or therapeutic intervention during the study period and remained on the waiting list.

2.4. Data Analysis

Data were analyzed using SPSS version 26. Descriptive statistics, including mean and standard deviation, were used to describe the demographic characteristics and research

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variables across the three assessment stages. Before conducting inferential analyses, the assumptions required for repeated-measures analysis of variance were examined, including normality of the data distribution, homogeneity of variances, and sphericity. Repeated-measures analysis of variance was used to examine within-group changes over time, between-group differences, and the interaction effect of time and group on self-care behaviors and daily physical activity levels. When necessary, post hoc comparisons were conducted to identify differences between the pretest, posttest, and follow-up stages. The significance level for all statistical tests was set at 0.05.

3. Findings and Results

A total of 40 overweight individuals at risk of developing diabetes participated in this study and were randomly assigned to the experimental group (n = 20) and the control group (n = 20). The mean age of participants was 47.40 ± 6.72 years in the experimental group and 47.70 ± 7.71 years in the control group. In terms of gender distribution, the experimental group included 11 men (55%) and 9 women (45%), while the control group included 10 men (50%) and 10 women (50%). Regarding marital status, 13 participants (65%) in the experimental group and 12 participants (60%) in the control group were married; 4 participants (20%) in each group were single; and 3 participants (15%) in the experimental group and 4 participants (20%) in the control group were classified in other marital status categories. Overall, the two groups were relatively similar in terms of demographic characteristics.

Table 1

Descriptive Statistics of the Research Variables at Pretest, Posttest, and Follow-Up Stages

Variable	Group	Pretest M	Pretest SD	Posttest M	Posttest SD	Follow-Up M	Follow-Up SD
Diabetes self-care	Experimental	34.90	6.35	44.65	6.13	44.55	6.12
Diabetes self-care	Control	35.00	4.62	35.20	4.53	35.15	4.51
Daily step count	Experimental	4320.50	410.60	4669.50	443.80	4665.00	445.90
Daily step count	Control	4293.50	226.00	4301.00	225.40	4299.50	227.60
Sedentary behavior index	Experimental	53.60	5.63	43.15	4.98	43.30	5.01
Sedentary behavior index	Control	54.05	3.84	53.95	3.87	54.00	3.89

As shown in Table 1, there were no substantial baseline differences between the experimental and control groups in diabetes self-care, daily step count, and sedentary behavior index at the pretest stage. After the implementation of healthy lifestyle education combined with yoga therapy, the experimental group showed a clear increase in diabetes self-care, from 34.90 at pretest to 44.65 at posttest and 44.55 at follow-up. Daily step count also increased in the experimental group, from 4320.50 at pretest to 4669.50 at posttest and 4665.00 at follow-up. In addition, the sedentary behavior index decreased from 53.60 at pretest to 43.15 at posttest and 43.30 at follow-up. In contrast, the control group showed only minimal changes across the three measurement stages.

Before conducting repeated-measures analysis of variance, the statistical assumptions were examined. The normality of the distribution of the variables, homogeneity of variances, and homogeneity of covariance matrices were evaluated and found to be acceptable. Since Mauchly's test of sphericity was significant for all three variables ($p < .001$), the assumption of sphericity was not met; therefore, the Greenhouse–Geisser correction was applied to the degrees of freedom in the repeated-measures analysis of variance.

Table 2

Results of Repeated-Measures Analysis of Variance for the Research Variables

Variable	Source of Variation	F	df	p	η^2
Diabetes self-care	Time	345.087	1.039, 39.481	< .001	.901
Diabetes self-care	Group × Time	321.010	1.039, 39.481	< .001	.894
Daily step count	Time	70.695	1.011, 38.410	< .001	.650
Daily step count	Group × Time	65.388	1.011, 38.410	< .001	.632
Sedentary behavior index	Time	2107.023	1.291, 49.059	< .001	.982
Sedentary behavior index	Group × Time	2046.551	1.291, 49.059	< .001	.982

