Effect of Intradialytic Aerobic Exercise on Serum Electrolytes Levels in Hemodialysis Patients

Atieh Makhlough,[1] Ehteramosadat Ilali,[2] Raheleh Mohseni,[2] Soheila Shahmohammadi[3]

[1]Department of Nephrology and the Cellular and Molecular Research Center, Mazandaran University of Medical Sciences, Sari, Iran
[2]Department of Medical-Surgical Nursing, Nasibeh Nursing and Midwifery Faculty, Mazandaran University of Medical Sciences, Sari, Iran
[3]Department of Nursing and Midwifery Research Center, Nasibeh Nursing and Midwifery Faculty, Mazandaran University of Medical Sciences, Sari, Iran

Keywords. exercise, hemodialysis, electrolytes, hemoglobin

Introduction. We aimed determine the impact of an 8-week intradialytic exercise program, consisting of 15 minutes of cumulative duration low-intensity exercise during the first 2 hours of dialysis on serum electrolytes levels and hemoglobin.
Materials and Methods. In a randomized controlled trial of in an outpatient hemodialysis unit, clinically stable hemodialysis patients (n = 47) were included and assigned into the aerobic exercise group (n = 25) and the control group (n = 23). Aerobic exercises were done in groups, 15 min/d, 3 times a week, for 2 months. The main outcome measures were biochemical variables including serum levels of calcium, phosphate, and potassium levels and hemoglobin level.
Results. After an 8-week intervention, significant improvements were seen in serum phosphate levels (decreased by 1.84 mg/dL) and serum potassium levels (decreased by 0.69 mg/dL). No side-effects were observed. Serum calcium and hemoglobin levels did not change significantly in the exercise group.
Conclusions. A simplified aerobic exercise program is a complementary, safe, and effective clinical treatment modality in patients with end-stage renal disease on dialysis.

IJKD 2012;6:119-23
www.ijkd.org

Original Paper

INTRODUCTION

According to the United States Renal Data System, the incidence of end-stage renal disease (ESRD) continues to increase each year.[1] In the United States, more than 320 000 patients with ESRD currently require hemodialysis.[2] In Canada, an increase of 18.8% in the number of patients being treated for ESRD has been reported in 5 years by the Canadian Institute for Health Information.[3] The rising incidence and prevalence trends are being reported in many other countries maintaining renal registries.[4] Approximately, 91.9% of patients diagnosed with ESRD receive maintenance hemodialysis treatment as renal replacement therapy.[1] This intervention is typically prescribed 3 times per week, 3 to 6 hours per session, and remains ongoing for the lifetime of the patient or until successful kidney transplantation.[5] In Iran, with over 13 000 dialysis patients, dialysis sessions are performed about 150 000 per month.[6]

Patients with ESRD have low levels of physical fitness and function. Their aerobic capacity tends to be only half of that of normal, their strength is low, and they are likely to have problems with mobility and basic activities of daily living.[7,8] They have an increased incidence of diabetes mellitus, anemia, peripheral vascular disease, hypertension, coronary artery disease, and stroke.[9,10] 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.[11] 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.[7,8,12-14] 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 because of fatigue. Transportation problems, lack of time, quick changes of medical status, functional dependency, depression, and lack of motivation are the other difficulties.[8] Despite the reported beneficial effects, exercise training may have a risk for patients who are predisposed to cardiovascular complications.[15]

Exercise might have beneficial effects on the quality of life of ESRD patients by improvement of mental and physical function and even through its contribution to maintaining electrolyte balance. Hyperphosphatemia is a well-recognized risk factor for cardiovascular mortality in dialysis patients. Despite advanced technology and regular and efficient dialysis treatment, the prevalence of hyperphosphatemia is still high.[16] Hyperkalemia is also common in patients with ESRD, and may result in serious electrocardiographic abnormalities,[17] and accounts for considerable morbidity and death.[18] Chronic kidney disease is accompanied by profound disturbances in calcium, too.[19] Finally, one of the most recurrent problems of hemodialysis is anemia. In order to live a better quality life, dialysis-dependent patients need to have an adequate hemoglobin level. Thus, anemia correction is a very significant part of the dialysis process.[20] In this study, we aimed to implement aerobic exercise movements for rehabilitation of dialysis patients and exaimine its effects on serum electrolyes and hemoglobin through a randomized controlled trial, and our hypothesis is that aerobic exercise movement can improve biochemical markers in this patient population.

