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Effects of Endurance Training on Serum Blood Electrolytes in End Stage Renal Failure Children.

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ABSTRACT

Purpose: This study was conducted to evaluate the effect of endurance training on functional performance and its correlation to serum electrolytes in children at end-stage renal failure.**Subjects and Methods:** Thirty Patients with age ranged from 10 to 15 years, who underwent hemodialysis for at least six months participated in this study. They were assigned into two groups of equal numbers to represent a control and study groups. The both groups received their ordinary hemodialysis regimen, while the study group received an additional endurance-training program for twelve weeks. Serum blood electrolytes and the distance walked in six-minutes were assessed at two intervals (pre- treatment and 12-week post-treatment). **Results***:* The results showed that there was a significant increase in the distance walked in six minutes in favor to the study group after the expected treatment duration and there was a positive correlation between the distance walked in the six-minute walk test and serum hemoglobin level and negative correlation to calcium level. Serum sodium, phosphorus and Potassium levels did not change significantly. **Conclusion:** A simplified aerobic exercise program is a complementary and effective clinical treatment modality in patients in end-stage renal failure

Keywords: End stage renal failure; Aerobic exercise; 6-minute walking test; Blood electrolytes.

INTRODUCTION

END-STAGE RENAL DISEASE (ESRD) is the point in kidney failure when approximately 90% of renal function has been lost, rendering the body incapable of maintaining proper fluid and electrolyte balance, adequate waste removal, and normal hormonal function [35]. Chronic kidney disease (CKD) has become a serious health problem due to its prevalence, high cost, and the subsequent reduction in life expectancy and quality of life. Cardiovascular disease is the main cause of death in ESRD patients [5].

Patients in ESRD show high rates of hospital admissions and mortality [29]. Cardiac complications cause over 50% of deaths and induce low tolerance to exercise, which consequently compromises the performance of daily activities [28]. For patients at this stage, it is important to practice physical exercise (aerobic or anaerobic) because it reduces the deleterious effects of this condition [16]. Alterations in patient’s condition as complain of pain, fatigue, and muscle weakness in the spine, hips, knees, and lower extremities may be caused by electrolyte imbalance and other factors. The pain worsens with weight-bearing activities and fractures in the vertebrae and long bones are common [23].

Patients at 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 [18, 27]. They have an increased incidence of diabetes mellitus, anemia, peripheral vascular disease, hypertension, coronary artery disease, and stroke [15, 7].

Despite advanced technology and regular and efficient dialysis treatment Hypophosphatemia is a well-recognized risk factor for cardiovascular mortality in dialysis patients and its prevalence is still high [19]. Hyperkalemia is also common in patients with ESRD, and may result in serious electrocardiographic abnormalities [31], and accounts for considerable morbidity and death [1]. Chronic kidney disease is accompanied by profound disturbances in calcium [21].

SUBJECTS AND PROCEDURES

Thirty children (17 boys and 13 girls) at ESRD receiving hemodialysis at the nephrology department of Pediatric Hospital - Cairo University, participated in this study. They were selected according to certain inclusion criteria as their age ranged from 10 to 15 years, all of them were medically stable and controlled by nephrologist and receiving hemodialysis three times per week and all of them were able to perform their daily living activities independently. Patients with hemodynamic instability, chronic obstructive pulmonary disease, congestive heart failure and diabetes preceding two years were excluded from the current study.

Children were assigned into two groups of equal number to represent control and study groups according to the zone in which they receive dialysis at the hospital, patients in zone (A) represented control group while patients in zone (B) represented the study group. Each child in both groups subjected to laboratory analysis before and after twelve weeks of treatment for detection of the levels of hemoglobin, Serum urea and creatinine, serum electrolytes including sodium, potassium, calcium and phosphorus levels.

Evaluation of functional capacity was detected by six minutes walking test (6MWT). The 6MWT is a practical simple test that requires a 100-feet hallway. This test measures the distance that a patient can walk on a flat, hard surface in a period of 6 minutes. Each individual is allowed to self-pace and rest as needed as they traverse back and forth along a marked walkway.

