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The Effectiveness of Problem-Solving Skills Training on Biological Indicators and Self-Care Behaviors in Patients with Diabetic Nephropathy

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ABSTRACT

Objective: Diabetic nephropathy is one of the most serious chronic complications of diabetes and requires strict behavioral management and control of metabolic indicators. The present study aimed to determine the effectiveness of problem-solving skills training on self-care activities and biological indicators (HbA1c, fasting blood glucose, and kidney function) in patients with diabetic nephropathy.

Methods: This study employed a quasi-experimental pretest–posttest design with a control group. The statistical population included all patients with diabetic nephropathy who referred to the Broadcasting Health and Treatment Center in 2024. Forty patients were selected through convenience sampling and randomly assigned to an experimental group (n = 20) and a control group (n = 20). The experimental group received eight sessions of problem-solving skills training, while the control group received routine care. Data collection tools included the Summary of Diabetes Self-Care Activities (SDSCA) questionnaire and biological tests (HbA1c, fasting blood glucose, and creatinine). Data were analyzed using repeated measures analysis of variance in SPSS version 26.

Results: The findings showed that problem-solving skills training led to a significant increase in self-care scores (diet, physical activity, blood glucose monitoring, and foot care) in the experimental group compared with the control group. In addition, significant reductions were observed in biological indicators, particularly HbA1c and fasting blood glucose, in the experimental group.

Conclusions: Based on the results, problem-solving skills training, as an effective non-pharmacological intervention, can empower patients to manage daily disease-related challenges, leading to improved self-care behaviors and better control of biological indicators in patients with diabetic nephropathy. Therefore, integrating this training into care programs for these patients is recommended.

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Introduction

Diabetic nephropathy (DN) is one of the most common and serious microvascular complications of diabetes and remains the leading cause of end-stage renal disease (ESRD) worldwide. Effective management of this condition requires strict adherence to complex therapeutic regimens and profound, long-term lifestyle modifications (Tuttle et al., 2022; American Diabetes Association, 2023). As the disease progresses, patients face not only increasing physical limitations but also a substantial biopsychosocial burden that significantly undermines their capacity for self-management and psychological well-being (Gonzalez et al., 2016). Evidence suggests that difficulties in regulating negative emotions and ineffective coping with daily illness-related stressors contribute to the development of diabetes-related distress, which in turn leads to deterioration in clinical outcomes and disease control (Dennick et al., 2020).

Consequently, growing attention has been directed toward the role of psychological interventions—particularly emotion regulation training and problem-solving skills—as strategic tools for improving both behavioral and biological outcomes in individuals with diabetes-related complications (Hill-Briggs et al., 2021). Problem-solving skills comprise a set of cognitive and behavioral abilities that enable individuals to systematically identify challenges, gather relevant information, generate and evaluate alternative solutions, and implement the most adaptive course of action. In studies involving patients with chronic illnesses, training in problem-solving skills has been associated with enhanced internal locus of control, increased motivation for self-care, reduced feelings of helplessness, and improved engagement with healthcare systems (Hessler et al., 2019).

Empirical evidence further supports the clinical utility of this approach. For example, Hill-Briggs et al. (2021) demonstrated that integrating problem-solving training with standard pharmacological treatment in patients with diabetes resulted in significant reductions in HbA1c levels, higher treatment satisfaction, and lower healthcare costs. However, many existing psychological interventions—such as Acceptance and Commitment Therapy (ACT) or mindfulness-based approaches—primarily emphasize acceptance of internal experiences or broad cognitive restructuring. While these approaches are valuable, patients with diabetic nephropathy are continuously confronted with concrete, real-world decisions that demand practical and immediate action. These challenges include managing dietary restrictions in social contexts,

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adjusting insulin dosages in response to glycemic fluctuations, and maintaining physical activity despite chronic fatigue and declining renal function. By directly targeting the *process* of responding to such challenges, problem-solving skills training effectively bridges the gap between "knowing what should be done" and "being able to do it in everyday life" (D'Zurilla et al., 2018). Beyond behavioral outcomes, there is a pressing need to examine the effects of psychological interventions on biological and clinical indicators, as many previous studies have been limited to psychological endpoints alone. From the perspective of stress physiology, chronic psychological stress resulting from persistent illness-related challenges can lead to sustained activation of the hypothalamic–pituitary–adrenal (HPA) axis and immune pathways. This dysregulation promotes the release of pro-inflammatory cytokines and biomarkers such as C-reactive protein (CRP), which exert deleterious effects on blood pressure regulation, insulin sensitivity, glycemic control (HbA1c), glomerular filtration rate (eGFR), and serum creatinine levels (Slavich & Irwin, 2017; Tuttle et al., 2022).

