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A modified yoga-based exercise program in hemodialysis patients: A randomized controlled study

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Summary
Aim: To evaluate the effects of a yoga-based exercise program on pain, fatigue, sleep disturbance, and biochemical markers in hemodialysis patients.
Materials and methods: In 2004 a randomized controlled trial was carried out in the outpatient hemodialysis unit of the Nephrology Department, Uludag University Faculty of Medicine. Clinically stable hemodialysis patients ($n = 37$) were included and followed in two groups: the modified yoga-based exercise group ($n = 19$) and the control group ($n = 18$). Yoga-based exercises were done in groups for 30 min/day twice a week for 3 months. All of the patients in the yoga and control groups were given an active range of motion exercises to do for 10 min at home. The main outcome measures were pain intensity (measured by the visual analogue scale, VAS), fatigue (VAS), sleep disturbance (VAS), and grip strength (mmHg); biochemical variables — urea, creatinine, calcium, alkaline phosphatase, phosphorus, cholesterol, HDL-cholesterol, triglyceride, erythrocyte, hematocrit — were evaluated.
Results: After a 12-week intervention, significant improvements were seen in the variables: pain −37%, fatigue −55%, sleep disturbance −25%, grip strength +15%, urea −29%, creatinine −14%, alkaline phosphatase −15%, cholesterol −15%, erythrocyte +11%, and hematocrit count +13%; no side-effects were seen. Improvement of the variables in the yoga-based exercise program was found to be superior to that in the control group for all the variables except calcium, phosphorus, HDL-cholesterol and triglyceride levels.
Conclusion: A simplified yoga-based rehabilitation program is a complementary, safe and effective clinical treatment modality in patients with end-stage renal disease.

Introduction

In the United States more than 320,000 patients with end-stage renal disease (ESRD) currently

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require hemodialysis.[1] In Canada the number of patients being treated for ESRD has risen from 13.3/100,000 in 1997 to 15.8/100,000 in 2001. An increase of 18.8% in 5 years has been reported by the Canadian Institute for Health Information.[2]

Patients with ESRD have low levels of physical fitness and function. Their aerobic capacity tends to be only half that of normal, their strength is low, and they are likely to have problems with mobility and basic activities of daily living.[3,4] They have an increased incidence of diabetes, anemia, peripheral vascular disease, hypertension, coronary artery disease and stroke.[5,6] Because of electrolyte imbalance and other factors, individuals usually complain of pain, fatigue and muscle weakness in the spine, hips, knees and lower extremities. The pain worsens with weight-bearing activities, and fractures in the vertebrae and long bones are common.[7] Patients with ESRD have a high risk of sustaining conditions that commonly lead to an inpatient rehabilitation unit.

Some of the systemic symptoms and physical and mental dysfunction can be reduced or eliminated by adequate exercise.[3,4,8–10] Results of the studies on exercise in hemodialysis patients suggest that there is no clear exercise regimen prescription for the rehabilitation of patients. The most appropriate exercise prescription for patients has yet to be determined. Patients with ESRD have a low capacity for exercise, and fatigue is the most common reason for its discontinuation.[11] Transportation problems, lack of time, quick changes of medical status, functional dependency, depression and lack of motivation are the other difficulties.[12] Despite the reported beneficial effects, exercise training may have a risk for patients who are predisposed to cardiovascular complications.

For the past decade it has been believed that yoga alleviates stress and induces relaxation. The word 'yoga' is probably derived from the Sanskrit verb 'yug' which means 'to unite'. It connotes 'the joining of the lower human nature to the higher'.[13] It is claimed that yoga practice allows a person to alter their mental and bodily responses normally thought to be beyond control.[12] Hatha yoga is the most popular yogic practice in the United States. It has three essential components: breathing exercises (pranayama), postures (asanas), and devotional sessions combined with meditation (dhyana).[14] It is reported that asanas (postures) can be used for the treatment of chronic painful conditions such as low back pain,[15,16] stroke,[17] depression[18] and rheumatoid arthritis.[19]

A randomized controlled trial studied a 6-week modified Hatha yoga protocol with 22 patients.[20] This underpowered pilot study found trends in functional measurement scores for improved balance and flexibility, as well as decreased disability and depression in the yoga group. In a survey of 3000 people receiving yoga, 98% claimed that yoga benefited them.[21]

In this study, we aimed to use some yogic postures and breathing exercises as a modified yoga-based exercise regimen in the rehabilitation of dialysis patients, and our hypothesis is that yoga exercise can improve pain, fatigue, sleep disorder and biochemical markers in this patient population.

