University of Hormozgan

Iranian Evolutionary Educational Psychology Journal

IEEPJ

Online ISSN: 2588 - 4395

Homepage: https://ieepj.hormozgan.ac.ir

Comparison of the Effectiveness of Emotion Regulation Training and Problem-Solving Skills Training on Self-Care in Patients with Diabetic Nephropathy

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Article Info

Article type:

Research Article

Article history:

Received 15 Aug. 2025

Received in revised form 16 Sep. 2025

Accepted 28 Sep. 2025

Published online 01 Dec. 2025

Keywords:

Diabetic nephropathy,
Self-care,
Emotion regulation,
Problem-solving skills,
Disease management

ABSTRACT

Objective: Patients with diabetic nephropathy experience significant self-care challenges due to the chronic nature of their condition and its associated emotional burden. This study aimed to compare the effectiveness of emotion regulation training and problem-solving skills training on self-care behaviors in patients with diabetic nephropathy.

Methods: This quasi-experimental study employed a pretest–posttest design with a three-month follow-up and a control group. The study population consisted of patients with diabetic nephropathy who referred to the IRIB Health Center in Tehran in 2024. Forty-five eligible participants were randomly assigned to three groups: emotion regulation training (n = 15), problem-solving skills training (n = 15), and a control group (n = 15). Self-care behaviors were assessed using the Summary of Diabetes Self-Care Activities (SDSCA) questionnaire. Data were analyzed using repeated-measures ANOVA with the Greenhouse–Geisser correction.

Results: Both intervention groups showed significant improvements in overall self-care and in dietary adherence, blood glucose monitoring, medication adherence, and foot care at posttest and follow-up ($P < 0.001$). No significant differences were found between groups or over time for physical activity ($P > 0.05$). Comparative analyses revealed that problem-solving skills training was more effective and demonstrated greater durability than emotion regulation training in executive self-care components, particularly dietary adherence and foot care ($P < 0.001$).

Conclusions: While emotion regulation training supports psychological adjustment to chronic illness, problem-solving skills training offers more structured and action-oriented strategies for effective disease management. Incorporating problem-solving–based interventions into diabetes care programs is therefore recommended.

Cite this article: Rezaei, L., Emamipour, S. & Sepah Mansour, M. (2025). Comparison of the effectiveness of emotion regulation training and problem-solving skills training on self-care in patients with diabetic nephropathy. *Iranian Evolutionary Educational Psychology Journal*, 7 (4), 1-15.

DOI: https//doi.org/ 10.22034/7.4.1

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Publisher: University of Hormozgan.

DOI: https// doi.org/ 10.22034/7.4.1

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Introduction

Diabetic nephropathy is not only of physiological significance but is also associated with a substantial psychological, social, and economic burden. Numerous studies have shown that patients with diabetic nephropathy experience higher levels of psychological distress, including anxiety, depression, feelings of helplessness, and chronic concern about their future (Fisher et al., 2019; Zhang et al., 2021). Research such as the study by Wang et al. (2020) has demonstrated that diabetic patients with higher levels of anxiety and depression exhibit significantly lower adherence to therapeutic, dietary, and exercise regimens. This is particularly concerning given that self-care is recognized as a vital component in the management of diabetic nephropathy.

Self-care encompasses a broad range of behaviors that enable patients to manage their condition, prevent disease progression, and improve their quality of life (Shrivastava et al., 2020). These behaviors include adherence to dietary recommendations and physical activity, medication compliance, regular blood glucose monitoring, blood pressure control, and routine medical follow-up. However, substantial evidence indicates alarmingly low levels of self-care among diabetic patients, particularly those suffering from advanced complications such as nephropathy (Chan et al., 2020).

Despite the established effectiveness of emotion regulation, systematic reviews suggest that many of the critical situations faced by patients require not only emotional management but also cognitive–behavioral problem-solving skills (Nezu et al., 2020). Problem-solving skills comprise a set of abilities that enable individuals to gather relevant information, analyze possible options, and select rational solutions in challenging situations. Studies conducted among patients with chronic illnesses have shown that training in these skills enhances internal locus of control, improves motivation for self-care, reduces feelings of inefficacy, and strengthens engagement with the healthcare system (Heisler et al., 2019). A study by Hill-Briggs et al. (2021) found that combining problem-solving training with pharmacological treatment in diabetic patients resulted in significant reductions in HbA1c levels, increased treatment satisfaction, and decreased healthcare costs. These findings underscore the importance of examining and comparing the effectiveness of cognitive–behavioral approaches within the context of complex conditions such as diabetic nephropathy.