MATERIALS AND METHODS

Participants

Forty-seven ESRD patients (17 women and 8 men) aged ranging from 18 to 76 years, consented to participate in this study. The patients were on hemodialysis for more than 3 months. They were receiving hemodialysis 3 times per week, 3 to 4 hours per treatment. All of the patients had arteriovenous grafts or native fistulas. For all of the patient, a high-flux dialysis membrane was in use. Because acetate solution causes hypotension during dialysis and also cardiovascular problems, imbalance syndrome, nausea, vomiting, fatigue, headache, and hypoxia, and because acetate solution inhibits hemoglobin saturated with oxygen,[21] only those patients who used bicarbonate solution were included. Each patient was asked to complete an informed consent and a medical history form prior to test. The physician of each patient completed a medical screening form (Table 1) in order to examine eligibility of the patients. Contraindications to exercise as listed in the medical screening form were the exclusion criteria. Demographic and clinical characteristics of the patients are presented in Table 2.

Randomization

In a single-blinded study, simple randomization was done using a computer-generated table of random numbers, and the 47 participants were allocated to 2 groups in odd and even days, so that the two groups of patients did not see each other.

Table 1. Medical Screening for Contradictions to Exercise in Dialysis Patients

Contraindications
Poorly controlled hypertension
Uncompensated heart failure
Cardiac arrhythmia requiring treatment
Recent unstable angina
Persistent hyperkalemia before dialysis
Significant valvular heart disease
Myocardial infarction within the past 6 months
Significant cerebral or peripheral arteriosclerosis
Bone disease with a risk of fracture
Orthopedic or musculoskeletal limitations
Weight gains > 4 kg from Friday to Monday or from Saturday to Tuesday
A recent significant change in the resting echocardiography
Third degree atroventricular heart block without pacemaker
Severe aortic stenosis
Suspected or known dissecting aneurysm
Active or suspected myocarditis or pericarditis
Thrombophlebitis or intracardiac thrombi
Recent systemic or pulmonary embolus
Acute infections

Table 2. Demographic and Clinical Characteristics of Hemodialysis Patients With and Without Intradialytic Exercise Therapy

Characteristic	Exercise	Control	*P*
Age, y	53.30 ± 14.27	56.16 ± 10.77	.55
Gender			
Male	73.9	54.2	
Female	26.1	45.8	.16
Time on dialysis, mo	25.50 ± 10.70	23.47 ± 13.59	.56
KT/V	0.92 ± 0.23	0.91 ± 0.29	.91
Duration of Hemodialysis, h	3.83 ± 0.38	3.78 ± 0.42	.76
Cause of kidney failure			
Diabetes mellitus	21.7	20.8	
Hypertension	25.0	33.3	
Diabetes and hypertension	17.4	29.2	
Others	21.7	12.5	
Unknown	13.0	4.2	.63

The procedure was concealed from the principal investigator and analysts.

Procedure and Protocol

The duration of the intervention was 2 months (from June 2010 to July 2010). Aerobic exercise movement was carried out 15 min/d, 3 times a week, during the dialysis. Before intervention and after sufficient explanation of the method of exercise, the participants practiced in 2 or more training sessions and received the training documents, including exercise movements instructions. The method was as follows: after connecting the patient to the dialysis machine and turning off all of the alarms associated with connecting the patient, aerobic movement exercise of range of motion joints was started and continued for a maximum of 15 minutes, based on patients capacity, so that the movements did not continue for the next 2 hours of dialysis. They included rotating the wrist (20 rpm clockwise and the 20 rpm counter-clockwise), wrist up and down (up to 20 moves on the forearm), ankle twisting motion (40 rotations clockwise and counterclockwise around the ankles), ankles up and down (20 times). It should be noted that the motion exercise was performed for only 15 minutes and for those patients who performed faster, the movements were started again, and for a patient who ran out of time exercise was limited to the same 15 minutes. The organ that was connected to the device was not given exercise, and attention was paid to the other organs that received exercise, in order not to cause disconnection of the needle. In addition, the patients were taught to stop the movement and notify the researcher if they felt any dizziness, headache, palpitations, nausea, anxiety, exhaustion, and any other adverse effects.

