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Research Article

Mindfulness Meditation Effects on Sleep, Stress, and Physiological Biomarkers in Hemodialysis Patients: A Randomized Controlled Trial

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Background

Patients with end-stage renal disease (ESRD) face significant physical and psychological challenges, highlighting the need for effective supportive interventions. Mindfulness meditation (MM) has emerged as a promising intervention for these patients.

Objective

This study examines the effects of MM on the quality of sleep, perceived stress, and levels of serum cortisol and C-reactive protein in ESRD patients undergoing hemodialysis.

Methods

A repeated measures design was employed, utilizing data collected from 56 patients with ESRD undergoing hemodialysis at Jahra Hospital. The intervention included a 30-min session of mindfulness techniques conducted during hemodialysis. Variables measured included quality of sleep, perceived stress, and levels of selected biomarkers. The study was registered under ClinicalTrials.gov.

Results

The analysis showed that patients in the intervention group had a significantly lower level of C-reactive protein at post-intervention. The intervention also contributed to a decreased level of perceived stress and serum cortisol, and improved quality of sleep at both measurement time points. Analysis of variance (within and between-subject) results demonstrated that the trial group had decreased subjective stress, serum cortisol level, C-reactive protein level, and sleep quality index over time, as opposed to the control group.

Conclusion

This study suggests that integrating psychological interventions, such as MM, into hemodialysis sessions may benefit patients. The inclusion of a liaison psychological counselor is recommended for consideration by decision-makers.

1. INTRODUCTION

End-stage renal disease (ESRD) is a serious medical condition characterized by kidney function reduced to below 10–15% of normal capacity.[1] It has been identified as a significant contributor to rising global disability and mortality rates, particularly driven by the increasing prevalence of diabetes and hypertension.[1] Regional studies on the burden of kidney disease showed that the Middle East has experienced notable declines in some countries, with Kuwait showing the highest reduction at −41.5%. Kidney disease accounted for about 744.4 age-standardized disability-adjusted life years in the region.[2] Globally, the number of individuals with ESRD ranges from 4.902 to 9.701 million, with the majority residing in low- and middle-income countries.[1] In North Africa and the Middle East, ESRD rates exceed 500 cases/100,000 population when age-standardized.[3] In Gulf Cooperation Council countries, the average ESRD prevalence is 551 cases/million population.[4] The incidence and prevalence rates of ESRD in Kuwait are reported to be below international averages, with 465 dialysis cases/million population and an incidence of 100/million population, respectively.[5,6]

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The final stage of chronic kidney disease requires replacement therapy, such as hemodialysis or kidney transplantation.[1] Hemodialysis is a critical treatment modality for individuals with ESRD, functioning to remove toxins from the body, typically requiring multiple weekly sessions lasting several hours each.[1-4] However, this treatment imposes substantial physical and psychosocial burdens,[1] including stress, insomnia, depression, and anxiety, which adversely affect patients' quality of life.[7,8] In addition, many ESRD patients exhibit elevated amounts of circulating pro-inflammatory markers, such as C-reactive protein.[9,10] Persistent stress activates the hypothalamic-pituitary-adrenal axis, elevating hormones, such as cortisol within 15 min of stress onset and sustaining elevated levels for several hours.[11-13] This physiological response contributes to disturbances in fluid balance, uremia, and frequent nocturnal muscle cramps, all of which disrupt sleep.[14,15] The requirement for frequent hemodialysis (three or more sessions per week, each lasting several hours) further stresses the body and disrupts natural circadian rhythms, compounding the effects of sleep disorders.[14] Literature consistently reports that sleep disturbances, such as insomnia, restless leg syndrome, and obstructive sleep apnea, are prevalent among dialysis patients and are linked to fatigue, cognitive distortion, and increased risk of depression and anxiety.[14] In addition, poor sleep can exacerbate cardiovascular risks, worsen pain perception, and weaken the immune system, all of which are critical concerns for ESRD patients.[16] These issues detrimentally affect patients' rest, physiological recovery, and mental health.[17] Notably, the quality of sleep in patients with ESRD is markedly worse compared to the general population or patients with other chronic illnesses.[1]

