

Evaluation of exercise training on work capacity, functional mobility, and quality of life in hemodialysis patients

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Introduction

Patients with chronic renal failure are restricted in their physical and social aspects of life because of their treatment and comorbid medical conditions.

Aim of the work

The aim of this study was to evaluate the effect of an exercise training program on functional work capacity, functional mobility, and quality of life (QOL) in patients with renal failure on hemodialysis.

Patients and methods

Thirty patients with chronic renal failure on maintenance hemodialysis participated in a regular exercise training program three times/week for 12 weeks. Each exercise session consisted of a warm up, cycle or trade mill exercises, stretching exercise, and cool down. All patients were subjected to a cardiovascular graded exercise tolerance test, the sit-to-stand-to sit test, and the 6-min walk test. A questionnaire was used to assess the QOL of the study group 1 week before and after the exercise training program. Fifteen normal individuals, age and sex matched with our patients, were used as controls to compare the respiratory function.

Results

There was a significant improvement in work capacity before and after the training exercise program, respectively (7.24 ± 0.90 to 9.62 ± 1.1 ; $P < 0.001$); also, there was a highly significant improvement in functional mobility. The QOL had improved after the exercise training program on four of five scales of the 36 questionnaire.

Conclusion

A suitable exercise training program is essential for improvement of work capacity and mobility, and improvement of psychological status and QOL.

Keywords:

exercise, hemodialysis, quality of life, work capacity

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Introduction

Patients with chronic renal failure (CRF) are restricted in the physical, emotional, and social aspects of their life because of their treatment and their comorbid medical conditions. This reduction in the physical functioning of patients with end-stage renal failure increases both morbidity and mortality. In addition, this situation reduces the patient's quality of life (QOL) [1].

Hemodialysis (HD), as a therapy for CRF, replaces the main functions of the kidney, although it cannot completely replace the entire organ function. As a result, impairment in multiple organ systems is common, among which the cardiovascular and musculoskeletal systems stand out. Psychosocial impairments (anxiety, depression, and poor QOL) are also common. All this limits patients' functional capabilities [2].

Aerobic work capacity tests measure the maximum amount of work that can be performed when there is enough oxygen to supply the muscles. Whole-body aerobic capacity tests use cardiac and cardiopulmonary

graded exercise tolerance testing. Exercise tolerance testing is mainly used to determine the functional work capacity, which in turn can be used to determine disability as well as guide the cardiac and/or pulmonary rehabilitation (e.g. to determine the intensity of the prescribed exercise or activity) [3].

Studies in the field of renal rehabilitation support the fact that exercise training in HD patients can ameliorate many of the morphological and functional disorders that accompany end-stage renal disease (ESRD) as well as enhance physical activity, physical fitness, and health-related QOL. The American College of Sports Medicine (ACSM) recommended that exercise should be designed to combine endurance and muscle strength exercise to decrease muscle weakness in HD patients [4].

Aim of the work

The aim of this study is to evaluate the effect of an exercise training program on the functional work

capacity, functional mobility, and QOL in patients with renal failure on HD.

Patients and methods

This study was a randomized clinical trial carried out at the Department of Rheumatology & Rehabilitation in Zagazig University Hospitals on 30 patients with ESRD who were diagnosed according to the reports available at dialysis centers and had been on maintenance HD for 2.57 ± 1.38 years. All of the patients fulfilled the following inclusion criteria: patients were on dialysis three times/week for at least 1 year before the study, could walk unaided, were older than 18 years old, had hemoglobin levels of at least 10 g/dl, and had no history of use of antidepressant drugs or other psychotropic agents.

A group of fifteen healthy normal subjects, matched in age, sex and height with our patients, served as a control group to compare the respiratory functions. Informed consents were obtained from all patients and controls. This study was approved by Zagazig Medical Ethical Committee.

Some diseases, which are considered absolute or relative contraindications for exercise testing in ESRD patients or that lead to severe limitation in walking or inability to walk, were excluded such as.

Lower-extremity amputation

Mechanical disorders associated with pain (such as lumbar disk, osteoarthritis, or lumbar spondylosis).

Uncontrolled diabetes mellitus or uncontrolled hypertension

Cerebral vascular disease caused by transient ischemic attacks and angina pain at rest or on exertion.

Chronic lung diseases that result in significant oxygen desaturations with exercise or pulmonary congestion.

Acute infections and suspected or known aneurysm *Hyperkalemia or hypokalemia*

All patients were subjected to the following:

- (1) Thorough assessment of medical history.
- (2) Complete clinical examination.
- (3) Investigations such as
 - (a) Fasting and postprandial blood sugar.
 - (b) Complete blood picture.
 - (c) Serum urea and creatinine before and after exercise.
 - (d) Pulmonary function test.