Materials and methods

Participants and subject selection

There were 157 potential subjects in the hemodialysis unit (Fig. 1). Hypertension was present in 91% of the patients, and 80% had cardiovascular diseases. Most were using antihypertensives. Before the exercise regimen, cardiovascular performance of the subjects was checked by a bicycle ergometer. Of the remaining hemodialysis patients who met the inclusion criteria, 40 agreed to be participants. They were having dialysis for at least 6 months (4 h/day and 3 times/week) and had no unstable hypertension, arrhythmia or cardiac angina after 10 min of fast pedaling.[22] Other inclusion criteria were no use of analgesic or non-steroid anti-inflammatory drugs and an average musculoskeletal pain score of at least 2 on a scale of 0–10 (the 'visual analogue scale', VAS) in the previous month.[23] The subjects who had ischemic cardiac pain, arrhythmia or unstable hypertension after 10 min fast pedaling were not included. Individuals with unstable angina, congestive heart failure (grade II), significant cardiac valve disease and conduction abnormalities according to the screening electrocardiogram, cerebrovascular disease, electrolyte imbalance, persistent hyper-

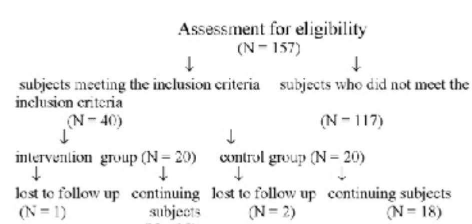

Figure 1 Diagram showing the flow of the participants through the study.

kalemia before dialysis, diabetes mellitus, active liver disease, arthritic or orthopedic problems limiting exercise, and peripheral vascular disease. Undisciplined patients were also excluded.

Intervention procedures were approved by the ethical committee of the university hospital, and informed consent was obtained from each patient.

Randomization

In the single-blind study, simple randomization was done by a physician using a computer-generated table of random numbers, and 40 participants were allocated to two groups. The procedure was concealed from the evaluating physician.

Clinical and laboratory variables

Clinical and laboratory variables were evaluated in the intervention and control groups. The physician who did the examination was blind to the allocation. At the beginning of the study, patient characteristics — age (years), duration of hemodialysis (months), gender (female/male), pain intensity by VAS, fatigue (VAS), sleep disturbance (VAS), grip strength (mmHg), body mass index (kg/m^2), urea (mg/dL), creatinine (mg/dL), and blood pressure (mmHg) — were recorded. Grip strength of the non-dominant hand was measured using a hand-held dynamometer,[24] and blood pressures of the subjects in the intervention group were checked with a sphygmomanometer before and after the exercises. Pain intensity (VAS), fatigue (VAS), sleep disturbance (VAS), grip strength (mmHg), plasma urea (mg/dL), plasma creatinine (mg/dL), plasma calcium (mg/dL), plasma alkaline phosphatase (U/L), plasma phosphorus (mg/dL), plasma cholesterol (mg/dL), plasma HDL-cholesterol (mg/dL), plasma triglyceride (mg/dL), hematocrit (%) and erythrocyte (M/μL) values were evaluated before and at the end of the study. Laboratory variables were calculated with Abbot Alcyon 300i and Cell-Dyn 1200 model machines.

Modified yoga-based exercise intervention

The duration of the intervention was 3 months, and yoga-based exercise was carried out 30 min/day twice a week.

Some modifications to the classic yoga program were done to increase patient compliance. The duration was 15 min/session at the beginning, gradually increasing to 30 min/session till the end of the first month. The intensity of the exercise was progressively increased and the asanas adjusted to meet the true physiologic condition of the subjects. As musculoskeletal alignment improves, the ability to perform the asanas should improve also. Potential benefits of this method include improvements in strength, coordination, flexibility and sense of well-being. The exercises were done in the standing, sitting and lying positions. Modifications of various postures were based on participant abilities/tolerance. Meditation (dhyana) was not done. The goal was to create an intervention that is easy to do and at the same time to adhere to the principles of the yoga tradition which emphasizes the need to individualize postures based on the needs of the class. Therefore, this is a semi-structured approach with selected poses and a modified duration.

Relaxation technique[15,16]

1. Standing position;
2. slow rhythm coordinated with breathing (there must be no excessive pressure on the joints).

The rhythm consisted of 6-s expiration and stretching/4-s inspiration and relaxing; 10 repetitions were done for every movement. Participants focus on the feedback from the stretch sensors in the muscles, ligaments and joints to prevent reflex contraction and enhance stretching. (The exercise has to be stopped if there is severe fatigue or pain lasting for longer than an hour after the exercise.) Blood pressures were measured before and after the exercise by the hemodialysis nurse.

