Exercise tolerance and fatigue response to aerobic versus resisted exercise among hemodialysis patients

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Abstract

Background: Hemodialysis (HD) patients usually suffer from exercise intolerance. However, exercise training improves their exercise tolerance and quality of life.

Objective: This study was designed to compare the effects of aerobic and resisted exercise on exercise tolerance and fatigue response in hemodialysis patients.

Methods: Fifty-six sedentary patients with CKD were recruited from the dialysis unit of the King Abdulaziz University Teaching Hospital (Jeddah, Saudi Arabia). Participants were allocated randomly into two study groups; group (A) received intradialytic aerobic exercise training on cycle ergometers. However, group (B) received intradialytic resisted exercise training for six months.

Results: There was a 30.05 % reduction in mean values of MFI total score and 32.04 % and 32.13 % increase in mean values of hand grip strength and six-minute walking test respectively in group (A). While, there was a 16.78 % reduction in mean values of MFI total score and 17.35 % and 16.20 % increase in mean values of hand grip strength and six-minute walking test respectively in group (B). In addition, the differences between both groups were significant at the end of the study.

Conclusion: Aerobic exercise alleviates fatigue and improves exercise tolerance more effective than resistance exercise among hemodialysis patients.

Keywords: Aerobic exercise; exercise tolerance; fatigue; hemodialysis; resistance exercise.

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Introduction

Chronic kidney disease (CKD) is a medical complain of millions of patients worldwide [1], with a global prevalence of around 10% with more incidence of progression to end stage renal failure associated with increased number of dialysis sessions [2-4]. Reduced level of daily activity is the usual life style of CKD patients [5], associated with skeletal muscle weakness that impairs their balance performance and physical function [6, 7].

Chronic kidney disease (CKD) deteriorates the patients physical function and exercise capacity that directly associated with higher mortality rate [8]. Physical inactivity, systemic inflammation, anemia, reduced muscle function and muscle wasting are the common causes for impaired physical function and increased risk for cardiovascular disorders among CKD patients [9, 10]. In the other hand, exercise training is an appropriate modality to prevent and ameliorate chronic disorders, however, this role in CKD is still not clear [11].

Fatigue is a common symptom affects the majority of hemodialysis patients that usually associated with poor quality of life (QOL) and higher mortality rate [12, 13]. Hemodialysis patients usually suffer from fatigue, some cardiovascular disorders and pain [14,15]. Physical deconditioning, anemia, uremia and depression are the famous factors causing fatigue among hemodialysis patients [16].

Exercise training was associated with improved muscle strength, cardiovascular fitness, exercise tolerance and QOL that reduced fatigue sensation among hemodialysis patients [17, 18]. Therefore, exercise training is so essential for CKD patients even during sessions of hemodialysis to alleviate fatigue and improve functional abilities and QOL [19]. However, studies involving comparison between impact of aerobic and resistance exercise training in HD patients is limited in number; this this study aimed to compare the effects of aerobic and resisted exercise on exercise tolerance and fatigue response in hemodialysis patients.

Patients and methods

Subjects

Fifty-six sedentary CKD patients who underwent to dialysis unit of the King Abdulaziz University Teaching Hospital, Jeddah, Saudi Arabia. The inclusion criteria included sedentary subjects, their age ranged from 29-56 year, regular HD with rate of three times / week. However, diabetes mellitus, ischemic heart disease, uncontrolled hypertension, lower limbs amputation, deep venous thrombosis, arrhythmias and acute systemic infection. The variables of tolerance to exercise and fatigue response were measured at the beginning of the study and after 6 months of intradialytic-exercise programs. Following pre-training testing, a randomized block procedure was used to assign qualified participants into two equal groups; group (A) received intradialytic aerobic exercise training on cycle ergometers. However, group (B) received intradialytic resisted exercise training for six months.

Measurements

A. Fatigue Assessment: The Multidimensional Fatigue Inventory (MFI) was used to measure degree of fatigue that composed of five subscales, the total score of MFI ranged from 4 to 20 where higher grade indicates great degree of fatigue [20].

B. Hand Grip Strength: Hand dynamometer (Jamar, Sammons Preston Rolyan, Cedarburg, WI, USA) was in assessment of grip strength. The mean value of two measurement trials that measured with elbow joint flexed at right angle without close contact with any part of their body.