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The results of repeated-measures analysis of variance showed that the main effect of time and the group × time interaction effect were statistically significant for all three research variables. For diabetes self-care, the effect of time was significant, $F(1.039, 39.481) = 345.087$, $p < .001$, $\eta^2 = .901$, and the group × time interaction was also significant, $F(1.039, 39.481) = 321.010$, $p < .001$, $\eta^2 = .894$. For daily step count, the effect of time was significant, $F(1.011, 38.410) = 70.695$, $p < .001$, $\eta^2 = .650$, and the group × time interaction was significant, $F(1.011, 38.410) = 65.388$, $p < .001$, $\eta^2 = .632$. For the sedentary behavior index, the effect of time was significant, $F(1.291, 49.059) = 2107.023$, $p < .001$, $\eta^2 = .982$, and the group × time interaction was also significant, $F(1.291, 49.059) = 2046.551$, $p < .001$, $\eta^2 = .982$. These findings indicate that healthy lifestyle education combined with yoga therapy had a strong and statistically significant effect on improving diabetes self-care, increasing daily physical activity, and reducing sedentary behavior among overweight individuals at risk of developing diabetes.

Table 3

Results of Bonferroni Post Hoc Pairwise Comparisons Across Measurement Stages

Variable	Comparison	Mean Difference	Standard Error	p
Diabetes self-care	Pretest – Posttest	-4.975	0.263	< .001
Diabetes self-care	Pretest – Follow-up	-4.900	0.265	< .001
Diabetes self-care	Posttest – Follow-up	0.075	0.043	.258
Daily step count	Pretest – Posttest	-178.250	21.122	< .001
Daily step count	Pretest – Follow-up	-175.250	20.847	< .001
Daily step count	Posttest – Follow-up	3.000	1.805	.314
Sedentary behavior index	Pretest – Posttest	5.275	0.105	< .001
Sedentary behavior index	Pretest – Follow-up	5.175	0.112	< .001
Sedentary behavior index	Posttest – Follow-up	-0.100	0.048	.132

The Bonferroni post hoc test results showed that, for diabetes self-care, the differences between pretest and posttest and between pretest and follow-up were statistically significant ($p < .001$), whereas the difference between posttest and follow-up was not significant ($p = .258$). For daily step count, the differences between pretest and posttest and between pretest and follow-up were statistically significant ($p < .001$), while the difference between posttest and follow-up was not significant ($p = .314$). Similarly, for the sedentary behavior index, the differences between pretest and posttest and between pretest and follow-up were statistically significant ($p < .001$), but the difference between posttest and follow-up was not significant ($p = .132$). These results indicate that the effects of the intervention were maintained during the follow-up period and that the improvements observed after the intervention did not significantly decline over time.

4. Discussion

The present study aimed to examine the effectiveness of healthy lifestyle education combined with yoga therapy on self-care behaviors and daily physical activity levels in overweight individuals at risk of developing diabetes. The findings showed that the intervention produced significant improvements in diabetes self-care, daily step count, and sedentary behavior indicators in the experimental group compared with the control group. Repeated-measures analysis of variance indicated significant effects of time and group × time interaction for all three outcomes, suggesting that the observed changes were attributable to the intervention rather than to the passage of time alone. Specifically, self-care behaviors increased substantially from pretest to posttest and remained stable at follow-up; daily step count also increased after the intervention and was maintained at follow-up; and the sedentary index decreased significantly after the intervention, with the reduction persisting during the follow-up phase. The Bonferroni post hoc comparisons further confirmed that changes from pretest to posttest and from pretest to follow-up were statistically significant, whereas differences between posttest and follow-up were not significant. This pattern indicates that healthy lifestyle education combined with yoga therapy was not only effective in producing short-term behavioral improvement but also contributed to the maintenance of these improvements over time.