As a result, reports have shown that ESRD patients sometimes employ ineffective or harmful coping strategies, resulting in negative impacts on their overall physical and psychological well-being and mortality and morbidity levels.[18,19] Mind-body techniques are believed to be beneficial for health by promoting a connection between the mind and body, enhancing present-moment awareness and acceptance without judgment.[20-22] Therefore, mindfulness meditation (MM) is assumed to be a promising approach for patients with ESRD. MM involves cultivating present-moment awareness with a positive attitude characterized by acceptance and non-judgmental perspectives.[23-26] MM is hypothesized to target multiple cognitive and emotional processes that contribute to improved management of stress and poor sleep quality.[21-23] MM has also been shown to promote psychological distancing, facilitate positive cognitive reappraisals, interrupt automatic and uncontrollable thought patterns, and reduce stress and cortisol levels.[21,22,27,28] Furthermore, improvements in trait mindfulness and emotional regulation among ESRD patients undergoing hemodialysis have been associated with a significant reduction in perceived stress.[24,29] Research has also found that guided meditation leads to substantial improvements in general physical health, perceived stress, and the effects of kidney disease.[30] Mindfulness training programs conducted over 6–8 weeks resulted in statistically significant improvements in C-reactive protein levels, quality of sleep, and depressive and anxiety symptoms among hemodialysis patients.[25,26,31] Furthermore, long-term mindfulness-based intervention over 12 weeks demonstrated notable enhancements in sleep quality, emotional well-being, C-reactive protein levels, and psychosocial and physiological factors.[23,32] These findings contribute to a growing body of evidence supporting mindfulness-based interventions in various chronic conditions.

Despite the potential of MM in addressing psychological and physiological symptoms in different patient groups, its application in patients with chronic illnesses, such as ESRD, remains limited.[33] No prior studies have investigated the impact of MM on subjective (sleep quality and stress levels) and objective (inflammatory markers, such as serum cortisol and C-reactive protein) outcomes among hemodialysis patients. While many recent studies have focused on perceived stress or sleep quality alone, this study uniquely combines subjective self-report measures (perceived stress and quality of sleep) with objective biomedical markers (serum cortisol and C-reactive protein). This multidimensional approach allows for a more comprehensive understanding of how MM may influence both mental and physiological health in ESRD patients.[23-26] The intervention used in this study, Smith's version of MM based on the Attentional Behavioral Cognitive (ABC_2) Relaxation theory, is a standardized, replicable, and time-efficient program that can be easily integrated into clinical care, especially during dialysis sessions.[24-26,34] This structured format is rarely used in comparable studies and enhances the feasibility and clinical utility of mindfulness practices in routine care.[24] Unlike many studies that require patients to engage in mindfulness practice at home or in separate clinical sessions, this trial uniquely delivers the intervention during dialysis, specifically between the first and 2nd h of hemodialysis. This integrated delivery approach minimizes barriers to participation (e.g., time, fatigue, transportation) and has practical implications for incorporating mindfulness into existing treatment regimens.[32,34]

This randomized controlled trial is the first study conducted among ESRD patients receiving hemodialysis that comprehensively addresses both subjective and objective outcomes. It uses a standardized, theory-based mindfulness intervention (Smith's ABC_2 model) delivered during dialysis sessions, particularly in underrepresented cultural and linguistic groups, thereby integrating therapeutic engagement into routine clinical care. The primary aim of this study is to assess the effectiveness of using MM intervention on the quality of sleep, stress, and levels of serum cortisol and C-reactive protein among ESRD patients undergoing hemodialysis. The study hypothesizes that the use of MM improves the quality of sleep, reduces stress, and lowers serum cortisol and C-reactive protein levels among ESRD patients undergoing hemodialysis.

2. MATERIALS AND METHODS

2.1. DESIGN

A repeated measures design was employed, utilizing a randomized parallel control approach to test the effectiveness of the MM intervention among patients with ESRD. The study was conducted between September 2024, and February 2025, at a renal dialysis center in Kuwait.

2.2. SAMPLE AND SETTING

Fifty-six hemodialysis patients with ESRD were selected using a simple random sampling technique from a government hospital that has one of the largest dialysis facilities in Kuwait and the Gulf region. This facility has 70 dialysis beds and machines, and on average, 30 patients are treated each day. The inclusion criteria were: (i) individuals receiving hemodialysis 3 times a week for a minimum of 1 year as an

ESRD patient, (ii) individuals who are at least 18 years old, (iii) patients having a urea reduction rate >65% or Kt/V >1.2 in the past month, and (iv) individuals possessing Arabic literacy skills. The exclusion criteria were (i) those suffering from cognitive impairment, (ii) those who have rheumatoid arthritis, (iii) those on psychopharmacological drugs to reduce stress and improve sleep, (iv) individuals participating in other psychological therapies at the time, or had prior formal training in MMs or a present meditation practice, and (v) individuals suffering from hearing or vision impairment. The CONSORT criteria were used to report the trial. The estimated sample size was calculated using G*Power 3.1.10, applying repeated measures analysis of variance as the test statistic, with a power of 0.95, a medium effect size of 0.25, and a two-tailed alpha level of 0.05. The calculation indicated a minimum required sample size of 44 patients.

2.3. INSTRUMENTS

Data were collected using the Arabic version of the scales.