Postures[15,16]

1. Chest expansion (ardha chakrasana);
2. triangle (trikonasana);
3. complete breathing (pranayama);
4. side bend (nitambasana);
5. standing abdominal lift (uddiyana);
6. back strength (paschimothanasana);
7. half-locust (salabhasana).

The patients of the yoga group were instructed on how to breath and how to focus on the physical body. Every session ended with relaxation using the relaxation response of savasana (corpse pose). During relaxation, the body was supposed to remain still.

The exercise instructor was a certified yoga teacher and also a lecturer in Uludag University Physical Education Department. Each patient in the yoga group was provided with an illustrated booklet explaining the poses, and was told to do the exercises only with the guidance of the exercise instructor at the hemodialysis unit. Yoga exercises were not done in one single group of patients. In order to increase compliance and adherence to the program, the regular supervised yoga training was done on the hemodialysis days of the patients. Yoga class took place every day except weekends, but each patient joined the yoga class only twice a week. Patients were instructed to inform us about special reasons for not coming to the yoga session (maximum three times in 3 months).

Patients in the control group ($n = 18$) did not join the yoga class and were instructed not to change their life-style for the duration.

Patients in the intervention and control groups did an active range of motion exercises at home for upper-lower extremities and spine. The home-based active range of motion exercises was demonstrated and explained to each patient in the hemodialysis unit by a physiotherapist until she was satisfied that all of them could do the exercises. They were instructed to do them at home once a day for 10 min. We kept close contact with all of the patients to answer any questions they had about the exercises or their disease, and to become familiar with their course and to modify the exercise program if necessary.

Patients in groups I and II received the usual care in order to exclude any impact from cardiovascular, metabolic and hematopoietic changes which may have negative effects on aerobic capacity or physical performance. Physical examinations, electrocardiograms and laboratory analysis of the patients were done every week. Heart rates and blood pressures were measured, using a stethoscope and a sphygmomanometer, at the end of the hemodialysis procedure and exercise sessions. The patients were on stable medical therapy during the study. Moreover, dialysis procedure was kept stable throughout the 3-month-period.

Statistical analysis

Data analysis was done using the SPSS (Statistical Package for the Social Sciences) Version 9.0 for Windows. Descriptive statistics (mean, S.D.) were calculated for age, duration of disease, gender, pain intensity, fatigue, sleep disturbance, grip strength, body mass index (BMI), urea, creatinine and blood pressure. The independent t-test was used to compare patient characteristics and baseline measures between the treatment and control groups (Table 1). Finally, Mann—Whitney U-test was used to compare the groups (G1 and G2) by the percentage changes in the variables: pain (VAS), fatigue (VAS), sleep disturbance, grip strength, levels of urea, creatinine, calcium, alkaline phosphatase, phosphorus, cholesterol, HDL-cholesterol, triglyceride, erythrocyte and hematocrit counts, and to indicate their statistical significance (Table 2). A probability value of 0.05 was accepted as the level of statistical significance.

Table 1 Patient characteristics in the yoga-based exercise and control groups

	Yoga-based exercise group ($n = 20$)	Control group ($n = 20$)
Age (years)	38 ± 14.2	41 ± 9.97
The duration hemodialysis (months)	21.5 ± 12.3	20.2 ± 14.4
Gender (F/M)	11/9	13/7
Pain intensity (VAS)	4.9 ± 2.3	4.6 ± 3.6
Fatigue (VAS)	7.4 ± 2.5	7.2 ± 5.3
Sleep disturbance (VAS)	4.6 ± 3.6	4.4 ± 3.7
Grip strength (mmHg)	150.3 ± 40.3	141.7 ± 45.8
Body mass index (kg/m^2)	28.5 ± 3.4	27.9 ± 4.5
Urea (mg/dL)	293.3 ± 45.7	244.43 ± 46.6
Creatinine (mg/dL)	14.4 ± 3.5	13.1 ± .3.6
Systolic blood pressure (mmHg)	134.7 ± 24.4	121.3 ± 31.9
Diastolic blood pressure (mmHg)	78.8 ± 19.5	72.4 ± 14.3

Results

The median duration of hemodialysis was 10.5 months (mean 21.9 ± 14.2 months) for the 40 subjects. The baseline values in the treatment and control groups were statistically similar (Table 1). The hemodialysis patients were stable on medical therapy for the study duration, and new medications were not started during the study period. Three of the 40 patients who met the inclusion criteria were dropped, as they missed three sessions in a 3-month-period and adhered poorly to the exercise instructions. Thus, 19 patients in the exercise group and 18 patients in the control group were left (Fig. 1).