Patients in control group received their ordinary hemodialysis regimen three times per week while children in the study group received an additional exercise program including 12 weeks duration in which subjects exercised, under the supervision of their physiotherapist, 3 times a week corresponding with their three times weekly dialysis schedule. The prescribed exercise duration was 30 minutes, performed as two 15-minute exercise with a 15-minute recovery period after 1 hour of their dialysis session. Exercise was performed using electronic treadmill, which allowed resistance application. Before starting exercise application, blood pressure and heart rate were recorded at rest and then patients selected their own exercise intensity (pace, load) in which they could comfortably complete 15 minutes of exercise. Regardless of the self-selected exercise intensity, heart rate was allowed to increase on average 20 beats per minute for all subjects.

Patients were taught to stop the movement and notify the therapist 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. Reevaluation of blood electrolytes and 6MWT distance were done after twelve weeks of treatment application by the same therapist to ensure accuracy of the data. The study was limited by the psychological condition of the children after long duration dialysis session.

Statistical analysis: Results are expressed as mean ± standard deviation (SD) or number (%). Comparison between the mean values of different variables measured post-treatment in the two groups was performed using unpaired student *t* test. Correlation between 6 minutes walking and different variables was performed using Pearson correlation test. Statistical Package for the Social Sciences SPSS was used for data analysis. P value less or equal to 0.05 was considered significant

RESULTS

Basic demographic data as well as the clinical characteristics of the participants are presented in Table 1. There were no significant differences between the two groups regarding age, gender and weight as age mean values were 12.60 ± 1.64 for the control group while for the study group it was 12.47 ± 1.60 years with P=0.823. Regarding gender, the percentage of boys and girls for both control and study groups were (67%, 33%) and (53%, 47%) respectively with P= 0.458. concerning weight mean values they were 41.67 ±2.69 and 41.13 ±2.670 with P=0.590. A significant difference was recorded in patients' height as mean values of children' height were116.60 ±10.60 and 132.73 ±6.65 with P=0.001

Table 1. Demographic and Clinical Characteristics of Hemodialysis Patients in both control and study groups:

	Control	**Study**	**P value**
Age (years)	12.60 ± 1.64	12.47 ± 1.60	0.823 (NS)
Gender (B/G)	10/5 (67%/33%)	8/7 (53%/47%)	0.456 (NS)
Weight (Kg.)	41.67 ± 2.69	41.13 ± 2.67	0.590 (NS)
Height (cm)	116.60 ± 10.60	132.73 ± 6.65	0.001 (S)

NS: Not significant S: Significant B: boys G: Girls

Comparison of pre-treatment results between control and study groups 6MWT distance and serum blood were statistically insignificant (P>0.05). Post treatment results revealed a statistical significant difference in hemoglobin with mean values between both control and study groups were 11.50 ± 0.81 and 12.11 ± 0.29 with P=0.074. Serum blood calcium level mean values were 8.27 ± 0.90 and 7.27 ± 1.09 and P=0.011. Regarding distance walked in 6MWT mean values for both control and study groups were 1424.0 ± 185.5 and 1650.67 ± 158.41 respectively and p=0.031) as shown in table(2).

Table 2. Comparison between control and study groups Blood Parameters and 6MWT distance in Hemodialysis Patients

Variable	**Control**	**Study**	**P value**
Hemoglobin mg/l			

Pre	11.51±0.77	11.35±0.60	0.32 (NS)
Post	11.50 ± 0.81	12.11 ± 0.29	0.074 (S)
Urea mg/l			
Pre	62.35 ±9.19	60.6 ±9.6	0.64 (NS)
Post	59.73 ± 8.31	58.53 ± 8.76	0.703 (NS)
Creatinine mg/l			
Pre	4.44 ±0.81	4.17 ±0.62	0.53 (NS)
Post	3.95 ± 0.70	3.73 ± 0.68	0.404 (NS)
Sodium mg/l			
Pre	130.93 ±3.88	132.13 ±4.98	0.14 (NS)
Post	127.27 ± 4.46	127.40 ± 6.51	0.948 (NS)
Potassium mg/l			
Pre	7.31 ±1.02	7.27 ±0.96	0.329 (NS)
post	6.48 ± 0.98	6.19 ± 0.8	0.399 (NS)
Calcium mg/l			
Pre	7.75 ±1.16	7.36 ±0.98	0.57 (NS)
Post	8.27 ± 0.90	7.27 ± 1.09	0.011(S)
Phosphorus mg/l			
Pre	3.77 ± 0.47	3.99 ± 0.52	0.249 (NS)
Post	3.08 ± 2.07	3.45 ± 0.65	0.132 (NS)
6 minutes walking Cm			
Pre	1405.76 ± 138.5	1424.0 ± ±185.5	0.140 (NS)
Post	1454.0 ± 171.5	1650.67 ± 158.41	0.031 (S)