Vital signs of the participants were examined during exercise at least once, and for those patients who had hemodynamic disorders, they were examined based on their need and exercise was stopped if unstable. Blood samples were compared between the two groups at the end of each month after dialysis, regarding the levels of phosphorus, calcium, and potassium and blood hemoglobin.

Statistical Analyses

Data analysis was done using the SPSS software (Statistical Package for the Social Sciences, version 18.0, SPSS Inc, Chicago, Ill, USA). Descriptive statistics (mean ± standard deviation) were calculated for age, time on dialysis (months), dialysis efficacy (KT/V), and duration of hemodialysis session (hours). The paired samples *t* test was used to compare serum electrolytes levels and the chi-square test was used to compare categorical patient characteristics. A *P* value less than .05 or less was used to indicate significance.

RESULTS

Basic demographic data as well as the clinical characteristics of the studied participants are presented in Table 2. There were no significant differences between the two groups in age, gender,

Table 3. Comparison of Blood Parameters in Hemodialysis Patients With and Without Intradialytic Exercise Therapy

Parameters	Baseline		4 Weeks		8 Weeks		
	Exercise	Control	Exercise	Control	Exercise	Control	*P**
Serum phosphate,mg/dL	1.99 ± 7.68	7.04 ± 1.94	6.87 ± 2.01	7.07 ± 2.08	5.83 ± 2.37	7.08 ± 2.07	.003
Serum calcium,mg/dL	8.58 ± 0.52	8.87 ± 0.81	8.68 ± 0.71	8.97 ± 1.12	8.81 ± 1.04	8.80 ± 0.74	.57
Serum potassium, mg/dL	5.81 ± 0.79	5.32 ± 0.97	5.45 ± 0.99	5.45 ± 0.88	5.12 ± 0.96	5.16 ± 0.67	.005
Hemoglobin, g/dL	9.63 ± 1.98	9.55 ± 2.56	9.79 ± 1.92	8.92 ± 1.89	9.87 ± 2.01	8.62 ± 2.14	.32

*Comparison of baseline and 8th week values in the exercise group time on dialysis, KT/V, duration of dialysis sessions, and comorbidities. The hemodialysis patients were stable on medical therapy for the study duration, and no new medications were started during the study period. Serum phosphate levels decreased by 1.85 mg/dL (P = .003) and serum potassium reduced by 0.69 mg/dL (P = .005) after 8 weeks of exercise therapy in the study group. There were no significant changes in serum calcium and hemoglobin levels (Table 3).

DISCUSSION

We found significant improvement of some electrolytes with aerobic exercise during hemodialysis. In the present study, the baseline serum phosphorus, calcium, and potassium, as well as hemoglobin were comparable between the two arms of the study. The data presented here suggest that an aerobic exercise movements regimen for 15 minutes during hemodialysis sessions improve serum phosphate and potassium levels in a period of 8 weeks. This observation might be due to direct beneficial effects of aerobic exercise or general effects of regular exercise.

