

ORIGINAL ARTICLE

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Every breath you take: How do yoga based breathing exercises affect quality of life and dialysis efficacy in peritoneal dialysis patients?

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Abstract

Peritoneal dialysis (PD) may lead to physical and psychological challenges that negatively affect patients' quality of life and treatment adherence. Although yoga based breathing exercises have been shown to improve stress management and well being in various chronic conditions, evidence regarding their effects in PD patients remains limited. This study aimed to evaluate the association between yoga based breathing exercises, quality of life, and dialysis adequacy in patients undergoing peritoneal dialysis. This prospective pilot study included 15 patients receiving routine peritoneal dialysis treatment at a tertiary nephrology center between June and August 2019. Participants performed supervised yoga-based diaphragmatic breathing exercises for 30 minutes, three times weekly, over an 8-week period. Following initial face-to-face training, patients continued the exercises at home and were monitored through telephone-based telemedicine follow-up. Quality of life was assessed using the Kidney Disease Quality of Life Short Form (KDQOL-SF™ 1.3), while dialysis adequacy was evaluated using weekly Kt/V measurements obtained during routine clinical follow-up. Pre- and post-intervention measurements were compared using paired statistical analyses. Following the intervention, a statistically significant reduction in KDQOL-SF scores was observed (pre-intervention: 183.53 ± 42.98 vs. post-intervention: 171.60 ± 37.48 ; $p = 0.008$). In addition, Kt/V values showed a significant increase after the breathing exercise program (pre-intervention: 2.36 ± 0.80 vs. post-intervention: 3.29 ± 1.22 ; $p = 0.023$). In this pilot study, yoga-based breathing exercises were associated with favorable changes in KDQOL-SF scores and dialysis adequacy parameters among patients undergoing peritoneal dialysis. These preliminary findings suggest that breathing exercises may represent a feasible complementary intervention in PD care. Larger controlled studies are needed to confirm these observations.

Keywords: Peritoneal dialysis, breathing exercises, quality of life, dialysis adequacy, telemedicine, pilot study

Introduction

Peritoneal dialysis (PD) is a home based renal replacement therapy that provides fluid and electrolyte balance through the peritoneal membrane. Compared with hemodialysis, PD offers a more physiological, home applicable, and hemodynamically stable treatment option. However, risks such as peritonitis and variability in treatment effectiveness related to patient adherence represent important limitations of this modality. In addition, long term use of PD may lead to progressive loss of peritoneal

membrane function, which can adversely affect treatment outcomes [1,2]. These clinical challenges may contribute to both psychological and physical difficulties experienced by patients undergoing peritoneal dialysis [3].

In the literature, yoga based breathing exercises have been shown to exert positive effects on stress management and quality of life [4]. Nevertheless, studies specifically investigating the impact of such interventions in patients receiving peritoneal dialysis remain limited. Available evidence regarding exercise

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interventions in PD patients is largely restricted to small sample sizes and selected populations. While current guidelines primarily emphasize the safety of physical activity in this group, there is still a need for high quality research focusing on evidence based exercise protocols tailored to PD patients [5].

Several studies have examined the effects of physical exercise on dialysis adequacy, particularly Kt/V values. Research conducted mainly in hemodialysis populations has demonstrated that exercise can lead to improvements in Kt/V. For instance, aerobic exercises performed during hemodialysis may alter patients' hemodynamics, allowing increased solute transport to the dialyzer and consequently enhancing Kt/V values [6]. In peritoneal dialysis, the peritoneal membrane functions as an active filter for the removal of fluid and toxins through physical transport mechanisms such as diffusion, osmosis, and convection [7]. These mechanisms may be influenced by body dynamics, including diaphragmatic motion and abdominal movements. Respiratory dynamics, in particular, may contribute to peritoneal fluid drainage by acting as a mechanical pump [8]. Therefore, the potential effects of breathing exercises and controlled physical movements on PD efficacy warrant further investigation. However, evidence regarding their impact on dialysis adequacy and long-term clinical outcomes in PD patients remains limited.

The rationale of the present study is grounded in this physiological framework. During physical activity, effective breathing is considered to involve diaphragmatic or focal breathing, a pattern that is naturally adopted by infants and young children [9]. In adulthood, however, inefficient breathing patterns become more prevalent, potentially limiting optimal respiratory mechanics. It has been hypothesized that diaphragmatic breathing may influence intra-abdominal pressure and peritoneal fluid dynamics. However, the physiological effects of breathing exercises on peritoneal membrane transport and dialysis adequacy have not been clearly established. Accordingly, this study aimed to explore the possible association between structured breathing exercises and Kt/V values in patients undergoing peritoneal dialysis.