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Nevertheless, in Iran and many developing countries, there remains a substantial gap in research on these interventions, particularly with respect to comparing the relative effectiveness of emotion regulation and problem-solving training on treatment outcomes. In recent years, researchers have increasingly focused on the role of psychological interventions—especially emotion regulation training and problem-solving skills—as tools for improving both biological and psychological outcomes in diabetic patients. At the same time, other interventions such as cognitive–behavioral therapy, mindfulness-based approaches, acceptance and commitment therapy, and general self-care education have also been discussed in the literature. Therefore, it is essential to clearly articulate why the present study has deliberately selected "emotion regulation" and "problem-solving" rather than other approaches.

First, emotion regulation is a core and relatively transdiagnostic construct in the psychological pathology of patients with chronic illnesses, and its contextual role in the development and maintenance of psychological distress has been well documented (Gross, 2019; Campbell-Sills & Barlow, 2020). For many patients with diabetic nephropathy, the primary challenge is not merely a lack of medical knowledge, but rather difficulty managing emotions such as fear of dialysis, hopelessness about the future, anger toward dietary restrictions, and feelings of guilt or shame related to perceived failure in disease control.

Second, problem-solving skills target the behavioral and decision-making dimensions of disease management and directly address daily self-care behaviors (D'Zurilla et al., 2018; Heisler et al., 2019). Accordingly, the rationale for selecting these two interventions in the present study is both causal and complementary: emotion regulation primarily targets the internal and emotional aspects of adaptation to illness, whereas problem-solving focuses on behavioral competence and practical decision-making.

Given the complex and stressful nature of diabetic nephropathy, patients require psychological interventions alongside pharmacological treatment that address two fundamental dimensions of their difficulties: (1) emotion regulation and management of psychological distress, and (2) empowerment in decision-making and problem-solving related to daily treatment demands. Emotion regulation training, by reducing stress, anxiety, and depression—partly through modulation of the hypothalamic–pituitary–adrenal (HPA) axis—may lead to improved physiological glycemic control (HbA1c) and reduced inflammatory markers. Conversely,

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problem-solving training enhances self-efficacy, strengthens decision-making skills, and improves adherence to treatment regimens, thereby promoting better self-care behaviors and disease control. The selection of these two educational approaches in the present study is grounded in both theoretical and empirical evidence indicating that each intervention can directly or indirectly influence self-care behaviors in diabetic patients. However, their simultaneous comparison may clarify which approach is more effective for patients with diabetic nephropathy.

In Iran and many developing countries, a significant research gap persists regarding these interventions, particularly in terms of comparing the relative effectiveness of emotion regulation and problem-solving training on treatment outcomes in patients with diabetic nephropathy. This gap gives rise to a fundamental research question in the present study: which psychological training—emotion regulation or problem-solving skills—has a greater impact on improving self-care behaviors in patients with diabetic nephropathy? Addressing this question is essential not only from a clinical perspective but also for advancing mental health policy, enhancing the effectiveness of intervention programs in healthcare settings, and designing evidence-based treatment protocols. If a brief educational intervention can meaningfully improve self-care behaviors, it would represent a significant step toward improving quality of life for these patients and reducing the burden on the healthcare system.

Accordingly, the present study seeks to answer the key question of whether emotion regulation training and problem-solving skills training differ significantly in their effectiveness in enhancing self-care behaviors among patients with diabetic nephropathy. This research question is important not only from a clinical and public health standpoint but also from a theoretical perspective, as it may deepen our understanding of the psychological mechanisms involved in the management of chronic diseases. Therefore, the primary question guiding this study is: which of the two interventions—emotion regulation training or problem-solving training—is more effective in improving self-care behaviors in diabetic patients with nephropathy?

Material and Methods

The present study employed a quasi-experimental design with pretest, posttest, and three-month follow-up assessments, including a control group.

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The statistical population of this study consisted of all patients diagnosed with diabetic nephropathy who referred in 2024 (1403 in the Iranian calendar) to the Endocrinology and Diabetes Clinic of the IRIB Health and Treatment Center in Tehran to receive diagnostic or therapeutic services. According to registered medical records at this center, between April 2024 and April 2025, a total of 211 patients with a confirmed diagnosis of diabetic nephropathy—based on endocrinologist or internist diagnosis and laboratory documentation—were identified and constituted the accessible population of the study.