2.3.1. DEMOGRAPHIC CHARACTERISTICS

This section included a question for each variable, comprising age, gender, nationality, marital status, dialysis vintage, Kt/V, educational attainment, employment status, family status, and comorbidities.

2.3.2. SLEEP QUALITY

Quality of sleep was measured using the Pittsburgh Sleep Quality Index (PSQI). The PSQI consists of seven dimensions: subjective, quality, latency, duration, habitual sleep efficiency, disturbances, sleeping aid usage, and daytime dysfunction. Seven different scores are calculated for each component, ranging from 0 (no problems) to 3 (severe problems).[35,36] The PSQI showed good reliability with a Cronbach's alpha of 0.83 for its seven components.[35,36] The Arabic version of PSQI had a Cronbach's alpha coefficient of 0.65–0.77, indicating satisfactory reliability.[37,38] The Arabic version provided accurate and dependable outcomes within Arabic cancer communities, adolescents, and young adults.[37,38] In our study, Cronbach's alpha coefficient for the PSQI was 0.77.

2.3.3. PERCEIVED STRESS

Perceived stress was measured using the Arabic version of the Perceived Stress Scale (PSS).[39] PSS assesses how stressful situations in one's life are perceived based on their unpredictability, lack of control, and the feeling of being overwhelmed. A five-point Likert scale (0 being never, and 4 being very often) was used to evaluate its 10 components, most of which are not unique to any one grouping. The PSS showed good reliability with a Cronbach's alpha coefficient of 0.85.[40] The Arabic PSS had a Cronbach's alpha coefficient of 0.80 and an intra-correlation coefficient of 0.90 for test-retest reliability, indicating satisfactory reliability levels, confirming the suitability of the Arabic PSS for Arabic individuals.[39,41] In our study, the PSS had a Cronbach's alpha coefficient of 0.76.

2.4. BIOMEDICAL MARKERS

Biomedical markers were measured using the Access Cortisol Assay 33600 (Beckman Coulter Inc., USA) and the C-reactive protein reagent 447280 33600 (Beckman Coulter Inc., USA) protocol, which required blood sampling. The Access Cortisol Assay is a paramagnetic particle, competitive binding immuno-enzymatic assay for the quantitative determination of cortisol levels in human serum, plasma (heparin, ethylenediaminetetraacetic acid), and urine using the Access Immunoassay Systems (Beckman Coulter Inc., USA), aiding in the diagnosis of adrenal-related disorders.[42,43] The C-reactive protein assay, along with the IMMAGE Immunochemistry Systems (Beckman Coulter Inc., USA), quantifies C-reactive protein in human serum or plasma (heparin, ethylenediaminetetraacetic acid), aiding in the evaluation of stress, trauma, infection, inflammation, and post-surgical infections.[44,45] Both protocols were precise, specific, and sensitive in accurately measuring serum cortisol and C-reactive protein levels.[42-44] A routine serum cortisol level check within the 1st h after waking up was considered a consistent biological indicator.[46,47]

2.5. THE INTERVENTION

2.5.1. EXPERIMENTAL GROUP

The experimental group received Smith's version of MM,[24-26,34] which stands for Attention, Breathing, Centering, and Concentration, and serves as a conceptual framework for guiding mindfulness-based interventions.[34] It integrates principles from cognitive-behavioral theory, mindfulness practices, and physiological self-regulation.[34] The core components of the theory emphasize cultivating a non-judgmental awareness of present-moment experiences, beginning with conscious breathing (A: attention and air), followed by grounding the body (B: breathing and body awareness), calming the mind (C: centering), and sustaining focused mental presence (C: concentration).[34] As proposed, focusing on a single stimulus, instead of being consumed by stress-related thoughts, is crucial for achieving a state of relaxation.[34] This theoretical framework has been applied in stress-reduction and health-promotion research across diverse populations and is particularly relevant for patients with chronic illnesses.[34] In the context of ESRD, where individuals often experience elevated psychological distress, physiological dysregulation, and a diminished sense of control, the ABC_2 theory offers a structured, accessible approach to foster both mental and physical relaxation.[34] The choice to use Smith's version of MM based on the ABC_2 theory in our study was guided by its emphasis on structured yet simple mindfulness techniques, making it feasible for delivery during hemodialysis without disrupting treatment routines. Moreover, previous studies have demonstrated the effectiveness of this model in reducing stress, improving sleep, and modulating physiological markers, thereby aligning well with the aim of our study.[24-26]

Smith's MM approach involves a series of six distinct practices, each lasting about 5 min. It begins with breath awareness, which involves taking deep, unforced breaths, focusing on the air as it moves through the nose and into the lungs, then returning to a natural rhythm. Next is body awareness, which involves scanning the body from head to toe, noticing physical sensations without judgment, and gently letting them pass. This is followed by thought awareness, where one observes thoughts and emotions as they arise, acknowledges them without engagement, and lets them go. The practice then shifts to sound awareness, attending to ambient sounds without interpreting them, simply noticing and releasing each one. Taste awareness involves mentally visualizing and experiencing the taste of favorite fruits, focusing on the sensation itself without thinking or analyzing. Finally, in full mindfulness, the eyes are gently opened, and awareness extends to the present moment—whether it is a thought, sound, feeling, or sight—each experience is observed, released, and followed by quiet attentiveness to whatever arises next.