Telemedicine provides opportunities for timely communication, patient monitoring, and continuity of care, particularly in the management of chronic diseases. Recent evidence suggests that telemedicine and remote patient monitoring may improve access to care, support treatment adherence, and facilitate long-term follow-up in patients with chronic kidney disease and dialysis-dependent kidney failure [10]. Owing to its accessibility and efficiency, telemedicine has contributed to improved access to healthcare services and follow up processes [11]. Telemedicine applications also play a critical role in enhancing patient adherence in chronic disease management [12]. Furthermore, they represent an effective tool for supporting continuity of exercise programs and facilitating ongoing contact with healthcare providers [13]. In the present study, telemedicine was used as a supportive follow-up tool to monitor patients' adherence to the breathing exercise program.

The aim of this pilot study was to evaluate the association between yoga-based breathing exercises, quality of life, and dialysis adequacy in patients undergoing peritoneal dialysis.

Material and Methods

This prospective pilot study was conducted between June 2019 and August 2019 at the Peritoneal Dialysis Unit of the Nephrology Clinic, Antalya Training and Research Hospital, Türkiye. Fifteen adult patients receiving routine peritoneal dialysis treatment were enrolled. Of these patients, 13 were undergoing automated peritoneal dialysis and 2 were receiving continuous ambulatory peritoneal dialysis. Patients with cognitive impairment, neurological deficits, psychiatric disorders, or cardiopulmonary insufficiency that could limit their ability to perform breathing exercises were excluded from the study. As this was an exploratory pilot study, a formal sample size calculation was not performed. All eligible and willing patients receiving peritoneal dialysis during the study period were invited to participate.

The exercise program was designed and delivered by an internal medicine specialist who was also a certified yoga instructor. The protocol was specifically adapted for patients undergoing peritoneal dialysis in order to avoid excessive abdominal strain and ensure the safety of the peritoneal dialysis catheter.

The program consisted primarily of breathing-focused exercises and gentle movements performed in seated and standing positions. Exercises included diaphragmatic (abdominal) breathing, thoracic breathing, alternate nostril breathing, seated spinal flexion-extension movements (cat-cow), gentle arm elevation synchronized with inhalation and lowering during exhalation, and lateral arm opening movements coordinated with breathing. Participants were instructed to perform the exercises in a slow and controlled manner, emphasizing breathing awareness rather than physical exertion.

Each session lasted approximately 30 minutes and was performed three times weekly for 8 weeks. During the initial phase of the program, participants received one-to-one face-to-face instruction to ensure proper technique and safe execution of all movements.

An educational brochure describing the breathing exercises was provided to support home practice. In the subsequent weeks, patients continued the exercise program at home. Follow-up was conducted exclusively through telephone calls; no video-based telemedicine platforms or mobile applications were used. Telephone follow-up was performed on exercise days, three times per week. During these calls, patients were asked whether they had completed the exercises, experienced any difficulties, or had any health related concerns.

Quality of life was assessed using the Kidney Disease Quality of Life Short Form questionnaire (KDQOL-SF™ 1.3) at baseline and at the end of the 8-week intervention period. For exploratory within-subject comparisons, KDQOL-SF responses were aggregated into a composite total score. According to the scoring

approach used in this study, lower composite scores reflected a more favorable quality-of-life profile. Therefore, reductions in total scores over time were interpreted as improvements in perceived quality of life. Dialysis adequacy was assessed using routinely collected Kt/V measurements obtained during standard clinical follow-up visits. No additional procedures were performed for study purposes. Kt/V values recorded before and after the intervention period were used for analysis.

The study was approved by the Clinical Research Ethics Committee of University of Health Sciences, Antalya Training and Research Hospital (30 May 2019; decision no: 14/9). As this study was designed as a prospective single-arm pilot interventional study, no specific reporting guideline was fully applicable; however, the manuscript was prepared according to the general principles of transparent reporting for pilot and feasibility studies.

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Normally distributed variables were compared using paired samples t-tests, whereas non-normally distributed variables were analyzed using the Wilcoxon signed-rank test. Effect size was calculated using Cohen’s d for paired comparisons and interpreted as small (0.20), medium

(0.50), and large (0.80). A p-value < 0.05 was considered statistically significant.