Percentage changes in the variables from baseline values were −37% in pain intensity, −55% in fatigue, −25% in sleep disturbance, +15% in grip strength, −29% in plasma levels of urea, −14% in creatinine, −15% in alkaline phosphatase, −12% in phosphorus, −15% in cholesterol, +7% in HDL-cholesterol, +11% in erythrocyte and +13% in hematocrit at the 12th week post-treatment in the intervention group. There were no changes in calcium and triglyceride levels (Table 2).

Table 2 Comparison of the yoga-based exercise (G1) and control (G2) groups by percentage changes from baseline

	Baseline			After treatment			% Changes	Significance
	MV	S.D.	95% CI	MV	S.D.	95% CI		
Pain (VAS)								
G1	4.9	2.3	9.5 to 0.4	3.1	7.2	17.2 to −11.0	−37 ± 36	$P=0.03^{*}$
G2	4.6	3.7	11.8 to −2.6	4.2	5.4	14.9 to −6.4	−8 ± 34	
Fatigue (VAS)								
G1	4.4	2.5	12.3 to 2.6	3.3	1.5	6.2 to 0.4	−55 ± 23	$P=0.008^{**}$
G2	7.2	5.3	17.6 to −3.2	6.9	7.2	21.1 to −7.2	−4 ± 41	
Sleep disturbance (VAS)								
G1	4.6	3.6	11.6 to −2.5	3.4	5.2	13.6 to −6.8	−25 ± 37	$P=0.04^{*}$
G2	4.6	3.7	11.8 to −2.6	4.3	8.2	20.4 to −11.7	−5 ± 54	
Grip strength (mmHg)								
G1	150.3	40.3	229.4 to 71.3	172.6	50.8	272.2 to 72.9	15 ± 32	$P=0.006^{**}$
G2	141.7	45.8	231.5 to 51.9	138.3	44.8	226.2 to 50.5	−2 ± 29	
Urea (mg/dL)								
G1	293.3	45.7	382.9 to 203.7	207.4	56.3	317.8 to 96.9	−29 ± 12	$P=0.02^{*}$
G2	244.4	46.6	335.7 to 153.2	237.3	56.9	348.9 to 125.8	−3 ± 87	
Creatinine (mg/dL)								
G1	14.4	3.5	21.4 to 7.5	12.7	2.6	17.8 to 7.6	−14 ± 43	$P=0.007^{**}$
G2	13.1	3.6	20.2 to 6.0	14.8	3.9	22.4 to 7.1	13 ± 9	
Calcium (mg/dL)								
G1	9.5	1.1	11.7 to 7.3	9.5	1.2	11.9 to 7.2	0 ± 0	$P=0.3$
G2	9.8	0.9	11.6 to 8.1	9.5	1.1	11.7 to 7.3	−3 ± 59	
Alkaline phosphatase (U/L)								
G1	581.7	116.1	809.3 to 354.1	491.2	110.3	707.4 to 274.9	−15 ± 63	$P=0.02^{*}$
G2	558.7	86.4	728.1 to 389.3	520.0	13.3	546.1 to 493.9	−7 ± 8	
Phosphorus (mg/dL)								
G1	6.7	5.9	18.3 to −4.9	5.9	2.5	10.9 to 0.9	−12 ± 50	$P=0.5$
G2	6.4	1.3	9.0 to 3.9	5.6	1.4	8.3 to 2.9	−12 ± 65	
Cholesterol (mg/dL)								
G1	157.6	39.9	235.9 to 79.4	134.0	30.4	193.6 to 74.4	−15 ± 23	$P=0.02^{*}$
G2	138.2	22.6	182.6 to 93.9	155.5	16.9	188.7 to 122.3	12 ± 19	
HDL-cholesterol (mg/dL)								
G1	40.8	12.1	64.6 to 17.1	44.0	13.1	69.7 to 18.3	7 ± 21	$P=0.8$
G2	41.3	14.5	69.8 to 12.9	41.2	17.3	75.2 to 7.3	0 ± 0	
Triglyceride (mg/dL)								
G1	200.5	92.3	381.5 to 19.6	200.7	62.2	322.6 to 78.7	0 ± 0	$P=0.6$
G2	199.5	33.9	266.0 to 133.0	200.5	16.9	233.8 to 167.3	1 ± 34	
Erythrocyte (M/μL)								
G1	2.2	0.6	3.4 to 1.1	2.5	0.8	4.0 to 0.9	11 ± 7	$P=0.04^{*}$
G2	2.6	0.6	3.8 to 1.5	2.5	0.3	3.1 to 1.9	−4 ± 85	
Hematocrit (%)								
G1	18.8	5.2	29.0 to 8.6	21.3	8.1	37.2 to 5.4	13 ± 20	$P=0.03^{*}$
G2	22.6	6.7	35.8 to 9.5	22.4	3.9	30.1 to 14.7	−1 ± 27	