The participants in the intervention group underwent a 30-min MM program thrice a week for 8 weeks, scheduled during their dialysis sessions, specifically between the 1st and 2nd h of hemodialysis.[32] The program was based on the ABC_2 theory and incorporated MM techniques, a standardized intervention that has been proven effective in reducing stress and associated health issues.[24-26,34] The researcher in the study documented the intervention guidelines in Arabic following the outlined protocol. The participants were required to finish a 2-h introductory course conducted in a private setting by the certified researcher before starting the training sessions in a room in the dialysis center. The introduction course educated the participants on the fundamentals, advantages, procedures, and delivery methods of the intervention. The recorded audio instructions were dispatched to the subjects via email and WhatsApp to guarantee a uniform administration of the intervention. Participants followed the recommended instructions through their mobile phones and headphones during the hemodialysis sessions, as documented.[9,31] The individualized intervention was administered and supervised at the patients' chairside during hemodialysis. By employing audio-recorded instructions to deliver the intervention, the researcher was able to provide a simultaneous intervention session for five patients. Based on the physical assessments, the experimental group participated in a 30-min MM session thrice a week for 8 weeks (720 min).[48,49] The intervention was endorsed and monitored by a certified professional nurse specialist with experience and appropriate credentials.

2.5.2. CONTROL GROUP

Participants in the control group were instructed to close their eyes and avoid any social and environmental distractions for 30 min, thrice a week, over the 8-week study period. This procedure aimed to control for the non-specific effects of social interaction and environmental factors.[48,49] To prevent contamination bias, members of the experimental group were instructed not to discuss any details of the intervention with others throughout the study.

2.6. DATA COLLECTION

Permission was obtained for the instruments used in the study. After obtaining ethical approval, a list of all hemodialysis patients, both males and females, including their personal information, was collected from the selected dialysis center. Participants' files were reviewed for their Kt/V scores from the past month to assess eligibility and select the study sample. Participant recruitment was conducted by one of the study's researchers, who supervised the intervention delivery. Participants who met the study's inclusion criteria and agreed to take part were first asked to sign an informed consent form. This form explained the study's purpose and procedures and clarified that participation was entirely voluntary, with the option to withdraw at any time without penalty. Participants were also assured that their personal information would remain confidential and would not be shared without their permission. To protect anonymity, identifying details were replaced with codes, and all data were securely stored in a locked cabinet. After providing consent, participants completed baseline assessments (T0) using self-report questionnaires and physical measurements, assisted by a research nurse with a bachelor's degree and a decade of experience in nephrology, who had no further role in the study. Random assignment to the experimental or control group (34 participants each) was conducted by a PhD researcher, uninvolved in recruitment or data collection, using a simple computer-generated 1:1 randomization method. Blood sample collection and other data gathering were conducted by a separate research nurse with similar qualifications and no involvement in the other study phases. All assessments were conducted privately at the dialysis center.

2.7. DATA ANALYSIS

The data were analyzed using the Statistical Package for the Social Sciences software version 25. Descriptive statistics are used to summarize the study variables. All assumptions required for conducting repeated measures analysis were assessed before analysis. When Mauchly's test of sphericity was significant ($p<0.05$), degrees of freedom were adjusted using the Greenhouse–Geisser or Huynh–Feldt estimates of sphericity. Intervention and control groups were compared through pairwise comparisons, including independent sample t-tests. Chi-square tests, t-tests, and analysis of variances were used to assess differences in study variables with respect to sociodemographic and personal factors. A significance level of alpha = 0.05 was applied throughout.

3. RESULTS

3.1. PARTICIPANTS AND SOCIODEMOGRAPHIC CHARACTERISTICS

Among the 104 patients contacted to participate in the study, a total of 68 eligible patients agreed to participate and were randomly assigned to the intervention (n=34) and control groups (n=34). In the intervention group, five participants were excluded for not attending the first session, during which the baseline measurements were taken. Another participant was excluded due to irregular attendance throughout the study sessions. In the control group, six participants were excluded because they missed at least one measurement session. The excluded participants reported health-related issues as the reason for their absence. No statistically significant differences were observed between the participants who dropped out and those who completed the study. Participants' progression through each phase of the randomized trial is depicted in the study flow diagram (Figure 1).