Data are expressed as mean ± SD.NS= Not significant. S: significant

The correlation between hemoglobin level and six minute walking test in the study group after treatment is illustrated in figure (1) while Correlation between 6 minutes walking and calcium level is illustrated in figure (2).

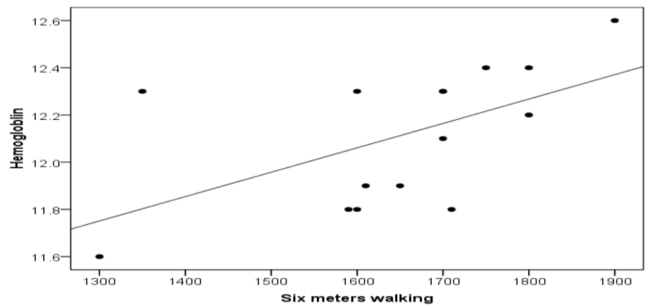

Fig 1. Correlation between 6 minutes walking and hemoglobin in the study group (r= 0.560; p= 0.03*).

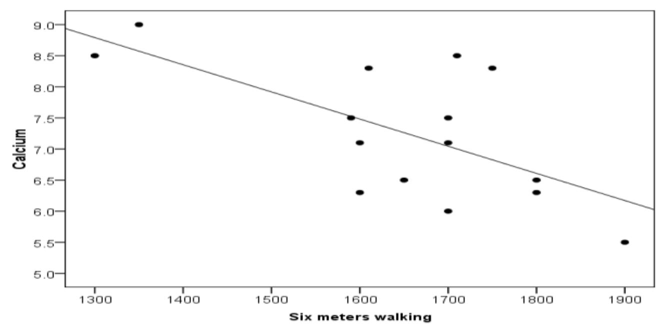

Fig. 2. Correlation between 6 minutes walking and calcium in the study group (r= -0.645; p= 0.009**).

DISCUSSION

Despite the deteriorating level of patient's conditions in ESRD, they are extremely inactive [12] and nephrologists rarely assess patients' physical activity levels or counsel patients to increase activity [13]. Patients in ESRD may have, Low exercise capacity [28, 2, 3, 25], muscle wasting [26, 34 14], and poor physical performance and function [24, 17]. These problems are associated with development of disability, loss of independence, and death. Lack of exercise assessment and counseling is almost certainly multi-factorial, related to such factors as long dialysis duration that lead to limited time available for exercise counseling, lack of training in exercise prescription, and fear of adverse events related to exercise in this population [9, 11].

Choosing 6MWT as a measuring tool in the current study may better reflect the functional exercise level for daily physical activities as it assesses the submaximal level of functional capacity. Most patients do not achieve maximal exercise capacity during the 6MWT; instead, they choose their own intensity of exercise and are allowed to stop and rest during the test this is because most activities of daily living are performed at sub- maximal levels of exertion [4].

The data presented in the current study suggest that an aerobic exercise regimen for 15 minutes after hemodialysis sessions improved hemoglobin level and the distance walked in 6MWT in a period of 12 weeks. This observation might be due to direct or general beneficial effects of aerobic exercise. It was hypothesized that with exercise, the increase in muscle blood flow and open capillary surface area would increase the flux of electrolytes from the tissue and resulting in increases in serum urea clearance and hence improvement in quality of life of ESRD patients by improvement of mental and physical function and even through its contribution to maintaining electrolyte balance [8, 20].

Also improvement in the current study may be explained as physical work capacity is generally reduced in hemodialysispatient, it was hypothesized that the increased muscle activity through aerobic exercise would improve muscle condition and minimize the effect of the increased toxic substances (urea and creatinine) on various physiologic systems, thereby enhancing cardiovascular and skeletal muscle performance and increase in distance walked on the 6MWT [22].