Reviewing the limited available research on the effects of exercise in reducing phosphorus levels showed that although exercise decreased the level of phosphorus, the significant effects and changes could be observed in long-term and perhaps more intense exercise might be required for some patients.[21-23] Calcium levels, however, did not have any significant change with exercise. Exercise movements also significantly reduced the amount of potassium at the end of the study. The amount of potassium in the control group remained the same until the end of the study. In a study by Borzou and colleagues, a blood flow velocity increase from 200 mL/min to 250 mL/min was effective in blood phosphorus removal but was ineffective in the removal of potassium.[24] Man and colleagues showed that in the first hour, maximum transport of phosphate (300 mg) from the extracellular fluid is done, and then after the third hour (100 mg per hour), it remains constant by the intracellular movement of its value.[25] Thus, performing movement exercises in the first hour of dialysis, by increasing of blood flow, increases the removal of phosphate from the blood. Anabolic effects of exercise on erythrocytes and increased production of hemoglobin has been documented. In a pilot study[26] in which the movement exercise was carried out in 8 patients, there was no tendency towards increasing of hemoglobin or decrease in dosage of erythropoietin, due to the time limitation of the study. In the present study, the level of hemoglobin increased in the patients with exercise compared to the beginning of the study. Although this increase was not statistically significant, it was clinically important. In Fallahi and colleagues' study of 8 weeks of pedal exercise, the level of hemoglobin increased by 0.6 mg dL, which was not statistically significant.[27]

The results of this study indicate the impact of aerobic exercise movements during hemodialysis in patients undergoing dialysis with bicarbonate solution, in terms of reduction of the amount of phosphorus and potassium and a minor increase of hemoglobin. Exercise during dialysis is recommended as a way to enhance the acceptance of doing it and all the beneficial effects to the amount of phosphorus, potassium, and anemia. Studies with larger sample sizes are recommended to examine the effect of exercise on other factors such as blood pressure and lipid levels in dialysis patients.

CONCLUSIONS

Intradialytic exercise has been described to improve dialysis efficacy. There limited information about the frequency and kind of exercise that can affect serum phosphate, calcium, and potassium levels as well as hemoglobin levels in patients undergoing dialysis. Therefore, it is not possible to identify which type of exercise carries the greatest advantages for patients undergoing dialysis. We demonstrated that 15 minutes of intradialytic range-of -motion exercise could cause significant reduction in serum phosphate and potassium and a slight increase in hemoglobin level.

