

Evaluation of the effect of exercise training program 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 physical and social dimensions of life because of their treatment and their comorbid medical conditions.

Aim of the work

The aim of this study was to evaluate the effect of exercise training programs on functional work capacity, functional mobility, and quality of life 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 per week for 12 weeks.

Each exercise session consisted of warm up, cycle or treadmill exercises, stretching exercises, and cool down. All patients underwent the cardiovascular graded exercise tolerance test, the sit-to-stand-to-sit test, and the 6-min walk test. Questionnaires were used to assess the quality of life of the study group 1 week before and after the exercise training program. A total of 15 normal individuals who were age-matched and sex-matched with our patients were used as controls to compare the respiratory function.

Results

There was significant improvement in work capacity after the training exercise program compared with that before the program (from 7.24 ± 0.90 to 9.62 ± 1.1 ; $P < 0.001$); in addition, there was also a highly significant improvement in functional mobility. The quality of life was improved after the exercise training program according to four of five scales of 36 questionnaires.

Conclusion

A suitable exercise training program is an important method for improvement of work capacity, mobility, psychological status, and quality of life.

Keywords:

exercise, hemodialysis, quality of life, work capacity

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Introduction

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

Hemodialysis (HD), as a therapy for chronic renal failure, restores the main functions of the kidney, although it cannot completely restore the function of the whole organ. As a result, impairment of multiple organ systems is common, among which impairment of the cardiovascular and musculoskeletal systems is the most prominent. In addition, psychosocial impairments, such as anxiety, depression, and poor quality of life, are common. All these factors limit the patients' functional capabilities [2].

Aerobic work capacity tests measure the maximum amount of work that can be done when there is enough oxygen supply the muscles. Whole-body aerobic capacity tests are based on 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 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 ESRD, as well as enhance physical activity, physical fitness, and health-related quality of life. The American College of Sports Medicine recommended that exercise should be designed to combine endurance and muscle strength exercises in order to decrease muscle weakness in HD patients [4].

Aim of the work

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

Patients and methods

This study is a randomized clinical trial carried out at the Rheumatology and Rehabilitation Department of Zagazig University Hospitals on 30 patients with ESRD who were diagnosed according to the reports present at dialysis centers and had been on maintenance HD for 2.57 ± 1.38 years. Patients who were dialyzed three times per week for at least 1 year before the study, those who could walk unaided, those older than 18 years, those with hemoglobin levels of 10 g/dl or more, and those with no history of antidepressant drug use or use of other psychotropic agents were included in the study.

A group of 15 healthy normal individuals, matched for age, sex, and height with our patients, served as the control group to compare the respiratory functions.

ESRD patients who has either absolute or relative contraindications for exercise testing or that lead to severe limitations in the ability to walk or to the inability to walk were excluded. These conditions include:

- (1) Lower-extremity amputation.
- (2) Mechanical disorders associated with pain (such as lumbar disk, osteoarthritis, or lumbar spondylosis).
- (3) Uncontrolled diabetes mellitus or uncontrolled hypertension.
- (4) Cerebral vascular diseases manifested as transient ischemic attacks and angina at rest or on exertion.
- (5) Chronic lung diseases, which result in significant oxygen desaturation on exercise or pulmonary congestion.
- (6) Acute infections and suspected or known aneurysm.
- (7) Hyperkalemia or hypokalemia.

All patients were subjected to the following:

- (1) Thorough medical history taking.
- (2) Full clinical examination.
- (3) Investigations.
 - (a) Fasting and postprandial blood sugar estimation.
 - (b) Complete blood picture.
 - (c) Serum urea and creatinine level measurements before and after exercise.
 - (d) Pulmonary function test.

Training protocol

All patients participated in a regular exercise training program three times per week for 12 weeks. Each exercise session included warm up for 5 min, cycle or treadmill exercises for 15 min, stretching exercises for large muscle groups of 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 by the baseline treadmill exercise stress test [1].

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

Description of outcome measures*Cardiovascular graded exercise tolerance test [3]*

All patients underwent the cardiovascular graded exercise tolerance test (i.e. ECG exercise test) on a nondialysis day (i.e. a day free from dialysis) for determining functional work capacity and to ascertain the safety of the exercise training program.

Each patient underwent the maximal exercise test 1 week before the beginning of and 1 week after the end of 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. Exercise stress test was performed using the treadmill ECG exercise stress test on a Quinton 3000 treadmill ECG device (A.H. Robins company; Seattle, Washington, USA).

The test used continuous incremental workloads, which began at a low workload and progressed to higher workloads until either subjective or objective (maximal) endpoints precluded further exercise. The incremental workload 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 the commencement of the exercise training program and soon after its completion; they include:

The sit-to-stand-to-sit test [6]: This test 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. Participants were asked to rise from a standard-height (nearly 43 cm) chair that was without

armrests, 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 participant was began the test by sitting down, with his/her arms crossed over the chest or placed on the waist.