The significant improvement in diabetes self-care behaviors is consistent with the theoretical assumption that

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preventive interventions should not be limited to clinical risk reduction but should also strengthen the daily behavioral competencies through which individuals manage their health. Self-care behaviors in individuals at risk of diabetes include dietary regulation, regular physical activity, stress management, self-monitoring, adherence to health recommendations, and reduction of unhealthy routines. The present findings align with evidence showing that structured self-care promoting programs can improve engagement in self-care behaviors and related health outcomes among individuals with diabetes-related conditions (Kim et al., 2022). They are also consistent with findings from educational interventions based on behavioral theories, which have demonstrated that improving the cognitive and motivational foundations of health behavior can enhance self-management in people with type 2 diabetes (Ranjbar et al., 2024). In the present study, the educational component likely increased participants' awareness of diabetes risk, clarified the practical meaning of self-care, and strengthened their perceived responsibility for lifestyle modification. Such mechanisms are important because overweight individuals at risk of diabetes may not yet experience severe symptoms and may therefore underestimate the need for sustained self-care. By providing structured knowledge and practical strategies, the intervention appears to have transformed diabetes prevention from an abstract medical recommendation into a set of achievable daily behaviors.

The improvement in self-care can also be interpreted in relation to self-regulation. Lifestyle change requires individuals to set goals, monitor behavior, manage barriers, and maintain motivation despite gradual progress. Previous research among adults with prediabetes has shown that intervention structure and sequencing can influence self-regulatory and behavioral outcomes, indicating that how an intervention is delivered may be as important as the content itself (Miller et al., 2024). The current intervention combined lifestyle education with yoga therapy, which may have created a more integrated self-regulatory process. Educational sessions provided cognitive understanding and behavioral guidance, while yoga practices provided embodied experiences of control, relaxation, breath regulation, and self-awareness. This combination may have improved participants' ability to notice their physical condition, regulate stress-related impulses, and adhere to health-promoting routines. Such an interpretation is also supported by qualitative evidence indicating that people with prediabetes face barriers related to motivation, risk perception, emotional responses, practical constraints, and social-environmental conditions (Wierdsma et al., 2022). Therefore, the effectiveness of the intervention may be explained by its capacity to address both informational and psychological barriers to self-care.

The significant increase in daily step count indicates that healthy lifestyle education combined with yoga therapy was effective in improving daily physical activity. This finding is important because physical inactivity is a major modifiable risk factor for diabetes, and increasing daily movement is one of the most accessible preventive strategies for overweight adults. Previous evidence has shown that physical activity change among women with prediabetes is a long-term process rather than a temporary behavioral adjustment, and that different patterns of change require different strategies across time (Bean et al., 2020). The maintenance of step-count improvement at follow-up in the present study suggests that the intervention did not merely create a short-term increase in activity but helped participants incorporate movement into their daily routine. This result is also consistent with research showing that lifestyle interventions for adults with prediabetes can produce measurable changes in physical activity when behavioral monitoring and practical activity strategies are included (Klos et al., 2024). In the present study, education about physical activity, gradual activity planning, and reduction of sedentary behaviors may have encouraged participants to increase walking and routine movement. At the same time, yoga therapy may have reduced physical discomfort, improved flexibility, and increased confidence in movement, thereby making activity more feasible for overweight participants.

The reduction in sedentary behavior is another important finding. Sedentary behavior is not simply the absence of exercise; it is an independent behavioral risk factor that can contribute to poor metabolic health even when some structured physical activity is present. The significant decrease in the sedentary index in the experimental group suggests that the intervention influenced participants' broader activity pattern, not only their formal exercise behavior. This result is theoretically meaningful because yoga-based lifestyle interventions may increase body awareness and make participants more attentive to prolonged inactivity. The breathing exercises, relaxation practices, and gentle postures used in yoga therapy may help individuals develop a stronger connection with bodily signals, which can encourage them to interrupt sedentary routines and engage in light movement. Studies on yoga delivery have emphasized that the essential properties of

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E-ISSN: 3041-9026

yoga include not only physical postures but also attention, breath regulation, mindfulness, and relaxation (Sherman et al., 2024). Therefore, the decrease in sedentary behavior observed in the present study may reflect the combined effect of lifestyle education and the self-awareness-enhancing properties of yoga practice.