C. Six Minute Walk Test (6MWT): The mean distance walked by each participant within 6 minutes in two different days was analyzed [21, 22].

Clinical evaluations and laboratory analysis were performed by independent assessors who were blinded to group assignment and not involved in the routine treatment of the patients. However, measurements of handgrip strength, six-minute walk test and MFI were taken before and after 6 months at the study.

Procedures

1. Group (A) participated in an intra-dialysis cycle ergometer aerobic exercise training on (Rehab Trainer 881E; Monark), 3times / week usually within the beginning of each dialysis for 6 months. The intensity of training was 60-70% of each individual maximal heart rate and duration of each session was 30 minutes.
2. Group (B) submitted to 30 min session of an intra-dialysis resisted exercise training using 8 different resistance machines (Nautilus Sports/Medical Industries, Independence, VA, England). The intensity of training was 60-70% of each individual one maximal repetition weight (1-RM) with three sets of 8–12 repetitions and one-minute rest in between each two sets.

Results

Table (1) shows the basic criteria of the participants, where the two groups were homogenous with no significant variations in these parameters.

Table (1): Basic criteria of the participants

Characteristic	Group (A)	Group (B)	Significance
Age (years)	43.68 ± 13.21	42.52 ± 14.32	P > 0.05
BMI (kg/m^2)	21.34 ± 4.26	19.87 ± 4.51	P > 0.05
FBS (mg/dl)	83.17 ± 6.18	81.54 ± 6.43	P > 0.05
HbA1c	6.32 ± 1.27	6.15 ± 1.19	P > 0.05
SBP (mm Hg)	136.13 ± 10.24	133.86 ± 11.21	P > 0.05
DBP (mm Hg)	84.55 ± 7.39	82.47 ± 6.12	P > 0.05
Hemoglobin	10.38 ± 1.61	10.25 ± 1.74	P > 0.05
eGFR (mL/min/1.73(m^2)	19.27 ± 4.21	18.95 ± 4.16	P > 0.05

BMI: Body Mass Index ; FBS: Fasting blood sugar ; eGFR : estimated Glomerular Filtration Rate ; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HbA1c: glycated hemoglobin.

There was a 30.05 % reduction in mean values of MFI total score and 32.04 % and 32.13 % increase in mean values of hand grip strength and six-minute walk test respectively in group (A) (table 2). While, there was a 16.78 % reduction in mean values of MFI total score and 17.35 % and 16.20 % increase in mean values of hand grip strength and six-minute walk test respectively in group (B) (table 3). In addition, there were significant differences between both groups at the end of the study (table 4).

Table 2: Mean value and significance of handgrip strength, six-minute walk test and MFI total score and fatigue symptom dimensions in group (A) before and after training

	Mean + SD		t-value	Significance
	Pre	Post		
Hand grip strength (mmHg)	138.15± 16.38	182.42 ± 21.26*	9.74	P <0.05
Six minute walk test (meter)	326.27 ± 35.19	431.12 ± 42.51*	10.27	P <0.05
MFI total score	55.34 ±11.62*	38.71 ± 9.31	8.96	P <0.05
Fatigue symptom dimensions				
General fatigue	14.26 ± 1.98*	10.22 ± 1.83	7.85	P <0.05
Physical fatigue	13.43 ± 2.46*	9.13 ± 1.74	7.64	P <0.05
Reduced activity	10.82 ± 2.31*	7.21± 2.11	6.43	P <0.05
Mental fatigue	9.61 ± 2.11*	6.58 ± 1.76	6.28	P <0.05
Reduced motivation	9.27 ± 1.94*	6.43 ± 1.62	5.97	P <0.05

MFI: Multidimensional Fatigue Inventory; (*) indicates a significant difference, P < 0.05.

Table 3: Mean value and significance of handgrip strength, six-minute walk test and MFI total score and fatigue symptom dimensions in group (B) before and after training.