$^{*}P<0.05$, $^{**}P<0.01$.

Comparison of the groups on the basis of percentage changes indicated statistical significance for subjective and objective variables: pain intensity ($P=0.03$), fatigue ($P=0.008$), sleep disturbance ($P=0.04$), grip strength ($P=0.006$), plasma levels of urea ($P=0.02$), creatinine ($P=0.007$), alkaline phosphatase ($P=0.02$), cholesterol ($P=0.02$), erythrocyte ($P=0.04$) and hematocrit count ($P=0.03$) in the yoga-based exercise group. Changes in calcium, phosphorus, HDL-cholesterol and triglyceride were not statistically significant (Table 2). No side-effects were declared during the exercise intervention.

Discussion

As far as we know, this is the only study with the application of yoga-based exercise intervention to hemodialysis patients. The data presented here suggest that a modified yoga-based exercise regimen for half an hour twice a week improves pain, fatigue, sleep disturbance symptoms and grip strength, in addition to the laboratory variables urea, creatinine, alkaline phosphatase, cholesterol, HDL-cholesterol, erythrocyte and hematocrit, in a period of 12 weeks (Table 2). This observed clinical improvement may be due to direct beneficial effects of yoga or to an indirect socialization effect of group exercise which provides support and offers a safe way to manage pain and other symptoms. On the other hand, improvements in the laboratory variables may not be related directly to yoga intervention as such but to the general effects of regular exercise. These are points for further discussion.

With the increasing demand for and usage of complementary medicine by the general public, it is vital that health-care professionals can make informed decisions when advising their patients who wish to use alternative medicine. Yoga, through static physical postures (asanas), uses stretching to improve muscular strength and flexibility which could be beneficial for musculoskeletal pain management.[25,26] In a case series of 16 patients with low back pain, various asanas were used for rehabilitation, and significant improvements in mobility and pain intensity were reported.[27] Pain is a prominent symptom and so requires attention in therapeutic interventions such as the present study. Though this study was not designed to address underlying mechanisms of pain attenuation by yoga, it is another point that needs further investigation if yoga-induced relaxation and muscular flexibility are accompanied by an increased pain threshold, as in aerobic exercise training.[28]

Musculoskeletal problems, insomnia and fatigue are reported to improve with yoga, as in the present study.[29–33] Twenty-one women aged $\geq$60 years (mean age 75) with hyperkyphosis participated in 1-h sessions of Hatha yoga twice-weekly for 12 weeks. Measured height increased by a mean of 0.5 cm, forward curvature diminished, patients were able to get out of chairs faster, and they had a longer functional reach; 48% of the patients reported increased postural awareness and improved well-being.[29] In the study of Cohen et al.[31] sleep quality was found to improve with 7 weeks of Tibetan yoga practice in 39 patients with lymphoma. Tibetan yoga of Tsa Lung and Trul Khor incorporates controlled breathing, visualization, and low-impact postures, just like Hatha yoga. In another study by Khalsa,[32] a simple daily yoga treatment for 8 weeks was evaluated in a population with chronic insomnia. For 20 participants completing the protocol, statistically significant improvements were observed in sleep efficiency, total sleep time, sleep onset latency and wake time after sleep onset at the end of the treatment. Bentler et al. investigated 155 subjects with unexplained chronic fatigue and observed that treatments at 6 months which predicted subsequent fatigue improvement were yoga (P = 0.002) and magnesium (P = 0.002). Yoga appeared to be most effective for subjects who did not have unclear thinking associated with fatigue.[33]