In this context, problem-solving skills training may exert a causal and multi-level impact: first, by enhancing perceived control and self-efficacy, it improves adherence to self-care behaviors; and second, by reducing allostatic load and modulating physiological stress responses, it may slow the progression of renal damage. Despite the clinical relevance of this integrated approach, there remains a substantial gap in the literature—particularly in Iran and other developing countries—regarding the evaluation of such interventions in patients with diabetic nephropathy. Existing domestic studies have largely focused on "soft" psychological variables, while the biological and clinical effects of structured psychological interventions in complex conditions such as diabetic nephropathy have been relatively neglected.

Therefore, given the urgent need for integrated therapeutic approaches that simultaneously address behavioral, emotional, and physiological dimensions of chronic illness, the present study was designed to investigate the effectiveness of problem-solving skills training on biological indicators and self-care behaviors in patients with diabetic nephropathy.

Material and Methods

The present study employed a quasi-experimental design with a pre-test, post-test, and follow-up, including an experimental and a control group. This design was selected to evaluate the

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effectiveness of problem-solving skills training on self-care behaviors and biological indicators in patients with diabetic nephropathy. The statistical population of this study consisted of all patients diagnosed with diabetic nephropathy who referred to the Endocrinology and Diabetes Clinic of the Broadcasting Organization Health and Medical Center in Tehran during 2024. Based on registered medical records, a total of 211 patients with a confirmed diagnosis of diabetic nephropathy—established by an endocrinologist or internist and supported by laboratory documentation—were identified between April 2024 and April 2025. This group constituted the accessible population of the study.

The study sample was selected from the above population based on predefined inclusion and exclusion criteria. Inclusion criteria included: diagnosis of type 2 diabetes mellitus with diabetic nephropathy, age range of 40 to 55 years, a documented history of the disease, stability of pharmacological treatment during the study period, and willingness to participate in the research. Patients with severe psychiatric disorders, cognitive impairment, or major changes in medical treatment during the intervention were excluded.

Initially, a list of eligible patients was prepared using medical records and referrals from endocrinologists and internists at the center. From this list, 40 patients who met the inclusion criteria and provided informed consent were selected through convenience sampling and subsequently allocated to the experimental and control groups.

Instruments

Diabetes Self-Care Activities Questionnaire (SDSCA): Self-care behaviors were assessed using the Diabetes Self-Care Activities Questionnaire developed by Toobert et al. (2000). This instrument evaluates multiple dimensions of diabetes self-care across six main components: general diet, specific diet, physical activity, blood glucose testing, medication or insulin adherence, foot care, and smoking behavior.

The general diet subscale assesses adherence to overall dietary recommendations for diabetes management, such as reducing saturated fat and simple sugar intake and increasing consumption of vegetables and low-glycemic fruits. The specific diet subscale focuses on compliance with individualized dietary plans prescribed by healthcare professionals, including meal frequency, carbohydrate distribution, and renal-related dietary restrictions (e.g., protein, sodium, and potassium control in patients with nephropathy). The physical activity subscale measures

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engagement in regular physical activities (e.g., walking or light-to-moderate exercise) during the past week—behaviors that are critical for glycemic control, blood pressure regulation, weight management, and slowing nephropathy progression.

The blood glucose testing component assesses the frequency of self-monitoring of blood glucose, reflecting the patient's active involvement in disease management. The medication adherence subscale evaluates compliance with prescribed insulin or oral hypoglycemic agents, which is particularly important in preventing glycemic fluctuations and reducing metabolic burden on the kidneys in patients with diabetic nephropathy. Higher scores indicate better self-care performance in each domain and overall.

International evidence supports the SDSCA as one of the most widely used tools for assessing diabetes self-care behaviors. In their original study, Toobert et al. (2000), reporting data from seven independent studies involving 1,988 patients with diabetes, demonstrated acceptable validity and reliability for the scale. Mean inter-item correlations across subscales were moderate (approximately 0.47), and test–retest reliability coefficients over various time intervals were also moderate (around 0.40), indicating reasonable temporal stability. Convergent validity has been supported through correlations between dietary and physical activity subscales and other measures of similar behaviors, and sensitivity to change has been demonstrated in several educational intervention trials.

In Iran, the Persian version of the SDSCA has been used in multiple studies, with confirmed psychometric properties. Didarloo et al. (2012), in a study of women with type 2 diabetes, reported good internal consistency for the total scale (Cronbach's alpha ≈ 0.83) and supported its validity through correlations with theoretically related constructs such as self-efficacy and health attitudes.