	Mean + SD		t-value	Significance
	Pre	Post		
Hand grip strength (mmHg)	136.72 ± 17.14	160.45 ± 19.13	6.23	P <0.05
Six minute walk test (meter)	322.91 ± 34.26	375.23 ± 38.21	7.12	P <0.05
MFI total score	56.78 ± 11.45	47.25 ± 10.17	5.24	P <0.05
Fatigue symptom dimensions				
General fatigue	14.41 ± 1.86	11.53 ± 1.75	4.21	P <0.05
Physical fatigue	13.56 ± 2.28	10.49 ± 1.87	3.72	P <0.05
Reduced activity	10.72 ± 2.21	9.15 ± 2.16	3.63	P <0.05
Mental fatigue	10.13 ± 2.12	8.62 ± 1.85	3.47	P <0.05
Reduced motivation	9.64 ± 1.32	8.23 ± 1.27	3.42	P <0.05

MFI: Multidimensional Fatigue Inventory; (*) indicates a significant difference, P < 0.05.

Table 4: Mean value and significance of handgrip strength, six-minute walk test and MFI total score and fatigue symptom dimensions in group (A) and group (B) after training.

	Mean + SD		t-value	Significance
	Group (A)	Group (B)		
Hand grip strength (mmHg)	182.42 ± 21.26*	160.45 ± 19.13	4.21	P <0.05
Six minute walk test (meter)	431.12 ± 42.51*	375.23 ± 38.21	4.53	P <0.05
MFI total score	38.71 ± 9.31	47.25 ± 10.17	3.81	P <0.05
Fatigue symptom dimensions				
General fatigue	10.22 ± 1.83	11.53 ± 1.75	3.76	P <0.05
Physical fatigue	9.13 ± 1.74	10.49 ± 1.87	3.62	P <0.05
Reduced activity	7.21± 2.11	9.15 ± 2.16	3.48	P <0.05
Mental fatigue	6.58 ± 1.76	8.62 ± 1.85	3.41	P <0.05
Reduced motivation	6.43 ± 1.62	8.23 ± 1.27	3.39	P <0.05

MFI: Multidimensional Fatigue Inventory; (*) indicates a significant difference between the two groups, P < 0.05.

Discussion

Reduced physical functioning and muscle wasting are common among HD patients [23–26]. Many studies approved that exercise training improved exercise tolerance and quality of life of HD patients [27,28]. The differences between aerobic and resisted exercise on exercise tolerance and fatigue response in HD patients is not clear although about 8% of HD patients practice physical training at least one training session weekly [29].

Regarding fatigue symptoms, the results of our study approved that 6 months of exercise training program modulated fatigue symptoms in HD patients. Many previous trials repoted that exercise training to alleviate fatigue sensation in HD patients [30,31]. While, Maniam et al. mentioned that low to moderate intensity exercise training conducted for three months with three sessions/week resulted in reduced fatigue and improved QOL [32]. However, Yang et al., stated that low to moderate intensity exercise training conducted for six weeks resulted in reduced fatigue among Taiwanese breast cancer women receiving radiotherapy [33]. Moreover, Sangelaji et al. conducted a randomized controlled study of combined aerobic and strengthening exercise for ten weeks that resulted in improved QOL and alleviate fatigue [34].

Both intra-dialysis aerobic and resisted exercise-training sessions for six months resulted in improved exercise tolerance with greater significant changes in HD patients received aerobic exercise training. Results of our study approved with Bae et al. stated that aerobic exercise training significantly improved physical function and QOL in ten HD patients [35]. In addition, Chang et al. proved that intradialysis leg ergometry for two months alleviated fatigue and improved physical fitness among CKD patients[36]. However, Vanden Wyngaert et al. mentioned that aerobic exercise improved exercise capacity and glomerular filtration rate of CKD patients [37]. While, Esteve Simo et al. found that low intensity 3 months exercise program improved maximum quadriceps length strength, handgrip, six-minutes walking test, Beck Depressive Inventory (BDI) and Health-related quality of life questionnaire in 22 elderly patients on HD [38]. In addition, Molina-Robles et al. found that functional capacity significantly improved in 68 elderly patients on haemodialysis following 12 weeks of physical activities [39]. In the other hand, Ribeiro and colleagues reported that 8 weeks of resisted intradialytic training resulted in significant improvement in QO of 15 renal patients chronic in hemodialysis [40]. Moreover, Frih et al. stated that 4 months of combined resistance and endurance training program had a beneficial effect on QOL measured by SF-36 questionnaire and physical capacity measured by 6-min walk test, handgrip force and sit-to-stand-to-sit tests in chronic hemodialysis patients [41]. However, Uchiyama et al. reported that QOL subscales and exercise tolerance improved following 3 months of home-based aerobic exercise performed thrice weekly and resistance training twice weekly in dialysis patients [42]. Similarly, three months of aerobic and resisted exercise training improved exercise capacity in CKD patients [43].