Assessment of functional work capacity

The functional work capacity was determined by the measurement of metabolic equivalent (MET) during the exercise test [3]. Functional work capacity was measured before starting the exercise training program and after its completion using the cardiovascular graded exercise tolerance test [3].

All patients were subjected to the cardiovascular graded exercise tolerance test (i.e. ECG exercise test) on a nondialysis day (i.e. a day free from dialysis) to determine functional work capacity and to assess the safety of exercise training.

Training protocol

All patients had been participating in a regular exercise training program three times/week for 12 weeks. Each exercise session consisted of a warm up for 5 min, cycle or treadmill exercise for 15 min, stretching exercises for large muscle groups of the lower limbs for 5 min, and cool down for 10 min. The target exercise intensity was set at 40–60% of the peak heart rate, as determined in the baseline treadmill exercise stress test [1].

Exercise intensity was monitored throughout the sessions using heart rate, blood pressure, and ratings of perceived exertion responses (Brog's rate of perceived exertion scale method) [5].

Description of outcome measures

Each patient was subjected to a maximal exercise test 1 week before beginning and 1 week after completing the training program to determine the intensity of the exercise training program and to assess the functional work capacity before and after the training program. The entire exercise testing was performed using the treadmill ECG exercise stress test. An A.H. Robins Company treadmill ECG (Quinton 3000) device was used.

The test used continuous incremental workloads, which begin at a low work load and progress to higher workloads until either subjective or objective (maximal) end-points preclude further exercise. The incremental work lasted for a reasonable period of time (i.e. a minimum of 8 min and a maximum of 18 min).

Physical function tests

The two following established performance-based physical function tests were used to assess changes in measured physical functioning and functional mobility. These tests were performed before starting the exercise training program and soon after it was completed, which are.

The sit-to-stand-to-sit test [6]

This was used to assess lower-extremity muscle strength. It is especially indicative of quadriceps strength and is used as a measure of functional mobility, balance, and lower limb strength. Patients were asked to rise from a chair of almost standard height (43 cm) without armrests and with a backrest and adjusted in depth 10 times as fast as possible. The height and depth of the chair were adjusted such that the knee angle in the sitting position was 90°. The subject starts sitting down, with their arms crossed over the chest or put in the waist. The time was recorded by using stopwatch.

The 6-min walk test [7]

The patient was asked to wear comfortable clothes, low-heeled walking footwear, eyeglasses, and hearing aids (if any were used). (FEV₁/FVC) ratio in the study group and the control group was (80.93%), indicating mild restrictive pattern of pulmonary functions allowed, because even if we walk behind them, this will alter their pace. Patients were allowed to use the bathroom before starting the test.

We did not use a treadmill or bike on which the patient adjusts the speed and/or the slope. We did not use an oval or a circular track. Before the test, we ensured that the pulse rate, blood pressure, and breathing rate of the patients were within the normal range. We used standardized phrases when speaking to the patient such as 'keep going' and 'you are doing well' every 30 s because the extent of encouragement and support provided can make a difference of up to 30% in the 6-m walking distance. Every 2 min, we provided the patient with a time check. The test was performed before beginning the exercise training program to determine the baseline and after its completion to show improvement in the physical function of our patients. The patient was instructed 'to cover as much distance as possible in 6 min' on an established walking course. We used a stopwatch to estimate 6 min. We started by saying '1, 2, 3, GO'. The result was reported as the distance covered in meters (m).

Kidney disease quality of life-36 [8]

This questionnaire was used to assess the QOL of the study group 1 week before and after the exercise training program.

The Quality of Life Short-Form 36 [kidney disease quality of life-36 (KDQOL-36)] questionnaire was translated into Arabic in accordance with the aim of this study to evaluate self-reported health status domains of the patients on dialysis.

Results

Table 1 shows that the mean age of the patients in the study group was 44.87 years and the mean duration of HD was 2.57 years.

Table 2 shows that.

- (1) There was a mild reduction in both the mean forced vital capacity (FVC) (72% of the predicted) and the mean forced expiratory volume in the first second (FEV₁) (74.39% of the predicted) (FEV₁/FVC) ratio in the study group and the control group was (80.93%), indicating restrictive pattern of pulmonary functions.
- (2) The respiratory system was specifically affected by the disease and by the treatment (HD or peritoneal dialysis).
- (3) Forced expiratory flow between 25 and 75% of vital capacity was slightly below normal in the dialysis patients.