Problem-Solving Skills Training Intervention

Participants in the experimental group received problem-solving skills training delivered in eight weekly sessions, each lasting 90 minutes. The overall structure of each session included a review of the previous session and homework assignments, presentation of the main educational content, and session summarization with assignment of new homework.

The intervention was designed based on the cognitive–behavioral problem-solving model proposed by D'Zurilla and Goldfried and included the following components: accurate problem identification in living with diabetes and nephropathy; differentiation between solvable and

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unsolvable problems; generation of multiple alternative solutions; evaluation of potential consequences; selection of the most adaptive solution; implementation planning; and evaluation of outcomes.

Throughout the sessions, concrete and illness-specific examples were used to enhance relevance and applicability, including challenges such as coordinating dietary restrictions with family and work demands, medication adherence, scheduling and following up laboratory tests, managing fatigue and physical limitations, and coping with medical and financial stressors. Participants were encouraged to apply the structured problem-solving steps to their real-life challenges. Homework assignments involved recording weekly problems, practicing the problem-solving steps, and reporting outcomes in subsequent sessions. Table 1 presents the detailed protocol of the problem-solving skills training sessions based on the D'Zurilla and Goldfried model.

Table 1. Problem-Solving Skills Training Protocol Based on the D'Zurilla and Goldfried Model

Session	Content
Session 1	Understanding problem-solving ability; acceptance of problems as natural and potentially changeable; examining beliefs about the effectiveness of problem-solving
Session 2	Problem definition and formulation; information gathering; distinguishing facts from assumptions; problem decomposition and goal setting
Session 3	Generation of alternative solutions; identifying a range of possible responses
Session 4	Decision-making; prediction and evaluation of potential consequences
Session 5	Training in implementation of selected solutions
Session 6	Review, monitoring, and evaluation of implementation outcomes
Session 7	Evaluation of chosen solutions and decision-making regarding continuation or replacement
Session 8	Comprehensive review of all problem-solving stages and practice of learned skills

Ethical Considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the relevant institutional ethics committee prior to data collection. All participants were informed about the study objectives, procedures, voluntary nature of participation, and their right to withdraw at any stage without any consequences for their medical care. Written informed consent was obtained from all participants. Confidentiality of personal and medical information was ensured, and data were analyzed and reported anonymously.

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Results

In this study, a total of 40 patients with diabetic nephropathy were examined and assigned to an experimental group (n = 20) and a control group (n = 20). The mean age of participants in the experimental group was 47.35 years (SD = 4.12), while the mean age in the control group was 48.10 years (SD = 3.98). In terms of gender distribution, 22 participants (55%) were female and 18 (45%) were male.

The results of the chi-square test and independent samples *t*-test indicated no statistically significant differences between the two groups with respect to demographic variables ($P > 0.05$). Therefore, baseline homogeneity between the experimental and control groups was confirmed. The means and standard deviations of self-care scores and biological indicators at the pre-test and post-test stages for both groups are presented in Table 2.

Table 2. Means and Standard Deviations of Self-Care Scores and Biological Indicators in the Experimental and Control Groups

Variable	Stage	Experimental Group (M ± SD)	Control Group (M ± SD)
Total self-care	Pre-test	42.15 ± 6.32	41.80 ± 6.10
	Post-test	58.90 ± 5.48	43.05 ± 6.25
HbA1c (%)	Pre-test	8.42 ± 0.76	8.35 ± 0.72
	Post-test	7.18 ± 0.64	8.21 ± 0.70
Fasting blood glucose (mg/dL)	Pre-test	176.40 ± 18.25	173.90 ± 17.80
	Post-test	148.60 ± 15.40	170.85 ± 18.10
Serum creatinine (mg/dL)	Pre-test	1.82 ± 0.31	1.79 ± 0.29
	Post-test	1.70 ± 0.28	1.77 ± 0.30

To examine the effectiveness of problem-solving skills training, a repeated-measures analysis of variance (RM-ANOVA) was conducted with one within-subjects factor (time: pre-test, post-test) and one between-subjects factor (group: experimental, control). The assumptions of normality, homogeneity of variances, and sphericity were examined and met. The results of the repeated-measures ANOVA are presented in Table 3.

Table 3. Results of Repeated-Measures ANOVA for the Study Variables

Variable	Effect	F	df	P	η^2
Total self-care	Time × Group	28.64	1, 38	< 0.001	0.43
HbA1c	Time × Group	19.82	1, 38	< 0.001	0.34
Fasting blood glucose	Time × Group	16.45	1, 38	< 0.001	0.30
Serum creatinine	Time × Group	4.12	1, 38	0.049	0.09

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As shown in Table 3, the interaction effect of time × group was statistically significant for total self-care, HbA1c, and fasting blood glucose ($P < 0.001$), indicating that problem-solving skills training was effective in improving self-care behaviors and glycemic control. The observed effect sizes ranged from moderate to large. Although a reduction in mean serum creatinine levels was observed in the experimental group, the effect size for this variable was small. To provide a more detailed understanding of the intervention effects, the components of the diabetes self-care questionnaire were analyzed separately using repeated-measures ANOVA (table 4).