Yoga-based exercise is also found to be beneficial in asthma,[34] tuberculosis,[35] hypertension,[36,37] pain management,[38] diabetes,[39] and mood.[40] Specific yoga breathing practices (pranayamas), 20 min a day for 2 months, are reported to play a complementary role in the management of pulmonary tuberculosis with symptomatic relief, better weight gain, increased lung capacity, and improved level of infection.[35] Patel[36] observed reductions in blood pressure with yoga and reported that a controlled study was under way; Hatha yoga relaxation slowed breathing rate in chronic heart failure and reduced dyspnea, and an improvement in pulmonary gas exchange and exercise performance was reported. Yogic practice, through the restoration of baroreceptor sensitivity, caused a significant reduction in the blood pressure of the subjects who participated in yoga exercise.[4,5,37]

Clinical improvement is supported by lots of interventions,[34,36–42] but the question to be answered is: do these changes in turn affect the laboratory variables in the long-term? Long-term (12 months) moderate pre-conditioning exercise interventions (cycling, aerobic exercise) induce a decrease in cholesterol and normalization of the blood pressure and hemogram values in hemodialysis patients.[41,42] Harter and Goldberg[43] demonstrated that non-diabetic hemodialysis patients could significantly reduce fasting plasma glucose and insulin concentrations while significantly increasing insulin-binding affinity and glucose disappearance rates with aerobic training (walking/cycling three times a week). The authors also reported an increase in hematocrit, hemoglobin, aerobic capacity, and fasting plasma HDL-cholesterol levels and a reduction in LDL triglyceride levels. These findings are assumed to be the results of the physiological and metabolic adaptations secondary to aerobic exercise training. However, there are as yet no documented data in the literature highlighting the effects of yoga training in hemodialysis patients.

Individuals with ESRD have a low activity tolerance with an average maximal oxygen consumption, due to: (1) decreased cardiac output and a blunted heart-rate response, (2) anemia, and (3) decreased ability to extract oxygen secondary to musculature changes. The primary limiting factor during the exercise test appears to be muscle fatigue, and individuals are therefore unable to reach the desired maximum intensity level.[44] The recommended exercise frequency for individuals with ESRD is between 2 and 6 days/week.[45] Because these individuals have low exercise capacity, internal training may be the best method when initiating a program. Lower-extremity fatigue impedes continuous exercise and is the most common reason for termination of exercise. The goal should be to exercise continuously for 30 min. The intensity should be low, especially on days that dialysis is administered.[45] Desired and documented benefits of exercise for people with ESRD include improved lipid profile, increased glucose metabolism, increased hematocrit/hemoglobin levels and improved psychosocial effects.[8,45–47] The present study meets most of these benefits and all of the mentioned principles for exercise training in hemodialysis patients.

In our study, exercise training on hemodialysis days is found to be a convenient exercise model with good compliance and adherence. In another trial, it is reported that exercise training during hemodialysis has the advantage of greater applicability, as the drop-out rate was lower when compared with home-based (unsupervised) exercise training and supervised exercise training on non-dialysis days.[48] It provided a more time-efficient model for training in patients on hemodialysis. It did not involve any extra time or transportation, unlike supervised exercise training on non-dialysis days. Painter et al. reported that compliance with exercise training during hemodialysis was >75% during the second 3 months.[49] It was technically feasible and effective as the cardiorespiratory capacity of the patients was significantly improved.

Thus, physical yoga training appears to be effective in the rehabilitation and complementary treatment of hemodialysis patients. However, there are several limitations. One is that a measure of dialysis dose and compliance should have been sought. Another is the lack of a quality-of-life assessment; fatigue contributes to impairments in health-related quality of life, and the improvement in fatigue is supposed to have effects on the quality-of-life assessments. A third limitation is the influence of group interaction, as occurs in a yoga class, which contributes to overall improvement of the intervention subjects through non-specific effects (the control group did not meet in any group activity). The absence of mood and cognitive measures also makes it impossible to reveal these contributing non-specific effects. The final limitation is that the results of this study may not be generalizable to a typical community of ESRD patients with unknown levels of cardiovascular fitness, physical function, and different concomitant diseases. Our subjects were almost all women, and this study may not represent the male population. Essentially, the lack of studies on yoga for patients with ESRD prompted us to present these preliminary data to encourage further clinical trials of this modality on this patient population.

This intervention supports the hypothesis that yoga-based exercise training on hemodialysis days could play a role in the treatment of hemodialysis patients. It is clear that a yoga-based exercise regimen has some beneficial effects on hemodialysis patients. However, larger randomized sample sizes in individualized formats are needed with the evaluation of biochemical markers and health-related quality of life to determine whether benefits may be generalizable to other patient populations.

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