The improvement of the study group may be explained as dialysis is usually carried out in the resting semi-recumbent position in which the circulation is relatively stagnant, particularly in the leg muscles. This could contribute to the delay in the equilibration of urea during dialysis. If significant quantities of urea are retained in the leg muscle during dialysis, then exercising the legs should reduce the post-dialysis urea rebound [33].

Skeletal muscle mass constitutes 40–45% of the total body weight, although it may be less in patients with end-stage renal failure [33]. Since the water content of muscles is relatively high, most of the body water is within the muscles. For solutes such as urea and creatinine, which are distributed in the body water, more than half of the total mass of these solutes will be held within the muscles. In order to be removed by dialysis, these solutes must transfer from the intracellular water, across the cell membranes, and into the fistula via the venous system and systemic circulation. At rest, most of the capillaries in the muscles are collapsed resulting in some of the regions of the skeletal mass being by-passed by dialysis. However, during exercise blood flow can rise from 3–4 ml/min per 100 g to 80 ml/min per 100 g, depending on the intensity, by opening up the capillary bed in the muscles. This increase in perfusion increases the area of exchange between the intravascular and intracellular compartments. This is the most likely explanation for the observed results [16].

The mechanisms governing potassium removal during dialysis are less clear. Potassium is predominantly intracellular and the most significant barrier to inter compartment transfer is the cell membrane. Trans membrane potassium efflux is controlled by Na-K-ATPase activity, which may be defective in uremia [6]. During exercise the plasma concentration of potassium increases due to efflux from the contracting muscles [10]. Exercise-induced potassium flux out of cells will increase the efficiency of potassium removal during dialysis. Plasma potassium levels do not reflect whole-body concentrations even in equilibrium, so it is impossible to quantify potassium removal using blood side measurements.

CONCLUSION

Endurance training is an effective clinical treatment modality in patients in end-stage renal disease by decreasing serum calcium and increasing hemoglobin levels that led to increase in their functional abilities.

REFRENCES

[1] Ahmed J. Weisberg L. Hyperkalemia in dialysis patients. Semin Dial. 2001; 14:348-56.

[2] Barnea H. Drory Y. Iaina A. et al., Exercise tolerance in patients on chronic hemodialysis. Isr J Med Sci1980;16: 17–21.

[3] Beasley C. Smith D. Neale T: Exercise capacity in chronic renal failure patients managed by continuous ambulatory peritoneal dialysis. Aust N Z J 1986; Med 16: 5–10.

[4] Brodin E, Ljungman S, Hedberg M, Sunnerhagen K: Physical activity, muscle performance, and quality of life in patients treated with chronic peritoneal dialysis. Scand J UrolNephrol2001; 35: 71–78.

[5] Brosnahan G. Fraer M. Chronic kidney disease: whom to screen and how to treat, part 1: definition, epidemiology, and laboratory testing. South Med J. 2010;103(2):140–6.[PubMed]

[6] Cotton J. Resting skeletal muscle membrane potential as an index of uremic toxicity. J Clin Invest 1979; 63: 501–506

[7] Deligiannis A. Kouidi E. Tassoulas E. et al., Cardiac effects of exercise rehabilitation in hemodialysis patients. Int J Cardiol. 1999; 70:253-66.

[8] functional health status predicts continued survival, hospitalization, and dialysis-attendance compliance. Am J Kidney Dis 1997; 30: 204–212.

[9] 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.

[10] Hnik P. Holas M. Krekule I; et al. Work-induced potassium changes in skeletal muscle and effluent venous blood assessed by liquid ion-exchanger microelectrodes. PflugersArchiv1976; 362: 85–94

[11] Johansen K, Chertow G, Silva M.: Determinants of physical performance in ambulatory patients on hemodialysis. Kidney Int2001;60: 1586–1591.

[12] Johansen K. Chertow G. Mulligan K. et al, Physical activity levels in patients on hemodialysis and healthy sedentary controls. Kidney Int 2000; 57: 2564–2570.

[13] Johansen K. Sakkas G. Doyle J. Exercise counseling practices among nephrologists caring for patients on dialysis. Am J Kidney Dis 2003;41: 171–178.