In the experimental group (n = 28), the mean age of the participants was 47.36 years (standard deviation = 10.08), with ages ranging from 25 to 67 years. Half of these participants were male (n=14, 50%), 21 were non-smokers (75%), and 25 were unemployed (89.3%). Most of the experimental group participants (n = 22, 78.6%) were Kuwaiti. In the control group (n=28), the mean age of the participants was 62.14 years (standard deviation = 9.53), with ages ranging from 38 to 74 years. The majority of these participants were female (n= 15, 53.6%), 25 were non-smokers (89.3%), and 25

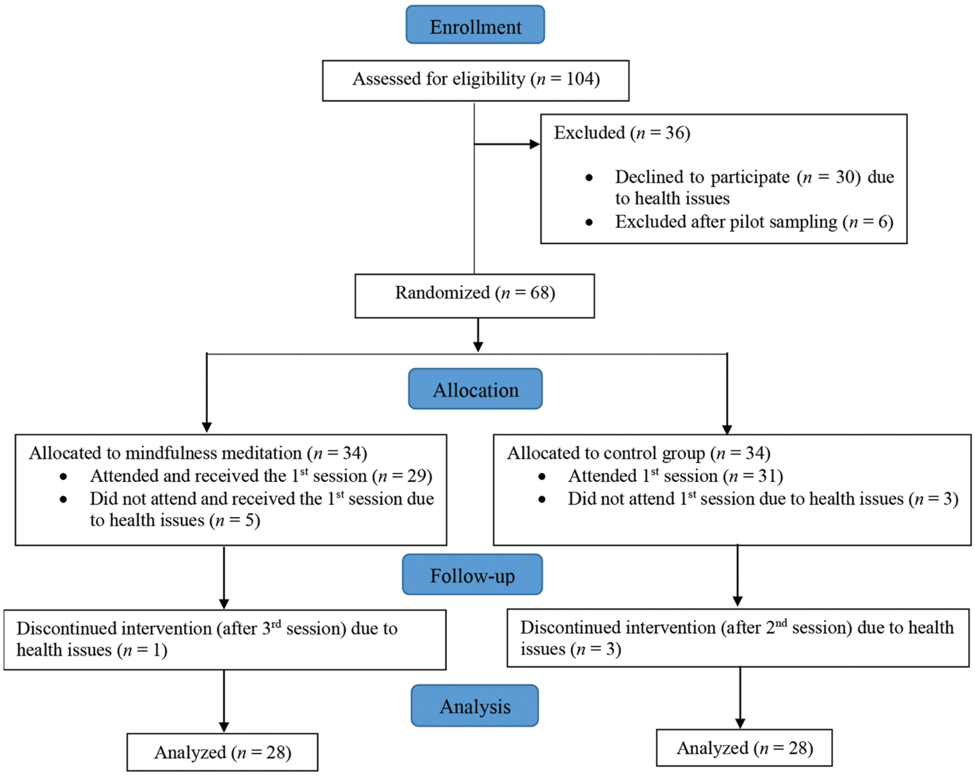

Figure 1. Flow diagram of the number of participants at each stage of the study

were unemployed (89.3%). Most of the participants (n = 26, 92.9%) were Kuwaiti. The demographic details of the participants in the experimental and control groups are displayed in Table 1, along with any notable group variations.

3.2. EFFECTIVENESS OF MM

At baseline (T0), the results showed no noticeable distinctions between the experimental and control groups on PSS scores (t [54] = −1.549, p=0.127), PSQI scores (t [54] = −1.364, p=0.178), cortisol levels (t [54] = 1.208, p=0.232), or C-reactive protein levels (t [54] = 1.237, p=0.221) (Table 2).

According to the experimental group's data, significant main effects of time were observed for PSQI, PSS, cortisol, and C-reactive protein. Similarly, the control group also exhibited significant main effects of time for these variables. This indicates that in both groups, the measured variables changed significantly over time, independent of group assignment. However, given that the intervention was effective in the experimental group, the magnitude or clinical relevance of the improvements—reflected by better sleep quality, reduced stress, decreased cortisol and C-reactive protein levels—was likely greater in the experimental group. Table 3 displays the PSQI and PSS scores and cortisol and C-reactive protein levels for both groups at time points T0, T1, and T2, along with the results of within-group repeated measures analysis of variance analyses.

The analysis, using repeated measures, showed significant time-by-condition interaction effects for PSQI, PSS, cortisol, and C-reactive protein of the two groups. These significant interactions indicate that the changes in these variables over the three time points differed significantly between the experimental and control groups. Specifically, the intervention had a measurable and distinct impact on the experimental group, leading to greater improvements in sleep quality, perceived stress, cortisol levels, and C-reactive protein levels compared to the control group. These results suggest that the intervention was effective in producing positive changes in the targeted outcomes over time. Results are shown in Table 4.