Results

Fifteen patients were enrolled in the study and all participants completed the 8-week intervention period. No participant withdrew from the study, and no exercise-related adverse events, episodes of peritonitis, or acute medical complications were observed during follow-up. The breathing exercise program was well tolerated throughout the study period.

This study evaluated the effects of yoga based breathing exercises on quality of life and dialysis adequacy in patients undergoing peritoneal dialysis. None of the participants experienced peritonitis or other acute medical conditions during the study period. Therefore, no major clinical events were identified that might substantially influence quality-of-life assessments or dialysis adequacy measurements during follow-up.

Descriptive Characteristics Before and After the Breathing Exercise Program

Table 1 presents the descriptive statistics of quality of life scores and Kt/V values measured before and after the breathing exercise intervention.

Table 1. Descriptive statistics before and after the breathing exercise program

Variable	Measurement	N	Min	Max	Mean ± SD
Survey	Pre-exercise	15	128.0	280.0	183.53 ± 42.98
	Post-exercise	15	123.0	261.0	171.60 ± 37.48
Kt/V	Pre-exercise	15	1.39	4.64	2.36 ± 0.80
	Post-exercise	15	1.46	5.06	3.29 ± 1.22

Following the intervention, total KDQOL-SF composite scores decreased from baseline to the post-intervention assessment. According to the scoring approach used in this study, lower composite scores reflected a more favorable quality-of-life profile. Interindividual variability was observed across participants. In addition, Kt/V values were higher at the post-intervention assessment compared with baseline. Interindividual variability was also observed in dialysis adequacy measurements.

Changes in Quality of Life Scores Over Time

The comparison of KDQOL-SF total scores before and after the breathing exercise program is shown in Table 2 and Figure 1.

Quality of Life Survey Score Change (Before and After Exercise)

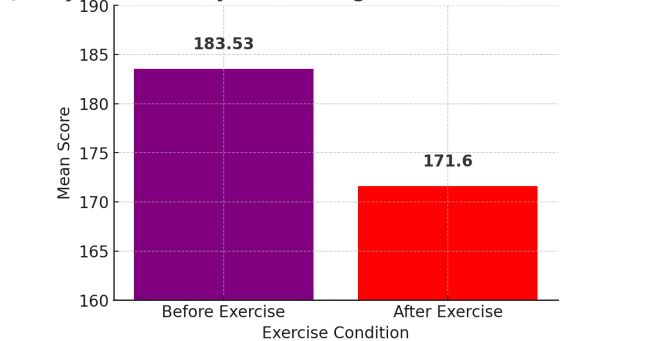


Figure 1. Change in KDQOL-SF total scores before and after the breathing exercise program

Table 2. Paired samples t-test results for KDQOL-SF total scores

Variable	Measurement	N	Mean ± SD	r	SD	t	p	d
Survey	Pre-exercise	15	183.53 ± 42.98	0.94	14	3.06	0.008	0.80
	Post-exercise	15	171.60 ± 37.48					

A statistically significant reduction in KDQOL-SF total scores was observed after the intervention ($t(14) = 3.06, p = 0.008$), with a large effect size (Cohen's $d = 0.80$). According to the composite scoring approach used in this study, this finding was consistent with a more favorable quality-of-life profile following the intervention.

Changes in Dialysis Adequacy (Kt/V) Over Time

Changes in Kt/V values before and after the breathing exercise program were analyzed using the Wilcoxon signed-rank test, as presented in Table 3 and Figure 2.

Kt/V values showed a statistically significant increase following the breathing exercise intervention ($Z = 2.27, p = 0.023$).

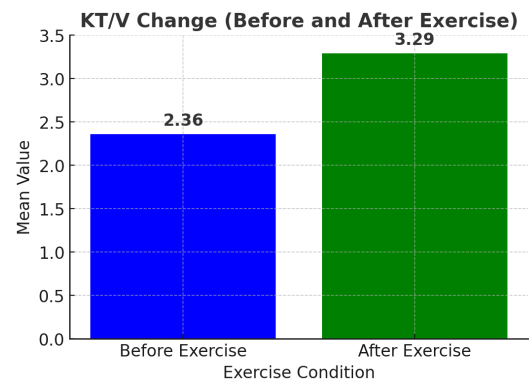


Figure 2. Changes in Kt/V values before and after the breathing exercise intervention

Table 3. Wilcoxon Signed-Rank test results for Kt/V values

Variable	Measurement	N	Mean Rank	Sum of Ranks	Z	p
Kt/V	Pre-Exercise	15	10.00	20.00	2.27	0.023
	Post-Exercise	15	7.69	100.00		

Discussion

The principal findings of this pilot study were that yoga-based breathing exercises were associated with a significant reduction in KDQOL-SF composite scores and a significant increase in Kt/V values after an 8-week intervention period. In addition, all participants completed the intervention and no exercise-related adverse events or episodes of peritonitis were observed. These findings suggest that breathing-focused exercise programs may be feasible in patients undergoing peritoneal dialysis.