Discussion

Most patients diagnosed with ESRD receive maintenance HD treatment as renal replacement therapy. This intervention is typically prescribed three times/week, 4–6 h per session, and remains ongoing for the lifetime of the patient or until successful kidney transplantation. Although advances in HD treatment have extended the lifespan of patients with ESRD, this treatment alone does not ensure preservation of QOL [9].

Exercise, that is, the type of physical activity, is defined as planned, structured, and repetitive bodily movement performed to improve or maintain one or more aspects of physical fitness [10].

Planned exercise, involving aerobic and resistance training modalities, has become well recognized as

Table 1 Demographic characteristics of the study group

Number of patients	30
Male [n (%)]	21 (70)
Female [n (%)]	9 (30)
Age (years)	44.87 ± 8.85
Duration of hemodialysis (years)	2.57 ± 1.38

Table 2 Pulmonary functions tests among the study group and the control group

Pulmonary function tests	Study group (mean ± SD) (%)	Control group (mean ± SD) (%)	t-test	Significance
FVC	72.46 ± 6.48	92.34 ± 2.97	15.28	0.000
FEV ₁	74.39 ± 7.11	82.50 ± 1.75	6.06	0.000
FEV ₁ /FVC	80.93 ± 4.25	89.35 ± 2.35	9.53	0.000

a therapeutic intervention that can ameliorate the marked physiological, functional, and psychological deterioration that commonly results as a consequence of biological aging, catabolic illness, and a sedentary lifestyle, factors that may all contribute toward the progressive decrease in vitality and QOL commonly observed in HD patients [7].

In our study, 30 patients with ESRD maintained on HD for at least 1 year participated in a regular exercise training program three times/week for a period of 12 weeks to examine the changes in physical functional performance, including functional work capacity, functional mobility, and QOL. The program duration of regular exercise training (12 weeks) in this study seems sufficient. However, the duration in some other studies varied from 2 months [11] up to 4 years [12]. Exercise programs lasted between 3 and 6 months in 90% of the studies. Only two studies created longer-duration programs with interventions during 12 months [13] and even 4 years, in the case of the longest study to date [12].

In this study, the mean HD duration was 2.57 ± 1.38 years. A common inclusion criterion for most of the studies was that patients had to have been on HD for at least 3 months [14]. Data for time on HD showed a maximum mean time of 84 months (7 years) [12] and a minimum mean time of 29.6 months on HD treatment [15]. Only one study reported these data as a range, which appeared as a minimum time of 3 months on HD and a maximum time of 288 months (24 years) [16].

The mean patient age was 44.87 ± 8.85 years (24–61 years). There were 21 men, 70% of the patients, and nine women, 30% of the patients.

In our study, the patients underwent the 6-m walking test, the same as in the studies of Fitts and colleagues and Heiwes *et al.* [15,17]. A stationary bicycle was used in many studies [12,13,18]. In most articles, cycling was combined with walking, jogging, fitness ball exercises, swimming, and basketball, whereas in other studies, exercise was based exclusively on a cycling workout [11,18]. Interventions with combined aerobic exercise and progressive-resistance strength training consisted of adding low-intensity lower limb strengthening exercises to the aerobic workout, and upper limb exercises were carried out in another study [15].

Table 3 showed the physical performance (including functional work capacity and functional mobility), in addition to estimation of the aerobic capacity, we also used performance-based functional tests (sit-to-stand

and 6-min walk tests) that were more practical and easy to apply.

Functional work capacity was measured in four different ways depending on the study. It was measured by the peak oxygen consumption reached in the cycloergometer test; the total exercise time; the power output reached; and the METs attained as in our study. This function increased from 7.24 ± 0.90 to 9.62 ± 1.1 MET after the exercise training program. The difference between before and after the exercise program was 2.38 MET (32.8%), which was highly statistically significant, with *P* value less than 0.000.

The improvement in functional work capacity found in this study (32.8%) is in agreement with the percent improvements reported in a previous study carried out in HD patients (30%) [19].

The use of functional tests (walking test and sit to stand test) in our study is useful in HD patients because they are easy to carry out and can be performed with no excess cost.

In a study [18] on HD patients, the exercise program resulted in an increase in the walking rate only in the group with low physical component scale (PCS) scores, whereas there were significant increases in both the low and the high PCS groups in the sit-to-stand-to-sit test.

In our study, in the sit-to-stand test, the time required to complete 10 cycles decreased from 24.67 ± 1.78 to 21.05 ± 1.91 s after the exercise training program, with an improvement of 14.67%. This result was similar to that obtained in another study [1] that was carried out on 20 patients with renal failure on HD; 14 of these patients completed the study. The patients underwent a 12-week exercise program of 90 min/day, three days/week. Walking capacity and functional mobility were evaluated before and after training. The score of the sit-to-stand test was 24.6 ± 3.9 at the start of the exercise program. After the completion of the exercise program, it was 20.4 ± 3.9 (with a 16.9% improvement).