The findings are also consistent with broader evidence supporting lifestyle intervention for diabetes prevention. The Diabetes Prevention Program demonstrated that lifestyle intervention can substantially reduce the incidence of type 2 diabetes among high-risk individuals, establishing lifestyle modification as a central preventive strategy (Knowler et al., 2002). The current study extends this evidence by focusing on behavioral outcomes among overweight individuals at risk of diabetes and by incorporating yoga therapy as a complementary component. In contexts such as Iran, where diabetes prevention and control are influenced by barriers at the individual, organizational, and health-system levels, interventions that are low-cost, accessible, culturally adaptable, and behaviorally acceptable are especially valuable (Sadeghi et al., 2023). Evidence from the Iranian diabetes care cascade also highlights the importance of improving prevention, risk identification, and care coverage in accordance with global health targets (Haghdoost et al., 2023). The present findings suggest that combined lifestyle and yoga-based programs may contribute to this preventive agenda by targeting self-care and daily activity before the progression to clinically diagnosed diabetes.

The beneficial effects observed in this study are also in line with previous studies and reviews on yoga and diabetes-related outcomes. Systematic reviews and meta-analyses have reported that yoga practice can improve glycemic control and other health parameters in individuals with prediabetes or diabetes (Jayawardena et al., 2019; Ramamoorthi et al., 2019). Evidence has also shown that yoga may improve blood glucose and lipid profile in patients with type 2 diabetes without complications (Saeed et al., 2022), and that yoga and walking can contribute to glycemic control in diabetes management (Jyotsna et al., 2023). More recent meta-analytic evidence has indicated that yoga as an adjunct to standard care may improve glycemic control, insulin resistance, oxidative stress, and quality of life among individuals with or at risk of type 2 diabetes (Popoviciu et al., 2025). Although the present study did not directly evaluate glycemic biomarkers, its findings are compatible with this literature because improvements in self-care, daily steps, and sedentary behavior are proximal behavioral changes that may precede or support later metabolic improvement. In other words, the behavioral improvements found in this study may be understood as mechanisms through which yoga-based lifestyle interventions could contribute to long-term metabolic risk reduction.

The mechanisms through which yoga therapy may influence diabetes-related outcomes are multidimensional. Yoga can affect health through physical movement, improved flexibility, breathing regulation, relaxation, stress reduction, autonomic modulation, and enhanced emotional regulation. Reviews of yoga mechanisms in type 2 diabetes have emphasized the role of neuroendocrine, immune, psychological, and behavioral pathways in explaining its preventive and therapeutic effects (Ranganathan et al., 2022; Tandon et al., 2021). More recent work has further suggested that yoga may target modifiable risk factors in diabetes and contribute to improvement in the immuno-metabolic axis (Joshi et al., 2025). From this perspective, the present findings may be explained by the interaction of physiological and psychological processes. Stress reduction may have improved participants' readiness to engage in self-care; breathing and relaxation exercises may have increased emotional control; and gentle physical postures may have provided a safe entry point into activity for individuals who might otherwise avoid exercise due to weight, fatigue, or low confidence.

The psychological dimension of yoga is especially relevant for self-care and physical activity maintenance. Earlier reviews suggested that yoga may have beneficial effects on neuropsychiatric and stress-related conditions (Balasubramaniam et al., 2013), while recent neurobiological accounts have described how yoga and mindfulness may affect neuronal function, stress regulation, and well-being (Bakshi & Srivastava, 2024). These mechanisms can help explain why the intervention effects in the present study were maintained at follow-up. When individuals learn only factual information about diabetes prevention, their behavior may improve temporarily but decline after the intervention ends. However, when lifestyle education is combined with yoga practices that cultivate relaxation, self-awareness, and internal regulation, participants may be more likely to internalize health behaviors as part of their daily routine. This interpretation is also consistent with research suggesting that self-compassion and psychological support may facilitate physical activity behavior among people with prediabetes (Signore et al., 2022). Thus, the durability of the present intervention may be related to its capacity to engage both behavioral and emotional determinants of change.