The study sample was selected from this population based on predefined inclusion and exclusion criteria, including: diagnosis of diabetic nephropathy comorbid with type 2 diabetes, age range of 40–55 years, a documented history of illness, stability of pharmacological treatment, and related clinical conditions. Initially, using medical records and referrals from endocrinologists and internists, a list of patients meeting the preliminary eligibility criteria was prepared at the IRIB Health and Treatment Center. From this list, 60 patients who met the inclusion criteria and voluntarily agreed to participate were selected using convenience sampling.

Sample size estimation was conducted using G*Power software, assuming an effect size of 0.25, a significance level of 0.05, statistical power of 0.90, and three group levels, which indicated a minimum required sample size of 45 participants. To compensate for potential attrition, a larger sample (60 participants) was initially enrolled. These participants were then randomly assigned using simple random allocation into three groups of 20 participants each:

Emotion Regulation Training Group

Problem-Solving Skills Training Group

Control Group (Treatment as Usual)

During the intervention and three-month follow-up period, 15 participants withdrew from the study due to reasons such as absence from more than one session, hospitalization, relocation, or voluntary withdrawal (4 participants from the emotion regulation group, 5 from the problem-solving group, and 4 from the control group). To ensure equal group sizes for analysis, 15 participants per group were retained for final analysis. Ultimately, 45 participants (15 per group) completed the study, and all statistical analyses were conducted based on data from these participants.

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Instruments

Diabetes Self-Care Activities Questionnaire (Toobert et al., 2000): The Diabetes Self-Care Activities Questionnaire assesses multiple dimensions of self-care through six primary components: general diet, specific diet, physical activity, blood glucose testing, insulin or oral medication adherence, foot care, and smoking behavior.

The general diet subscale evaluates adherence to overall dietary recommendations for diabetes management, such as reducing saturated fat and simple sugars and increasing the intake of vegetables and low-glycemic fruits. The specific diet subscale focuses on compliance with physician- or dietitian-recommended meal plans in recent days, including meal frequency, carbohydrate distribution, and dietary restrictions related to kidney function (e.g., protein, sodium, and potassium control in patients with nephropathy) (Toobert et al., 2000).

The physical activity subscale measures engagement in regular physical activities (e.g., walking or light-to-moderate exercise) during the previous week, which is critical for glycemic control, weight management, blood pressure regulation, and slowing nephropathy progression. The blood glucose testing subscale assesses the frequency of glucose monitoring, reflecting the degree of active self-monitoring. The medication adherence subscale evaluates compliance with prescribed insulin or oral hypoglycemic agents, a particularly important aspect for preventing glycemic fluctuations and reducing metabolic burden on the kidneys in diabetic nephropathy.

Higher scores indicate higher levels of self-care in the respective domain and overall self-care. International evidence supports this questionnaire as one of the most widely used tools for assessing diabetes self-care behaviors. In their original study aggregating data from seven independent studies involving 1,988 diabetic patients, Toobert et al. (2000) reported acceptable validity and reliability, with moderate-to-high inter-item correlations (mean ≈ 0.47) and moderate test–retest reliability coefficients (mean ≈ 0.40), indicating relative stability over time. Convergent validity has been supported through correlations between dietary and physical activity subscales and other behavioral measures, and sensitivity to change has been demonstrated in several educational trials.

In Iran, the Persian version of this questionnaire has been used in multiple studies with confirmed psychometric properties. Didarloo et al. (2012), in a study of women with type 2 diabetes, reported

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an overall Cronbach's alpha of approximately 0.83 and supported construct validity through correlations with related theoretical constructs such as attitudes and self-efficacy.

Interventions

Emotion Regulation Training (Experimental Group 1): The emotion regulation training group participated in eight weekly sessions, each following a relatively consistent structure. At the beginning of each session, approximately 10–15 minutes were devoted to reviewing the previous session and discussing homework assignments. The main instructional component (50–60 minutes) focused on session-specific content, including emotion identification, the relationship between emotions, thoughts, and behaviors, identification of emotional triggers related to living with diabetes and nephropathy, and training in adaptive emotion regulation strategies such as cognitive reappraisal, acceptance, emotional awareness, diaphragmatic breathing, and relaxation techniques. These strategies were practiced using examples directly related to participants' real-life experiences.