The mechanisms of improvements on HD patients following exercise training included reduction in the number and size of lower limb muscles fibers associated with improved type II muscle fibers cross-sectional area of [44], reduced inflammatory markers [45], increased in the protein synthesis [46], increased exercised muscles blood flow [47], in addition to improved QOL and emotional status[48]. The current study encountered few limitations that included short period of follow up, absence of combined resisted and aerobic training and inability to conduct the double blind study where exercise training type is unknown for both HD patient and physical therapist. The results of current study confirmed the value aerobic and resisted exercise in HD patients

Conclusion

Aerobic exercise alleviates fatigue and improves exercise tolerance more effective than resistance exercise among hemodialysis patients.

Conflict of interest

Authors declare no conflict of interest.

References

1. Patel N, Golzy M, Nainani N, Nader ND, Carter RL, Lohr JW, Arora P. Prevalence of various comorbidities among veterans with chronic kid¬ney disease and its comparison with other datasets. *Ren Fail*. 2016; 38: 204-208.
2. Jha V, Garcia-Garcia G, Iseki K, Li Z, Naicker S, Plattner B, Saran R, Wang AY, Yang CW. Chronic kidney disease: global dimension and perspec¬tives. *Lancet*. 2013; 382:260-272.
3. Hasan M, Sutradhar I, Gupta RD, Sarker M. Prevalence of chronic kidney disease in South Asia: a systematic review. *BMC Nephrol*. 2018; 19:291.
4. Chirakarnjanakorn S, Navaneethan SD, Francis GS, Tang WH. Cardiovas¬cular impact in patients undergoing maintenance hemodialysis: clini¬cal management considerations. *Int J Cardiol*. 2017; 232:12-23.
5. Hawkins MS, Sevick MA, Richardson CR, Fried LF, Arena VC, Kriska AM. Association between physical activity and kidney function: Na¬tional Health and Nutrition Examination Survey. *Med Sci Sports Exerc*. 2011; 43:1457-1464.
6. Clyne N. Physical working capacity in uremic patients. Scand J Urol Nephrol 1996; 30:247-252.
7. Beddhu S, Wei G, Marcus RL, Chonchol M, Greene T. Light-intensity physical activities and mortality in the United States general popula¬tion and CKD subpopulation. *Clin J Am Soc Nephrol*. 2015; 10:1145-1153.
8. Roshanravan B, Robinson-Cohen C, Patel KV et al. Association between Physical performance and all-cause

mortality in CKD. *J. Am. Soc. Nephrol.* 2013; 24: 822–30 PubMed .

9. Roshanravan B, Khatri M, Robinson-Cohen C et al. A prospective study of frailty in nephrology-referred patients with CKD. *Am. J. Kidney Dis.* 2012; 60: 912–21 PubMed .

10. Kosmadakis GC, Bevington A, Smith AC et al. Physical exercise in patients with severe kidney disease. *Nephron Clin. Pract.* 2010; 115: c7–c16.

11. Smith AC, Burton JO. Exercise in kidney disease and diabetes: Time for action. *J. Ren. Care.* 2012; 38 (Suppl 1): 52–8.

12. Jhamb M, Liang K, Yabes J, et al. Prevalence and correlates of fatigue in chronic kidney disease and end-stage renal disease: are sleep disorders a key to understanding fatigue? *Am J Nephrol.* 2013; 38(6):489-495.

13. Picariello F, Moss-Morris R, Macdougall IC, Chilcot J. 'It's when you're not doing too much you feel tired': a qualitative exploration of fatigue in end-stage kidney disease. *Br J Health Psychol.* 2018; 23(2):311-333.

14. Evangelidis N, Tong A, Manns B, et al. Developing a set of core outcomes for trials in hemodialysis: an international Delphi survey. *Am J Kidney Dis.* 2017; 70(4):464-475.

15. Ju A, Unruh M, Davison S, et al. Establishing a core outcome measure for fatigue in patients on hemodialysis: a Standardized Outcomes in Nephrology - Hemodialysis (SONG-HD) Consensus Workshop report. *Am J Kidney Dis.* 2018; 72(1): 104-112.