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The findings also correspond with evidence on yoga-based lifestyle protocols and weight-related interventions. A multicenter cluster-randomized controlled trial showed that a yoga-based lifestyle protocol can be effective in preventing diabetes in a high-risk cohort (Nagarathna et al., 2021). Furthermore, a randomized trial investigating yoga as an intervention approach for long-term weight loss suggested that yoga may support weight-related behavioral change and maintenance (Harrison et al., 2022). These studies support the idea that yoga is not merely an adjunct relaxation technique but can be integrated into comprehensive lifestyle interventions for populations with metabolic risk. In the present study, overweight individuals at risk of diabetes benefited from a program that combined education, physical movement, breathing exercises, relaxation, stress management, and behavioral goal setting. The strong effect sizes observed for self-care, daily steps, and sedentary behavior indicate that this integrated structure was capable of producing meaningful change in the targeted behavioral outcomes.

5. Conclusion

Overall, the results support the effectiveness of healthy lifestyle education combined with yoga therapy as a complementary preventive intervention for overweight individuals at risk of developing diabetes. The intervention improved self-care behaviors, increased daily physical activity, reduced sedentary behavior, and maintained these effects during follow-up. These findings suggest that combining cognitive-behavioral lifestyle education with embodied yoga practices may be more effective than education alone because it targets knowledge, motivation, stress regulation, movement confidence, and daily behavioral routines simultaneously. The results also contribute to the growing literature on integrative and preventive approaches to diabetes risk reduction by emphasizing behavioral outcomes that are clinically meaningful and modifiable before the onset of type 2 diabetes.

This study had several limitations that should be considered when interpreting the findings. First, the sample size was relatively limited, and participants were selected through purposive sampling from overweight individuals at risk of diabetes in Tehran; therefore, caution should be exercised in generalizing the results to other populations, age groups, clinical groups, or geographical regions. Second, some outcome variables were assessed through self-report or behavior-based indicators, which may be influenced by recall bias, social desirability, or participant motivation. Third, the study focused on behavioral outcomes, including self-care, step count, and sedentary behavior, and did not include biological indicators such as fasting blood glucose, HbA1c, insulin resistance, lipid profile, inflammatory markers, or body composition. Fourth, although a follow-up assessment was conducted, the duration of follow-up was limited, and the long-term stability of the intervention effects beyond the assessed period remains unclear.

Future studies should replicate this research with larger and more diverse samples to increase the generalizability of the findings and to examine whether the intervention is equally effective across sex, age, socioeconomic status, baseline activity level, and degree of diabetes risk. It is also recommended that future research use randomized controlled trial designs with longer follow-up periods to evaluate the durability of behavioral and metabolic outcomes over time. Future studies should include objective biological indicators such as HbA1c, fasting blood glucose, insulin resistance, lipid profile, waist circumference, and body composition in order to determine whether improvements in self-care and physical activity are accompanied by measurable metabolic benefits. In addition, future research may compare healthy lifestyle education alone, yoga therapy alone, and the combined intervention to clarify the independent and additive effects of each component.

The findings of this study suggest that healthy lifestyle education combined with yoga therapy can be used as a complementary preventive strategy for overweight individuals at risk of developing diabetes. Health professionals, psychologists, diabetes educators, and community health centers can integrate structured lifestyle education with safe and adaptable yoga-based practices to improve self-care, increase daily physical activity, and reduce sedentary behavior. For practical implementation, the intervention should be delivered in a gradual and participant-centered manner, with attention to physical limitations, motivation, stress level, and adherence barriers. Programs should include education about diabetes prevention, nutrition, physical activity, self-monitoring, stress management, breathing exercises, gentle yoga movements, relaxation practices, and home assignments to support transfer of learned skills into daily life. Such interventions may be particularly useful in preventive care settings because they are low-risk, relatively accessible, and capable

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E-ISSN: 3041-9026

of addressing both behavioral and psychological determinants of diabetes risk.

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. The ethics code for this study was approved on September 21, 2025, under the identifier IR.PNU.REC.1404.575.

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