The final 15 minutes of each session were allocated to summarizing content, addressing participants' questions, and assigning homework (e.g., recording daily emotional situations, practicing learned strategies in real-life illness and self-care contexts). All sessions were explicitly designed to link emotion regulation skills to self-care behaviors, such as dietary adherence, medication compliance, laboratory follow-up, and medical visits, enabling participants to directly apply the acquired skills to daily life with diabetic nephropathy.

Table 1. Emotion Regulation Training Sessions Based on Gross's Model (2001)

Session	Content
Session 1	Introduction of group members, establishment of therapeutic alliance, and rapport-building exercises
Session 2	Emotion recognition and identification of emotion-eliciting situations; education on types, dimensions, and short- and long-term effects of emotions
Session 3	Self-assessment of emotional experiences, emotional vulnerability, and individual emotion regulation strategies
Session 4	(a) Reducing social withdrawal and avoidance; (b) introduction to problem-solving strategies; (c) interpersonal skills training (assertiveness, communication, conflict resolution)
Session 5	(1) Reducing rumination and worry; (2) attention training
Session 6	(1) Identification of cognitive distortions and their emotional consequences; (2) training in cognitive reappraisal
Session 7	(1) Assessment of suppression strategies and emotional consequences; (2) exposure; (3) emotional expression; (4) behavioral modification through environmental reinforcement; (5) emotional discharge, relaxation, and opposite action
Session 8	(1) Evaluation of individual and group goal attainment; (2) application of skills in natural environments; (3) identification and resolution of barriers to homework completion

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Problem-Solving Skills Training (Experimental Group 2): The problem-solving skills training group also received eight weekly 90-minute sessions, following a structure similar to the emotion regulation group (review, core instruction, and homework assignment). Session content was based on the cognitive–behavioral problem-solving model and included: accurate problem definition in the context of diabetes and nephropathy, differentiation between solvable and unsolvable problems, generation of multiple solutions, evaluation of consequences, selection of optimal solutions, implementation planning, and outcome evaluation.

Concrete examples related to participants' daily challenges—such as coordinating dietary requirements with family and work demands, medication adherence, medical follow-ups, fatigue management, physical limitations, and medical or financial stressors—were used throughout sessions. Participants were encouraged to apply structured problem-solving steps to their real-life problems. Homework assignments included recording weekly problems, applying problem-solving steps, and reporting outcomes in subsequent sessions.

Table 2. 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

Results

Table 3 presents the means and standard deviations of the study groups for overall self-care behaviors and their components across the three measurement points (pretest, posttest, and three-month follow-up).

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Table 3. Means and Standard Deviations of Self-Care Behaviors Across Study Groups

Variable	Group	Pretest Mean	SD	Posttest Mean	SD	Follow-up Mean	SD
Dietary adherence	Emotion regulation	11.80	2.14	15.93	2.34	14.27	2.58
	Problem-solving	10.40	1.68	18.87	3.34	18.33	2.87
	Control	11.20	1.01	11.13	0.92	11.07	0.80
Physical activity	Emotion regulation	10.93	1.16	11.20	0.86	11.20	1.01
	Problem-solving	11.47	1.30	11.73	0.96	11.60	1.18
	Control	10.40	1.24	9.87	0.92	9.67	0.90
Blood glucose testing	Emotion regulation	5.53	1.96	9.80	1.45	8.83	0.92
	Problem-solving	5.80	2.01	10.40	1.35	10.25	1.40
	Control	6.27	2.40	7.61	1.17	7.05	1.04
Medication/insulin use	Emotion regulation	4.07	1.16	5.20	0.41	4.47	0.83
	Problem-solving	3.93	1.62	6.27	0.70	6.13	0.64
	Control	3.67	1.80	3.87	1.36	3.80	1.08
Foot care	Emotion regulation	10.80	1.86	15.53	2.64	14.80	2.08
	Problem-solving	11.67	1.45	18.73	2.31	18.93	2.46
	Control	11.07	1.75	11.47	1.60	11.87	1.46
Overall self-care score	Emotion regulation	43.13	3.14	57.67	3.14	53.56	3.04
	Problem-solving	43.27	3.51	66.00	4.94	65.25	3.64
	Control	42.60	4.22	43.94	3.89	43.45	2.59

As shown in Table 3, the mean scores of overall self-care and its components—including dietary adherence, physical activity, blood glucose testing, medication/insulin use, and foot care—differ across measurement stages. Specifically, scores at the posttest and follow-up assessments increased relative to the pretest in the experimental groups. To examine the significance of the main effect of time and the interaction effect of time × group on self-care behaviors and their components, a multivariate analysis of variance (MANOVA) with repeated measures was conducted. The results are presented in Table 4.