16. Chilcot J, Moss-Morris R, Artom M, et al. Psychosocial and clinical correlates of fatigue in haemodialysis patients: the importance of patients' illness cognitions and behaviours. *Int J Behav Med.* 2016; 23(3):271-281.

17. Painter, P.L., Carlson, L., Carey, M.S., Paul, S.M., Myll, J., 2000. Physical functioning and health-related quality-of-life changes with exercise training in hemodialysis patients. *American Journal of Kidney Diseases.* 35 (3), 482–492.

18. Suh, M.R., Jung, H.H., Kim, S.B., Park, J.S., Yang, W.S., 2002. Effects of regular exercise on anxiety, depression, and quality of life in maintenance hemodialysis patients. *Renal Failure.* 24 (3), 337–345.

19. Takreem, M., 2008. The effectiveness of intradialytic exercise prescription on quality of life in patients with chronic kidney disease. *Medscape Journal of Medicine* 10 (10), 226–251.

20. Smets, E.M.A., Garssen, B., Bonke, B., Haes de, J.C.J.M., 1995. The Multidimensional Fatigue Inventory (MFI); psychometric qualities of an instrument to assess fatigue. *J. Psychosom. Res* 39, 315–325.

21. Turner S, Eastwood P, Cecins M, Hillman D, Jenkins C. (2004). Physiologic responses to incremental and self-paced exercise in COPD: A comparison of three tests. *Chest*, 126, 766−773.

22. Blain H, Jaussent A, Béziat S, et al. (2012). Low serum IL-6 is associated with high 6-minute walking performance in asymptomatic women aged 20 to 70 years. *Exp Gerontol*, 47,143-148.

23. Fahal, I. H. Uraemic sarcopenia: aetiology and implications. *Nephrol. Dial. Transplant.* 9, 1655–1665 (2014).

24. Pereira, R. A. et al. Sarcopenia in chronic kidney disease on conservative therapy: prevalence and association with mortality. *Nephrol. Dial. Transplant.* 30, 1718–1725 (2015).

25. Tentori, F. et al. Physical exercise among participants in the Dialysis Outcomes and Practice Patterns Study (DOPPS): correlates and associated outcomes. *Nephrol. Dial. Transplant.* 25, 3050–3062 (2010).

26. Carrero JJ, Chmielewski M, Axelsson J, et al.: Muscle atrophy, inflammation and clinical outcome in incident and prevalent dialysis patients. *Clin Nutr*, 2008, 27: 557–564.

27. Greenwood, S. A. et al. Effect of exercise training on estimated GFR, vascular health, and cardiorespiratory fitness in patients with CKD: a pilot randomized controlled trial. *Am. J. Kidney Dis.* 65, 425–434 (2015).

28. Manfredini, F. et al. Exercise in patients on dialysis: A multicenter randomized clinical trial. *J. Am. Soc. Nephrol.* 28, 1259–1268 (2017).

29. Wang XH, Mitch WE: Mechanisms of muscle wasting in chronic kidney disease. *Nat Rev Nephrol*, 2014, 10: 504–516

30. Song YY, Hu RJ, Diao YS, Chen L, Jiang XL. Effects of exercise training on restless legs syndrome, depression, sleep quality, and fatigue among hemodialysis patients: a systematic review and meta-analysis. *J Pain Symptom Manage.* 2018; 55(4): 1184-1195.

31. Sheshadri A, Kittiskulnam P, Johansen KL. Higher physical activity is associated with less fatigue and insomnia among patients on hemodialysis. *Kidney Int Rep.* 2018; 4(2):285-292.

32. Maniam R, Subramanian P, Singh SK, Lim SK, Chinna K, Rosli R. Preliminary study of an exercise programme for reducing fatigue and improving sleep among long-term haemodialysis patients. *Singapore Med J.* 2014; 55(9):476-82.