4. DISCUSSION

This study highlighted the connection between the psychosomatic status of patients with chronic illness, such as those with ESRD, with healthcare outcomes. Our findings indicate that MM contributed to improvements in sleep quality, reductions in stress levels, and positive changes in biomarkers among patients in the intervention group. Such findings suggest that MM can effectively modulate both psychological and physiological stress responses. Sleep disturbances were notably decreased in the interventional group, likely reflecting the calming effect of mindfulness on both the mind and body. We believe that regular meditation helped participants develop greater awareness of their thoughts and emotions, reducing the mental chatter and stress that often interfere with falling and staying asleep. By promoting relaxation and emotional regulation, mindfulness may have created the mental conditions necessary for deeper, more restorative sleep. These findings highlight how a non-pharmacological, low-cost intervention like meditation can make a real difference in sleep quality. These results are in line with earlier research.[26] In another study, MM intervention alongside progressive muscle relaxation training increased exercise capacity and scores for kidney disease-related quality of life, including sleep quality in hemodialysis patients.[23] In systematic reviews of randomized controlled trials, interventions using the mindfulness approach have been found to effectively alleviate sleep issues in various populations.[48,49] These findings further support the theoretical claim that regular mindfulness-based programs can enhance sleep quality by decreasing ruminative thoughts,

Table 1. Demographic and clinical characteristics of participants

Characteristics	*n* (%)		Mean (standard deviation)		χ^2 (*p*)	*t*-test (*p*)
	Experimental	Control	Experimental	Control		
Sex					0.072 (0.789)	-
Male	14 (50)	13 (46.4)	0.50 (0.509)	0.54 (0.508)		
Female	14 (50)	15 (53.6)				
Marital status					7.3 (0.02)	-
Married	16 (57.1)	23 (82.1)	1.64 (0.82)	1.36 (0.78)		
Single	6 (21.4)	0 (0)				
Divorced/widowed	6 (21.4)	5 (17.9)				
Nationality					6.3 (0.17)	-
Kuwaiti	22 (78.6)	26 (92.9)				
Saudi	4 (14.3)	0 (0)				
Syrian	1 (3.6)	1 (3.6)				
Somali	1 (3.6)	0 (0)				
Sudanese	0 (0)	1 (3.6)				
Age (year)					22.4 (0.00)	−5.6 (0.00)
18–24	0 (0)	0 (0)	3.75 (1.0)	5.25 (0.96)		
25–34	3 (10.7)	0 (0)				
35–44	8 (28.6)	2 (7.1)				
45–54	11 (39.3)	4 (14.3)				
55–64	5 (17.9)	7 (25)				
65–74	1 (3.6)	15 (53.6)				
75+	0 (0)	0 (0)				
Education level					1.9 (0.58)	-
High school	21 (75)	23 (82.1)	1.32 (0.61)	1.29 (0.71)		
Diploma	5 (17.9)	3 (10.7)				
Bachelor	2 (7.1)	1 (3.6)				
Post-graduate	0 (0)	1 (3.6)				
Body mass index					5.0 (0.28)	-
Underweight	1 (3.6)	0 (0)				
Normal	7 (25)	4 (14.3)	3.4 (1.26)	3.7 (0.97)		
Overweight	7 (25)	6 (21.4)				
Obese	5 (17.9)	12 (42.9)				
Extremely obese	8 (28.6)	6 (21.4)				
Employment status					0.00 (1.0)	-
Employed	3 (10.7)	3 (10.7)	1.8 (0.31)	1.8 (0.31)		
Unemployed	25 (89.3)	25 (89.3)				
Family status					0.00 (1.0)	-
Lives with family	27 (96.4)	27 (96.4)	1.9 (0.18)	1.9 (0.18)		
Lives alone	1 (3.6)	1 (3.6)				
Exercise hours					6.8 (0.07)	-
No exercise	20 (71.4)	24 (85.7)	1.3 (.54)	1.3 (0.86)		
>1 h	7 (25)	1 (3.6)				
From 2–4 h	1 (3.6)	1 (3.6)				
More than 4 h	0 (0)	2 (7.1)				
Smoking					1.9 (0.16)	-
Yes	7 (25)	3 (10.7)	1.75 (0.44)	1.8 (0.31)		
No	21 (75)	25 (89.3)				
Other chronic diseases					-	-
Obesity	4 (14.3)	9 (32.1)	1.8 (0.35)	1.6 (0.47)		
Diabetes mellitus	9 (32.1)	20 (71.4)	1.6 (0.47)	1.2 (0.46)		
Hypertension	15 (53.6)	21 (75)	1.4 (0.50)	1.2 (0.44)		
Thyroid disease	1 (3.6)	1 (3.6)				
Cancer disease	1 (3.6)	0 (0)				
Asthma disease	0 (0)	1 (3.6)				
Nil	26 (92.9)	26 (92.9)				