Table 4. Results of Multivariate Analysis of Variance for the Effects of Time and Time × Group on Self-Care Behaviors

Variable	Test	Effect	Value	F	Hypothesis df	Error df	p-value	η^2	Power
Dietary adherence	Wilks' Lambda	Time	0.79	79.01	2	41	<0.0001	0.79	1.00
	Wilks' Lambda	Time × Group	0.91	17.68	4	84	<0.0001	0.46	1.00
Physical activity	Pillai's Trace	Time	0.99	0.18	2	41	0.83	0.01	0.08
	Pillai's Trace	Time × Group	0.13	1.43	4	84	0.23	0.06	0.43
Blood glucose testing	Wilks' Lambda	Time	0.34	39.85	2	41	<0.0001	0.66	1.00
	Wilks' Lambda	Time × Group	0.33	4.14	4	84	<0.0001	0.16	0.91
Medication/insulin use	Pillai's Trace	Time	0.55	24.92	2	41	<0.0001	0.55	1.00

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	Pillai's Trace	Time × Group	0.49	6.78	4	84	<0.0001	0.24	0.99
Foot care	Wilks' Lambda	Time	0.14	123.06	2	41	<0.0001	0.86	1.00
	Wilks' Lambda	Time × Group	0.24	21.61	4	82	<0.0001	0.51	1.00
Overall self-care score	Wilks' Lambda	Time	0.09	191.97	2	41	<0.0001	0.90	1.00
	Wilks' Lambda	Time × Group	0.13	24.21	4	82	<0.0001	0.64	1.00

According to the results shown in Table 4, the observed F value for physical activity was not statistically significant for either the main effect of time (F = 0.18) or the interaction effect of time × group (F = 1.43; p > 0.05). In other words, neither the passage of time nor the intervention groups produced a significant effect on physical activity, and therefore the necessary assumption for conducting further variance analysis on this variable was not met. This indicates that the experimental interventions did not have a significant impact on physical activity.

In contrast, the F values for overall self-care and its components—including dietary adherence, blood glucose testing, medication/insulin use, and foot care—were statistically significant (p < 0.05). This finding indicates that the experimental groups exerted significant effects on these self-care variables. Accordingly, the effects of each experimental group on each self-care component were further examined.

Within-Group Effects (Repeated Measures Analysis)

Table 5 presents the results of repeated-measures analysis of variance examining within-group effects over time for overall self-care and its components. The Greenhouse–Geisser correction was applied where appropriate.

Table 5. Repeated Measures ANOVA Results for Self-Care Behaviors and Their Components

Variable	Test	Source	Sum of Squares	df	Mean Square	F	p-value	η²	Power
Dietary adherence	G–G	Time	446.04	1.73	257.41	112.67	<0.0001	0.73	1.00
		Time × Group	358.36	3.47	103.40	45.26	<0.0001	0.68	1.00
		Error	166.27	72.78	2.28				
Blood glucose testing	G–G	Time	299.71	1.63	183.51	56.60	<0.0001	0.57	1.00
		Time × Group	69.06	3.27	21.14	6.52	<0.0001	0.24	0.97
		Error	222.38	68.60	3.24				

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Medication/insulin use	G–G	Time	36.31	1.56	23.27	26.79	<0.0001	0.39	1.00
		Time × Group	25.42	3.12	8.14	9.38	<0.0001	0.31	1.00
		Error	56.93	84.00	0.68				
Foot care	G–G	Time	490.77	1.68	291.65	167.25	<0.0001	0.80	1.00
		Time × Group	222.65	3.37	66.16	37.94	<0.0001	0.64	1.00
		Error	123.24	70.68	1.74				
Overall self-care score	G–G	Time	4376.30	1.68	2600.30	277.72	<0.0001	0.87	1.00
		Time × Group	2325.89	3.37	691.00	73.80	<0.0001	0.78	1.00
		Error	661.83	70.69	9.36				

Discussion

The purpose of the present study was to compare the effectiveness of two psychological interventions—Emotion Regulation Management Training and Problem-Solving Skills Training—on self-care behaviors in patients with diabetic nephropathy. The findings of the repeated-measures analysis of variance indicated that both interventions led to a significant improvement in overall self-care scores and most of their components (with the exception of physical activity) at the post-test and follow-up stages. However, the results demonstrated a relative superiority and greater durability of effects in the problem-solving skills training group.