[14] Johansen K. Shubert T. Doyle J. et al., Muscle atrophy in patients receiving hemodialysis: Effects on muscle strength,

muscle quality, and physical function. Kidney Int 2003; 63: 201–207.

[15] Kawamura M. Fijimoto S. Hisanaga S. et al., Incidence, outcome, and risk factors of cerebrovascularevents in patients undergoing maintenance hemodialysis. Am J Kidney Dis. 1998; 31:991-6.

[16] Kong C. Tattersall J. Greenwood R. et al; The effect of exercise during haemodialysis on solute removal. Nephrol Dial Transplant. 1999;14(12):2927–31.[PubMed

[17] Kouidi E, Albani M, Natsis K. The effects of exercise training on muscle atrophy in haemodialysis patients Nephrol Dial Transplant (1998) 13: 685–6992003;63: 201–207.

[18] 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.

[19] Kuhlmann M. Management of hyperphosphatemia. Hemodial Int. 2006;10:338-45.

[20] Medical outcomes study short form-36: A consistent and powerful predictor of mortality in dialysis patients. Am J Kidney Dis 2003, 41: 1286–1292, 2003

[21] Mahdavi-Mazdeh M. Zamyadi M. Norouzi S. et al., Management of calcium and phosphorus metabolism in hemodialysis patients in Tehran Province, Iran. Iran J Kidney Dis. 2007; 1:25-8.

[22] Mapes D, Lopes A, Satayathum S. et al; Health-related quality of life as a predictor of mortality and hospitalization: The Dialysis Outcomes and Practice Patterns Study (DOPPS). Kidney Int 2003; 64: 339–349.

[23] Massry S. Disorders of divalent ion metabolism. In: Eknoyan G, Knochel J, editors. Consequences of renal failure. Orlando, F: Grune& Stratum Inc; 1984. p. 233-63.

[24] McIntyre C. Selby N. Sigrist M. et al: Patients receiving maintenance dialysis have more severe functionally significant skeletal muscle wasting than patients with dialysis-independent chronic kidney disease. Nephrol Dial Transplant 2006; 21: 2210–2216.

[25] Moore G. Brinker K. Stray-Gundersen J, et al.,: Determinants of VO2 peak in patients with end-stage renal J Am SocNephrol 2007; 18: 1845–1854, Exercise in the ESRD Population 1851 disease: On and off dialysis. Med Sci Sports Exerc1993;25: 18–23.

[26] Moore G. Parsons D. Stray-Gundersen J. et al.; Uremic myopathy limits aerobic capacity in hemodialysis patients. Am J Kidney Dis 1993; 22: 277–287.

[27] Obrador G. Pereira B. Systemic complications of chronic kidney disease. Pinpointing clinical manifestations and best management. Postgrad Med. 2002; 111:115-22; quiz 21.

[28] Painter P. Messer-Rehak D. Hanson P. et al; Exercise capacity in hemodialysis, CAPD, and renal transplant patients. Nephron 1986; 42: 47–51.

[29] Painter P. Moore G. Carlson L., et al. Effects of exercise training plus normalization of hematocrit on exercise capacity and health-related quality of life. Am J Kidney Dis. 2002;39(2):257–65.[PubMed]

[30] Painter P. Physical functioning in end-stage renal disease patients: update 2005. Hemodial Int. 2005;9(3):218–35.[PubMed]

[31] Putcha N. Allon M. Management of hyperkalemia in dialysis patients. Semin Dial. 2007;20:431-9.

[32] Savazzi G. Cambi V. Marbibi A. et al; The influence of uraemic neuropathy on muscle EMG, histoenzymatic and ultrastuctural correlations. Proc EDTA 1980, 17: 312–317

[33] Unruh M. Benz R. Greene T, et al; Study: Effects of hemodialysis dose and membrane flux on health related quality of life in the HEMO Study. Kidney Int 2004; 66: 355–366.

[34] Violan M. Pomes T. Maldonado S. et al., Exercise capacity in hemodialysis and renal transplant patients. Transplant Proc2002; 34: 417–418.

[35] Zawada E. Initiation of dialysis. In: Daugirdas J, Blake P, Ing T, editors. Handbook of dialysis. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2001. p 3-11.

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