33. Yang TY, Chen ML, Li CC. Effects of an aerobic exercise programme on fatigue for patients with breast cancer undergoing radiotherapy. *J Clin Nurs*. 2015; 24(1-2):202-11.
34. Sangelaji B, Nabavi SM, Estebsari F, Banshi MR, Rashidian H, Jamshidi E, Dastoorpour M. Effect of combination exercise therapy on walking distance, postural balance, fatigue and quality of life in multiple sclerosis patients: a clinical trial study. *Iran Red Crescent Med J*. 2014; 16(6): e17173.
35. Bae YH, Lee SM, Jo JI. Aerobic training during hemodialysis improves body composition, muscle function, physical performance, and quality of life in chronic kidney disease patients. *J Phys Ther Sci*. 2015 May; 27(5):1445-9.
36. Chang Y, Cheng SY, Lin M, Gau FY, Chao YF. The effectiveness of intradialytic leg ergometry exercise for improving sedentary life style and fatigue among patients with chronic kidney disease: a randomized clinical trial. *Int J Nurs Stud*. 2010 Nov; 47(11):1383-8.
37. Vanden Wyngaert K, Van Craenenbroeck AH, Van Biesen W, Dhondt A, Tanghe A, Van Ginckel A, Celie B, Calders P. The effects of aerobic exercise on eGFR, blood pressure and VO2peak in patients with chronic kidney disease stages 3-4: A systematic review and meta-analysis. *PLoS One*. 2018 Sep 11; 13(9):e0203662.
38. Esteve Simo V, Junqué Jiménez A, Moreno Guzmán F, Carneiro Oliveira J, Fulquet Nicolas M, Pou Potau M, Saurina Sole A, Duarte Gallego V, Tapia Gonzalez I, Ramirez de Arellano M. Benefits of a low intensity exercise programme during haemodialysis sessions in elderly patients. *Nefrologia*. 2015; 35(4):385-94.
39. Molina-Robles E, Colomer-Codinachs M, Roquet-Bohils M, Chirveches-Pérez E, Ortiz-Jurado P, Subirana-Casacuberta M. Effectiveness of an educational intervention and physical exercise on the functional capacity of patients on haemodialysis. *Enferm Clin*. 2018 May - Jun; 28(3):162-170.
40. Ribeiro R, Coutinho GL, Iuras A, Barbosa AM, Souza JA, Diniz DP, Schor N. Effect of resistance exercise intradialytic in renal patients chronic in hemodialysis. *J Bras Nefrol*. 2013 Jan-Mar; 35(1):13-9.
41. Frih B, Jaafar H, Mkacher W, Ben Salah Z, Hammami M, Frih A. The Effect of Interdialytic Combined Resistance and Aerobic Exercise Training on Health Related Outcomes in Chronic Hemodialysis Patients: The Tunisian Randomized Controlled Study. *Front Physiol*. 2017 May 31; 8:288.
42. Uchiyama K, Washida N, Morimoto K, Muraoka K, Kasai T, Yamaki K, Miyashita K, Wakino S, Itoh H. Home-based Aerobic Exercise and Resistance Training in Peritoneal Dialysis Patients: A Randomized Controlled Trial. *Sci Rep*. 2019 Feb 22; 9(1):2632.
43. Rossi AP, Burris DD, Lucas FL, Crocker GA, Wasserman JC. Effects of a renal rehabilitation exercise program in patients with CKD: a randomized, controlled trial. *Clin J Am Soc Nephrol*. 2014; 9:2052-2058.
44. Kouidi E, Albani M, Natsis K, Megalopoulos A, Gigis P, Guiba-Tziampiri O, Tourkantonis A, Deligiannis A. The effects of exercise training on muscle atrophy in haemodialysis patients. *Nephrol Dial Transplant*. 1998; 13:685-699.
45. Moraes C, Marinho SM, da Nobrega AC, de Oliveira Bessa B, Jacobson LV, Stockler-Pinto MB, da Silva WS, Mafra D. Resistance exercise: a strategy to attenuate inflammation and protein-energy wasting in hemodialysis patients? *Int Urol Nephrol*. 2014; 46:1655-1662.
46. Rennie MJ, Wackerhage H, Spangenburg EE, Booth FW. Control of the size of the human muscle mass. *Annu Rev Physiol* 2004; 66:799-828.
47. Mohseni R, Emami Zeydi A, Ilali E, Adib-Hajbaghery M, Makhlough A. The effect of intradialytic aerobic exercise on dialysis efficacy in hemodialysis patients: a randomized controlled trial. *Oman Med J* 2013; 28: 345-349.
48. Tomich GM, Bernardino LS, Ferreira FO. Impact of physical therapy on functional capacity and life quality of patients with chronic kidney disease. *Fisioter Mov* 2014; 27:643-651.