Table 4. Repeated-Measures ANOVA Results for Self-Care Components

Self-care Component	F	P	η^2
General diet	21.36	< 0.001	0.36
Specific diet	18.92	< 0.001	0.33
Physical activity	15.47	< 0.001	0.29
Blood glucose monitoring	17.10	< 0.001	0.31
Foot care	12.84	< 0.001	0.25
Medication adherence	6.25	0.017	0.14

The results indicated that problem-solving skills training led to significant improvements across all self-care components. The largest effects were observed in dietary behaviors and blood glucose monitoring, suggesting that the intervention was particularly effective in enhancing daily disease-management behaviors that require ongoing decision-making and planning.

Discussion

The findings of the present study demonstrated that problem-solving skills training led to a significant improvement in self-care behaviors and metabolic status (biological indicators) in patients with diabetic nephropathy. These results highlight the effectiveness of problem-solving skills training as a non-pharmacological and supportive intervention in the management of this complex chronic condition.

One possible explanation for these findings is that managing a chronic disease such as diabetic nephropathy extends far beyond medication adherence and requires continuous, complex daily decision-making. According to the social problem-solving theory proposed by D'Zurilla and Nezu, when individuals encounter obstacles—such as adhering to strict dietary restrictions or balancing treatment demands with daily life—lack of problem-solving skills may result in helplessness, avoidance, or impulsive and maladaptive behaviors. In contrast, training in structured problem-

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solving helps individuals develop a positive problem orientation and approach challenges as manageable and solvable rather than overwhelming.

In the present study, problem-solving skills training enabled patients to adopt a more adaptive cognitive and behavioral approach by systematically defining problems, generating alternative solutions, evaluating potential outcomes, and selecting the most appropriate course of action. Through this process, barriers to effective self-care—such as difficulty following dietary recommendations, maintaining regular physical activity, or adhering to glucose monitoring routines—were reduced. These findings are consistent with previous studies by Toobert et al. (2000) and Hill-Briggs et al. (2003), which emphasized the critical role of problem-solving abilities in effective diabetes self-management. Similarly, national studies conducted by Didarloo et al. (2012) and Shayegian et al. (2016) have shown that cognitive–behavioral interventions significantly improve behavioral indices in patients with diabetes. Overall, problem-solving skills training appears to enhance self-efficacy, transforming patients from passive recipients of care into active managers of their treatment process.

Another important finding of this study was the significant reduction in fasting blood glucose and glycated hemoglobin (HbA1c) levels in the experimental group. From a physiological perspective, improvements in self-care behaviors—such as accurate carbohydrate regulation, restriction of sodium and protein intake, and engagement in regular physical activity—directly influence metabolic cycles and reduce glycemic variability. In patients with diabetic nephropathy, tight glycemic control is particularly crucial, as persistent hyperglycemia accelerates glomerular damage and progression of renal dysfunction.

These results are in line with the findings of Cook et al. (2009), who reported a direct effect of problem-solving training on the reduction of HbA1c levels in patients with diabetes. Another plausible explanation is that problem-solving skills training reduces disease-related psychological stress. Chronic stress activates the hypothalamic–pituitary–adrenal (HPA) axis and increases stress hormones such as cortisol, which contribute to insulin resistance and elevated blood glucose levels. By equipping patients with effective coping and problem-solving strategies, this intervention may indirectly improve metabolic outcomes through stress reduction.

Despite these promising findings, several limitations should be acknowledged. The use of convenience sampling and the restriction of the study population to a single medical center limit

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the generalizability of the results. Additionally, reliance on self-report measures for assessing self-care behaviors may introduce response bias. Future studies are recommended to replicate this intervention in more diverse clinical settings with larger sample sizes and longer follow-up periods. Incorporating objective behavioral measures and additional biological markers could further strengthen the evidence base.

From a clinical perspective, the results of this study suggest that problem-solving skills training can be effectively integrated into routine care for patients with diabetic nephropathy. Healthcare professionals are encouraged to include practical problem-solving techniques as part of supportive educational programs, alongside pharmacological treatment, to enhance long-term self-management, improve metabolic control, and potentially slow the progression of renal complications.

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the ethics committee of Islamic Azad University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors contributed to the study conception and design, material preparation, data collection, and analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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