ACKNOWLEDGEMENTS

We would like to appreciate the deputy of Mazandaran University of Medical Sciences, who approved this research project and provided the funding, as well as the head and staff of the dialysis department of Imam Khomeini Hospital, Sari, for their cooperation in implementing the study.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. United States Renal Data System. 2004 Annual Data Report: Atlas of ESRD in the United States. Bethesda: National Institutes of Health, National Institute of Diabetes and digestive and Kidney Diseases, 2004.
2. Xue JL, Ma JZ, Louis TA, Collins AJ. Forecast of the number of patients with end-stage renal disease in the United States to the year 2010. J Am Soc Nephrol. 2001;12:2753-8.
3. Chauhan T. End-stage renal disease patients up nearly 19%. Can Med Assoc J. 2004;170:1087-9.
4. The Scottish Renal Registry. Scottish renal registry report 2011. Available from: http://www.srr.scot.nhs.uk/Publications/Main.html
5. Cheema BS, Singh MA. Exercise training in patients receiving maintenance hemodialysis: a systematic review of clinical trials. Am J Nephrol. 2005;25:352-64.
6. Rambod H. [Chronic renal failure]. Sci Dial Patient Nurs Phys. 2008;3:1-2. Persian.
7. Deligiannis A, Kouidi E, Tassoulas E, Gigis P, Tourkantonis A, Coats A. Cardiac effects of exercise rehabilitation in hemodialysis patients. Int J Cardiol. 1999;70:253-66.
8. Kouidi E, Albani M, Natsis K, et al. The effects of exercise training on muscle atrophy in haemodialysis patients. Nephrol Dial Transplant. 1998;13:685-99.
9. Obrador GT, Pereira BJ. Systemic complications of chronic kidney disease. Pinpointing clinical manifestations and best management. Postgrad Med. 2002;111:115-22; quiz 21.
10. Kawamura M, Fijimoto S, Hisanaga S, Yamamoto Y, Eto T. Incidence, outcome, and risk factors of cerebrovascular events in patients undergoing maintenance hemodialysis. Am J Kidney Dis. 1998;31:991-6.
11. Massry SG. Disorders of divalent ion metabolism. In: Eknoyan G, Knochel JP, editors. Consequences of renal failure. Orlando, FL: Grune & Stratum Inc; 1984. p. 233-63.
12. Kraut JA. Uremia. In: Gennari JF, editor. Medical management of kidney and electrolyte disorders. New York, NY: Marcel Dekker Inc; 2001. p. 39-55.
13. Harter HR, Goldberg AP. Endurance exercise training. An effective therapeutic modality for hemodialysis patients. Med Clin North Am. 1985;69:159-75.
14. Cowen TD, Huang CT, Lebow J, DeVivo MJ, Hawkins LN. Functional outcomes after inpatient rehabilitation of patients with end-stage renal disease. Arch Phys Med Rehabil. 1995;76:355-9.
15. Yurtkuran M, Alp A, Yurtkuran M, Dilek K. A modified yoga-based exercise program in hemodialysis patients: a randomized controlled study. Complement Ther Med. 2007;15:164-71.
16. Kuhlmann MK. Management of hyperphosphatemia. Hemodial Int. 2006;10:338-45.
17. Putcha N, Allon M. Management of hyperkalemia in dialysis patients. Semin Dial. 2007;20:431-9.
18. Ahmed J, Weisberg LS. Hyperkalemia in dialysis patients. Semin Dial. 2001;14:348-56.
19. Mahdavi-Mazdeh M, Zamyadi M, Norouzi S, Heidary Rouchi A. Management of calcium and phosphorus metabolism in hemodialysis patients in Tehran Province, Iran. Iran J Kidney Dis. 2007;1:25-8.
20. West RM, Harris K, Gilthorpe MS, Tolman C, Will EJ. Functional data analysis applied to a randomized controlled clinical trial in hemodialysis patients describes the variability of patient responses in the control of renal anemia. J Am Soc Nephrol. 2007;18:2371-6.
21. Asadi Noghabi A, Bassampour SH, Zolfaghari M. Critical care nursing ICU, CCU, dialysis. Salemi publication; 2th ed. 2007; p. 448-53.
22. Cappy CS, Jablonka J, Schroeder ET. The effects of exercise during hemodialysis on physical performance and nutrition assessment. J Ren Nutr. 1999;9:63-70.
23. Vaithilingam I, Polkinghorne KR, Atkins RC, Kerr PG. Time and exercise improve phosphate removal in hemodialysis patients. Am J Kidney Dis. 2004;43:85-9.
24. Borzou R, Galyaf M, Amin R. [Assessment of effect of increased blood flow on blood levels of potassium and phosphorus in hemodialysis patients]. Ardebil Univ Med Sci. 2008;8:235-40. Persian
25. Man NK, Chauveau P, Kuno T, Poignet JL, Yanai M. Phosphate removal during hemodialysis, hemodiafiltration, and hemofiltration. A reappraisal. ASAIO Trans. 1991;37:M463-5.
26. Coyne DW, Delmez J, Spence G, Windus DW. Impaired delivery of hemodialysis prescriptions: an analysis of causes and an approach to evaluation. J Am Soc Nephrol. 1997;8:1315-8.
27. Fallahi M, Shahidi SH, Farajzadegan Z. The effect of intradialytic exercise on dialysis efficacy, serum phosphate, hemoglobin and blood pressure control and comparison between two exercise programs in hemodialysis patients. Isfahan Med Sci J. 2007;26:152-61.

Correspondence to:
Raheleh Mohseni, MSc
Department of Medical-surgical Nursing, Nasibeh Nursing and Midwifery Faculty, Vesal St, Amir Mazandarani Blvd, Sari, Iran
Tel: +98 151 226 7342-5
Fax: +98 151 226 8915
E-mail: nu.mohseni@gmail.com

Received July 2011
Revised October 2011
Accepted October 2011