The effectiveness of emotion regulation management training can be explained by the fact that patients with diabetic nephropathy, due to the chronic and progressive nature of their condition, experience a substantial emotional burden, including anxiety related to dialysis, fear of complications, and feelings of helplessness (Zhang et al., 2021). The application of strategies derived from Gross's process model of emotion regulation, particularly cognitive reappraisal, appears to have enabled patients to reinterpret the meaning of their illness and reduce the dominance of negative emotions that often interfere with adherence to self-care behaviors. As Gross (2019) emphasizes, effective emotion regulation reduces physiological stress responses and psychological distress, thereby freeing cognitive resources necessary for sustained adherence to medical and self-care protocols. From this perspective, emotion regulation serves as a foundational mechanism that facilitates engagement in health-promoting behaviors by mitigating emotional barriers.

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Nevertheless, the greater effectiveness of problem-solving skills training, particularly in components such as dietary adherence and foot care, can be attributed to the action-oriented, structured, and practical nature of this intervention. While emotion regulation primarily targets internal emotional experiences, problem-solving training directly addresses the concrete challenges patients face in their daily lives. The findings of the present study regarding emotion regulation are consistent with Gross's theory (2001) and with the work of Campbell-Sills and Barlow (2020), who argue that modulation of negative emotions contributes to improved health-related functioning. Similarly, Iranian studies by Besharat (2007) and Didarloo (2012), which emphasize the role of self-efficacy in self-care behaviors, support the indirect influence of emotion regulation through enhanced psychological resources.

With respect to problem-solving skills training, the results are aligned with studies by Hissler et al. (2019) and Nezu (2020), which demonstrate that empowering patients in decision-making processes has a direct positive impact on self-care behaviors such as foot care, medication adherence, and glucose monitoring. According to D'Zurilla et al. (2018), problem-solving is a self-regulatory process that engages directly with real-life stressors and demands. Patients who acquire problem-solving skills learn to move beyond passive or avoidant coping when faced with obstacles such as "managing dietary restrictions during social gatherings" or "forgetting to take prescribed medications." Instead, they are trained to systematically define the problem, generate alternative solutions, evaluate their consequences, and select the most effective course of action (Hill-Briggs et al., 2021).

This process enhances patients' self-efficacy, transforming self-care behaviors from externally imposed medical tasks into internally regulated and manageable skills. The sustained effectiveness of problem-solving training observed at the three-month follow-up in the present study further supports the notion that skills-based interventions produce more durable behavioral change by fostering autonomy and active coping.

Overall, the findings of this study highlight the indispensable role of integrating psychological interventions into routine care programs for patients with diabetic nephropathy. While emotion regulation training assists patients in adapting emotionally to the suffering associated with chronic illness, problem-solving skills training equips them with concrete tools for managing daily treatment demands related to diet, medication adherence, and monitoring. Given the greater

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effectiveness and long-term stability of the problem-solving approach, it is recommended that healthcare providers and health psychologists in diabetes care centers prioritize educational protocols that focus on empowering patients in everyday decision-making and practical problem resolution.

Such an approach not only improves individual health outcomes but may also reduce hospitalization rates and secondary complications, thereby alleviating the economic burden on healthcare systems. Despite its contributions, the present study is not without limitations. One limitation is the restriction of the statistical population to a single healthcare center (the Broadcasting Organization Health and Treatment Center), which necessitates caution in generalizing the findings to the broader population. Future research is therefore encouraged to replicate these findings in more diverse clinical settings and populations.

Finally, it is recommended that future studies examine the mediating role of family social support in the relationship between psychological training interventions and self-care behaviors in patients with diabetic nephropathy, as social support may play a critical role in sustaining behavioral change and treatment adherence.

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 authors state that all procedures were performed in accordance with relevant guidelines and regulations regarding ethical approval and company consent.

Author contributions

This article is taken from the doctoral thesis of the first author, which was done with the help and guidance of the supervisors and advisors.

Funding

The authors did (not) receive support from any organization for the submitted work.

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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