Peritoneal dialysis is associated with both physical and psychological challenges that may adversely affect patients' quality of life by imposing physical limitations, impairing social functioning, and contributing to psychological distress [14]. In a systematic review and meta-analysis conducted by Luca Zazzeroni et al., quality of life in patients undergoing peritoneal dialysis and hemodialysis was evaluated using the KDQOL-1.3 and KDQOL-36 questionnaires. The authors reported that chronic kidney disease negatively affected quality of life in both patient groups; however, no significant differences were observed according to dialysis modality, and the negative impact was found to be relatively less pronounced in patients receiving peritoneal dialysis [15]. Based on these findings, the present study aimed to investigate the potential effects of yoga-based breathing exercises on quality of life in patients undergoing peritoneal dialysis using the KDQOL-SF™ 1.3 questionnaire.

Previous studies conducted in patients with chronic obstructive pulmonary disease have demonstrated that breathing exercises performed for 20-30 minutes over a period of 6 weeks can lead to significant improvements in respiratory function and quality

of life [16]. Moreover, it has been suggested that a minimum duration of 6-8 weeks is required for breathing exercises to induce optimal physiological adaptations. In the study by Hota et al., a 6 week breathing exercise program was shown to improve cardiorespiratory and general health parameters, with each 30 minute session contributing to reduced stress levels [17]. In accordance with this evidence, the breathing exercise protocol in the present study was designed to last 30 minutes per session and was implemented over an 8 week period.

To enhance adherence to the breathing exercise program and support continuity, patients were followed regularly by telephone throughout the 8 week intervention period. During these follow-up contacts, patients were asked about exercise compliance and the presence of any health related problems. Previous studies have shown that telemedicine supported approaches in the management of chronic diseases may positively influence patient adherence and treatment outcomes [18]. In addition, systematic reviews have reported that telemedicine applications can improve patient experience [19], and studies in populations with heart failure have demonstrated beneficial effects on quality of life associated with telemedicine use [20]. In this context, telemedicine in the present study was used as a supportive follow up method rather than a primary intervention. However, because telemedicine follow-up was used to support adherence throughout the intervention period, its potential contribution to patient engagement and perceived well-being cannot be completely separated from the effects of the breathing exercise program itself.

In the current study, a reduction in postintervention KDQOL-SF total scores was observed compared with baseline. According to the composite scoring approach used in this study, lower scores

were interpreted as reflecting a more favorable quality-of-life profile. As lower KDQOL-SF total scores were defined as indicative of better perceived quality of life in this analysis, this finding may reflect favorable changes in patients' perceptual or psychological status. Although the change reached statistical significance ($p = 0.008$), the relatively small sample size and the potential influence of psychosocial variability among participants may have limited the magnitude of the observed effect. In a review by Osasuyi Iyasere et al. examining exercise interventions in peritoneal dialysis patients, improvements in quality of life measures were reported following a three month exercise program [5]. In comparison, the present study focused exclusively on yoga-based breathing exercises and was limited to an eight-week intervention period. To date, evidence specifically addressing the effects of isolated yoga-based breathing exercises in peritoneal dialysis patients remains scarce. It is plausible that longer intervention durations and larger study populations may yield more pronounced effects on quality of life outcomes. Nevertheless, the interpretation of these findings should be approached cautiously because the study used a composite KDQOL-SF score rather than domain-specific analyses, and the observed changes may have been influenced by psychosocial and behavioral factors not captured within the study design. Recent consensus recommendations have also emphasized that regular physical activity and structured exercise programs may improve physical function, overall well-being, and health-related quality of life across the spectrum of chronic kidney disease, including patients receiving dialysis therapy. These findings support the growing recognition of exercise-based interventions as an important component of comprehensive kidney care [21].

The interpretation of KDQOL-SF findings should be considered within the context of the composite scoring approach used in this study. Because no standard overall KDQOL-SF summary score exists, the present analysis was based on an aggregated composite score designed for within-subject comparisons. Consequently, the observed changes should be interpreted as reflecting variation in the composite score rather than changes in specific KDQOL-SF domains.