(*Cont'd...*)

Table 1. (*Continued*)

Characteristics	*n* (%)		Mean (standard deviation)		χ^2 (*p*)	*t*-test (*p*)
	Experimental	Control	Experimental	Control		
Kt/V (Last month)					2.2 (0.53)	−1.1 (0.27)
1.20–1.24	22 (78.6)	20 (71.4)				
1.25–1.29	5 (17.9)	4 (14.3)	1.29 (0.65)	1.54 (0.99)		
1.30–1.34	0 (0)	1 (3.6)				
Dialysis vintage (year)					6.3 (0.27)	2.1 (0.039)
1–3	4 (14.3)	6 (21.4)	3 (1.54)	2.29 (0.89)		
3–6	7 (25)	10 (35.7)				
6–9	11 (39.3)	10 (35.7)				
9–12	1 (3.6)	2 (7.1)				
12–15	1 (3.6)	0 (0)				
15+	4 (14.3)	0 (0)				
Hemodialysis access					3.3 (0.19)	-
Arteriovenous fistula	18 (64.3)	13 (46.4)	1.4 (0.69)	1.5 (0.50)		
Perm catheter	9 (32.1)	15 (53.6)				
Arteriovenous graft	0 (0)	0 (0)				
Femoral catheter	1 (3.6)	0 (0)				

Table 2. Baseline group comparison on dependent variables

Outcomes	Baseline means (standard deviation)		*t*-test	
	Experimental group	Control group	*t*	*p*
Perceived Stress Scale	20.21 (4.756)	22.04 (4.014)	−1.549	0.127
Pittsburgh Sleep Quality Index	7.18 (3.422)	8.43 (3.436)	−1.364	0.178
Cortisol level	297.18 (100.64)	265.61 (94.867)	1.208	0.232
C-reactive protein level	0.983 (1.198)	0.685 (.441)	1.237	0.221

Note: Significance determined at $p<0.05$.

Table 3. Results of repeated measures analysis of variance (within-group)

Variables	Means (standard deviation)			F (*p*)
	Time 0	Time 1	Time 2	
Perceived Stress Scale				
Experimental group	20.21 (4.756)	14.39 (4.306)	8.25 (3.708)	460.6 (0.00)
Control group	22.04 (4.014)	25.75 (3.351)	30.36 (3.684)	78.16 (0.00)
Pittsburgh Sleep Quality Index				
Experimental group	7.18 (3.422)	6.32 (3.982)	4.68 (3.528)	4.66 (0.014)
Control group	8.43 (3.436)	10.71 (2.623)	13.54 (1.527)	63.09 (0.00)
Cortisol				
Experimental group	297.18 (100.6)	292.86 (139.1)	242.29 (106.5)	8.05 (0.003)
Control group	265.61 (94.8)	326.89 (93.5)	380.61 (103.8)	61.31 (0.00)
C-reactive protein				
Experimental group	0.9839 (1.19)	1.039 (1.07)	0.7686 (0.89)	4.04 (0.035)
Control group	0.6854 (0.44)	1.4971 (1.69)	3.1157 (4.80)	5.9 (0.016)

Notes: T0 refers to baseline. T1 is 4 weeks post the start of the intervention. T2 is at the end of the final session.

diminishing emotional reactivity, and promoting impartial reappraisal of salient experiences.[48-50]

In the present study, MM substantially lowered the experimental group's PSS scores over time compared to the control group. This reduction in perceived stress is likely due to the way mindfulness helps individuals shift their relationship with stressors. Instead of reacting automatically or feeling overwhelmed, participants appeared to become more present and accepting and were able to regulate their emotional responses better. Regular mindfulness practice may have helped them develop a sense of inner calm and control, making daily stressors feel less intense or threatening. These findings support the notion that mindfulness can empower individuals to manage stress more effectively by changing how they respond internally, without changing external circumstances. These outcomes are in line with previous research that found patients who received mindfulness-based therapy during their hemodialysis

Table 4. Analyses of variance on dependent variables across three repeated measures by group

Variable	Mauchly's test			F (*p*)			η^2
	Epsilon	χ^2	*p*	Group	Time	G×T	
Perceived Stress Scale	0.620	50.290	0.00	147.0 (0.00)*	11.1 (0.00)*	343.2 (0.00)*	0.864
Pittsburgh Sleep Quality Index	0.942	3.183	0.204	54.76 (0.00)*	3.78 (0.02)*	32.47 (0.00)*	0.376
Cortisol	0.896	5.843	0.54	3.09 (0.084)	6.74 (0.00)*	43.27 (0.00)*	0.445
C-reactive protein	0.601	57.654	0.00	3.92 (0.053)*	4.77 (0.02)*	7.10 (0.007)*	0.116