The 6-min walking test (6MWT) has been used as an outcome measure of physical function in a number of exercise training programs in the ESRD population. The distance covered by the patients in 6MWT in our study increased from 427.29 ± 39.35 to 521.23 ± 42.07 m after the exercise training program, with a 21.98% increase in the distance walked. The difference between before and after the program was highly statistically significant (*P* = 0.000).

However, other studies reported lesser or no change in 6MWT performance in HD patients. Painter *et al.* [18]

found an 8% increase in the distance walked on the 6MWT in patients who participated in an 8-week home program and an 8-week intradialytic exercise program compared with their baseline distance.

The 21.98% increase in 6MWT performance is most likely not because of learning effects because with the 6MWT, these have primarily been shown with repeated measures within the same day. In the current study, each patient performed the test only once at baselines and at 12 weeks. It is highly unlikely that a learning effect persists for 12 weeks and no data have been published on repeatability greater than 4 weeks; however, it is assumed that this effect wears off after several weeks [20].

Regular physical activity increases physical fitness as well as the quality of life. The results of our study in Table 4 showed that the quality of life has been improved after exercise training program and there is a highly statistically significance as regard to the first four scales of KDQOL-36 questionnaire before and after exercise (symptoms and problems scale improved from 67.50 ± 12.46 to 73.09 ± 10.50 with $P < 0.001$), (effect of kidney disease on daily life scale improved from 63.02 ± 15.49 to 70.83 ± 13.54 with $P < 0.001$), (burden of kidney disease scale improved from 35.42 ± 10.55 to 44.16 ± 8.83 with $P < 0.001$) and physical component scale (PCS) improved from 41.71 ± 10.93 to 43.94 ± 8.47 with $P < 0.001$).

There was also a statistically significant improvement in the mental component scale, which improved from 50.39 ± 7.79 before exercise to 54.12 ± 4.84 after exercise, P value less than 0.05.

A previous study [21] observed improvements only in the SF-36 physical function scores following a 6-month rehabilitation program. Compared with the controls, no change could be observed in other PCS scores.

Johansen *et al.* [22] carried out a study using SF-36 and found correlations between physical function scales and all physical performance measurements in the patients.

Similar to our study, one study [23] concluded that the development of a structured exercise program can improve QOL, physical functioning, phosphorus levels, and urea clearances of dialysis patients.

Other authors [24] reported significant improvements in the mental component summary.

Conclusion

The results of our study indicate that the appropriate application of an exercise program would improve

Table 3 Comparison between work capacity and functional mobility before and after the exercise training program in our study

Physical function tests	Mean \pm SD		t-test	P value
	Before	After		
Functional work capacity	7.24 ± 0.90	9.62 ± 1.1	-24.95	<0.001
Sit-to-stand	24.67 ± 1.78	21.05 ± 1.91	26.54	<0.001
6 min walk	427.29 ± 39.35	521.23 ± 42.07	-26.77	<0.001

The work capacity and functional mobility improved after the exercise training program and the difference before and after the program was highly statistically significant ($P < 0.001$).

Table 4 Comparison between scales of quality of life before and after the exercise training program

Scales	Mean \pm SD		Paired t-test	P value
	Before	After		
Symptoms and problems scale	67.50 ± 12.46	73.09 ± 10.50	-9.20	<0.001
Effect of kidney disease on daily life scale	63.02 ± 15.49	70.83 ± 13.54	-12.04	<0.001
Burden of kidney disease scale	35.42 ± 10.55	44.16 ± 8.83	-9.41	<0.001
Physical component scale	41.71 ± 10.93	43.94 ± 8.47	-9.00	<0.001
Mental component scale	50.39 ± 7.79	54.12 ± 4.84	-2.66	0.013

The quality of life improved after the exercise training program and there was a highly statistically significance in the first four scales of the KDQOL-36 questionnaire before and after the program ($P < 0.001$) and statistical significance in the mental component scale before and after the program ($P < 0.05$).

functional mobility and QOL as well as increase the work capacity in long-term maintenance HD patients.

Our analysis indicates that health-related QOL in ESRD is most affected in the first four scales of the KDQOL-36 questionnaire and less affected in the mental component scale.

Every patient on HD without medical contraindications to exercise should be encouraged to participate in an aerobic exercise training program.

Acknowledgements

Conflicts of interest

None declared.

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