With regard to dialysis adequacy, the present study demonstrated a statistically significant increase in Kt/V values following the breathing exercise intervention ($p = 0.023$), suggesting a potential improvement in peritoneal dialysis efficacy. In a review evaluating the effects of various exercise modalities on physical function, dialysis adequacy, and health-related quality of life in hemodialysis patients, exercise interventions were reported to improve Kt/V, although the overall quality of evidence was considered low [4]. Notably, the exercise types evaluated in that review did not include yoga-based breathing exercises. While evidence regarding the effects of exercise on Kt/V in peritoneal dialysis patients is limited, the observed improvement in dialysis adequacy in the present study may be related to physiological mechanisms involving diaphragmatic

movement, intra-abdominal pressure modulation, and enhanced peritoneal fluid dynamics. Furthermore, processes such as inflammation, fibrosis, angiogenesis, and lymphangiogenesis have been identified as key contributors to peritoneal membrane dysfunction and reduced dialysis efficacy [22]. Non pharmacological approaches that potentially support peritoneal membrane function, such as breathing exercises, may therefore represent a complementary strategy in peritoneal dialysis care. Because dialysis adequacy may be influenced by several factors, including dialysis prescription, residual renal function, and patient-related characteristics, the observed increase in Kt/V should not be interpreted as a direct causal effect of the breathing exercise program. Although a statistically significant increase in Kt/V was observed, the absence of a control group prevents attribution of this change directly to the breathing exercise intervention. Other factors influencing dialysis adequacy, including patient-related characteristics and unmeasured clinical variables, may also have contributed to the observed findings.

Several factors should be considered when interpreting the present findings. Because the study lacked a control group, placebo effects, increased attention from healthcare providers, regression to the mean, and other unmeasured confounding factors cannot be excluded. Consequently, causal inferences should not be drawn from the observed associations.

Overall, the findings of this study suggest that yoga based breathing exercises may be associated with improvements in perceived quality of life and dialysis adequacy in patients undergoing peritoneal dialysis. However, these effects may vary according to individual patient characteristics, and the results should be interpreted with caution given the study's design and sample size. Further large-scale, controlled, and long-term studies are warranted to better elucidate the physiological and psychological mechanisms underlying these observations and to determine the clinical relevance of breathing exercise interventions in peritoneal dialysis populations.

Limitations

The primary limitation of this study is the absence of a control group, which restricts the ability to draw comparative conclusions regarding the observed effects of the intervention. In addition, the small sample size limits the statistical power of the study and reduces the generalizability of the findings. The relatively short follow-up period precludes assessment of the long term effects of yoga-based breathing exercises on quality of life and dialysis adequacy. Furthermore, the heterogeneity of the patient population may have contributed to interindividual variability in the outcomes. Another important limitation is the potential influence of psychosocial factors. Differences in socioeconomic and sociocultural backgrounds among participants may have affected individual responses to the breathing exercises and influenced both perceived quality of life and clinical parameters.

Additional limitations should also be acknowledged. The study used a composite KDQOL-SF score rather than domain-specific quality-of-life analyses, and detailed adherence metrics were not systematically recorded. Furthermore, factors that may influence dialysis adequacy, including residual renal function, possible variations in dialysis prescription, and other clinical parameters, were not specifically controlled for during follow-up. These factors may have contributed to the observed changes in Kt/V values and should be considered when interpreting the results.

Conclusion

In this pilot study, yoga-based breathing exercises were associated with favorable changes in KDQOL-SF composite scores and dialysis adequacy parameters among patients undergoing peritoneal dialysis. The intervention was well tolerated, and all participants completed the 8-week program without major adverse events. These preliminary findings suggest that breathing-focused exercise programs may represent a feasible complementary approach in peritoneal dialysis care. However, given the small sample size, the absence of a control group, and the exploratory nature of the study, the findings should be interpreted cautiously. Larger controlled studies with longer follow-up periods are needed to confirm these observations and to further investigate the physiological and psychological mechanisms underlying the observed associations.

Ethical Approval

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Clinical Research Ethics Committee of University of Health Sciences, Antalya Training and Research Hospital (approval date: 30 May 2019; decision no: 14/9).

Patient Consent

Written informed consent was obtained from all participants prior to enrollment.

Conflict of Interest

The authors confirm the absence of any conflicts associated with this work.

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