Note: *Statistically significant at $p<0.05$.

sessions reacted less to stressful circumstances.[30] In other randomized controlled trials, patients with ESRD receiving hemodialysis who received a 30-min mindfulness training showed reduced perceived stress.[24] Similarly, another randomized clinical trial investigated the feasibility and efficacy of a mindfulness-based stress reduction intervention tailored to a workshop and teleconference format in lowering stress symptoms in patients awaiting kidney or pancreas transplants.[51]

In the present study, mindfulness intervention contributed to lower post-intervention serum cortisol and C-reactive protein levels among participants in the intervention group compared to those in the control group. These physiological changes indicate that MM not only facilitates mental stress management but also influences the body's biological stress and inflammation responses. Cortisol, being a key stress hormone, often remains elevated under chronic stress. The calming and grounding effects of mindfulness may have helped reduce this overactivation of the stress response. Similarly, the reduction in C-reactive protein, a marker of inflammation, may reflect a downstream effect of lower stress and improved emotional regulation. These findings reinforce the growing understanding that mind-body practices, such as mindfulness can promote measurable physical health benefits, particularly by reducing the physiological burden of chronic stress. These results are in line with earlier research showing a significant decrement in C-reactive protein and tumor necrosis factor-alpha over time among hemodialysis patients.[25] In hemodialysis patients, an MM intervention led to notable decreases in certain inflammatory markers, including high-sensitivity C-reactive protein levels of patients undergoing maintenance hemodialysis.[23] In systematic reviews of randomized controlled trials, mindfulness-based interventions have effectively alleviated physiological stress indicators, such as cortisol and C-reactive protein, in populations with multiple chronic conditions. These findings provide confidence in the theoretical assertion that serum cortisol and serum C-reactive protein levels may decrease following 8 weeks of mindfulness-based practices (1–3 times weekly, totaling 60–180 min).[49,50]

One limitation of this study concerns the small sample size drawn from a single setting, which restricts the generalizability of the findings. Conducting a multicenter study could provide more comprehensive and representative data. Furthermore, baseline assessments revealed significant differences in age and marital status across the study groups at the pre-test phase. These disparities would suggest that the groups were not fully equivalent on these variables, likely due to the study's basic random assignment approach. The use of more rigorous randomization techniques may improve group comparability in future studies.

5. CONCLUSION

The findings of this study support the hypothesis that MM intervention significantly improves the quality of sleep, reduces stress, and lowers serum cortisol and C-reactive protein levels among ESRD patients undergoing hemodialysis. These results suggest that MM may be an effective complementary therapy for enhancing the well-being of patients undergoing hemodialysis. Mindfulness has been proven to be an effective intervention among patients with various diseases. In addition, we also found that the intervention was effective in improving biomarkers of the disease. These findings have implications for mental health counselors and psychologists concerned about the connection between the mind and the body. The observed reductions suggest that mindfulness may help regulate both emotional responses and stress-related biological processes. These positive findings offer promising evidence that MM can serve as a practical, low-cost intervention to support psychological and physiological well-being in patients undergoing hemodialysis. These results reinforce the importance of interdisciplinary approaches to care, where mental health support is integrated into broader treatment settings. Counselors and general health practitioners can play a key role in introducing and guiding mindfulness practices as part of holistic care, stress management, and psychoeducation plans for individuals facing chronic health challenges. Therefore, creating and implementing MM training as an adjunctive therapy in chronic patients' care plans may enhance their mental, physical, and social well-being. Future research should expand on these findings by exploring additional health outcomes and assessing long-term effects in more diverse clinical and community settings using more effective random assignment methods and procedures. To minimize potential expectancy effects and better isolate the unique effects of MM, future studies should incorporate an active control condition, such as health education, guided imagery, or another non-mindfulness-based intervention. Furthermore, double-blinding procedures for outcome assessors should be implemented in future studies to minimize the risk of detection bias. More structured tracking should also be implemented in future studies, such as standardized dietary logs, sleep monitoring, or medication documentation, to further isolate the intervention's effects on cortisol, C-reactive protein, or other biomarker levels.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the ethical committees at the School of Nursing at the University of Jordan (Approval no.: N4\2024\402, May 21, 2025) and the Kuwaiti Ministry of Health (Approval no.: 1461\September 09, 2024). Informed consent was obtained from all individual participants included in the study.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants included in the study.

DATA AVAILABILITY STATEMENT

Data will be available upon request from the corresponding author.

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