The 6-min walk test [7]: The patient was asked to wear comfortable clothes, low-heeled walking footwear, and eyeglasses and hearing aids (if applicable). During the test, the patients were required to walk alone, because walking behind them would alter their pace. Participants were allowed to use the bathroom before commencement of the test.

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

Kidney disease quality of life [8]

The kidney disease quality of life short-form 36 (KDQOL-36) questionnaire was used to assess the quality of life of the study group 1 week before and 1 week after the exercise training program.

The KDQOL-36 questionnaire was translated into Arabic to evaluate self-reported health status domains of the patients on dialysis.

Results

Table 1 show that the mean age of the study group is 44.87 years, and the mean duration of HD is 2.57 years.

Table 2 shows that:

- (1) There is 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), with a preserved ratio between them (FEV1/FVC=80.93%), in the study group compared with the control group, which indicates a mild restrictive pattern of pulmonary functions.
- (2) The respiratory system is specifically affected by the disease and by the treatment (HD or peritoneal dialysis).
- (3) Forced expiratory flow between 25 and 75% of the vital capacity was slightly below normal in the dialysis patients (Tables 3 and 4).

In addition, this table shows that the work capacity and functional mobility were improved after the exercise training program and that the difference between the results obtained before and after the program is highly statistically significant ($P \leq 0.001$).

This table also shows that the quality of life improved after the exercise training program and that there is

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 function tests in the study group and the control group

	Study group [mean ± SD] (%)	Control group [mean (%) ± SD] (%)	t-test	Significance
FVC	72.46 ± 6.48	92.34 ± 2.97	15.28	0.000
FEV1	74.39 ± 7.11	82.50 ± 1.75	6.06	0.000
FEV1/FVC	80.93 ± 4.25	89.35 ± 2.35	9.53	0.000

FEV1, forced expiratory volume in the first second; FVC, forced vital capacity.

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

	Before (mean ± SD)	After (mean ± SD)	t-test	P-value
Functional work capacity	7.24 ± 0.90	9.62 ± 1.1	- 24.95	0.001
Sit-to-stand-to-sit	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

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

Scale	Before (mean ± SD)	After (mean ± SD)	Paired t-test	P-value
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

high statistical significance as regards the first four scales of the KDQOL-36 questionnaire (before and after; $P \leq 0.001$) and the mental component scale (before and after; $P \leq 0.05$).

Discussion

Most patients diagnosed with ESRD receive maintenance HD treatment such as renal replacement therapy. This intervention is typically prescribed three times per week, 4–6 h/session, and is continued throughout 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 the quality of life [9].

Exercise, a type of physical activity, is defined as planned, structured, and repetitive bodily movements undertaken 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 a therapeutic intervention that can ameliorate the marked physiological, functional, and psychological deterioration that commonly accrues as a consequence of biological aging, catabolic illness, and a sedentary lifestyle, factors that may all contribute to the progressive decline of vitality and quality of life, as commonly observed in HD patients [7].

Our study including 30 patients with ESRD, maintained on HD for at least 1 year, participating in a regular exercise training program three times per week for a period of 12 weeks aimed at examining the changes in physical functional performance, including functional work capacity, functional mobility, and quality of life. The program duration of regular exercise training (for 12 weeks) in this study is sufficient as the duration in most studies varied between 2 months [11] and 4 years [12]. Exercise programs lasted between 3 and 6 months in 90% of the studies. Only two studies included programs of longer duration, with interventions lasting 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 participants 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 [15]. Only one study expressed this 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 age of the patients was 44.87 ± 8.85 years. The youngest patient was 24 years old, whereas the oldest was 61 years. The number of male patients was 21 (70%), whereas the number female patients was nine (30%).

In our study and in the studies by Fitts *et al.* [12] and Heiwe *et al.* [17], the patients were subjected to 6MWT. A stationary bicycle was used in most studies [12,13,18]. In most studies, 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, and upper limb exercises were carried out in the study [15].

In the evaluation of physical performance (including functional work capacity and functional mobility), in addition to estimating the aerobic capacity, we also used performance-based functional tests (sit-to-stand-to-sit test and 6MWT) that were more practical and easy to apply.

Functional work capacity was measured in four different ways depending on the study. It was measured in terms of the peak oxygen consumption reached in the cycloergometer test, the total exercise time, the power output reached, and the metabolic equivalents (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 in MET before and after the program was 2.38 MET (32.8%), which was highly statistically significant ($P \leq 0.001$).

The improvement in functional work capacity demonstrated in this study (32.8%) is in accordance

with the percentage improvements reported in a previous study on HD patients (30%) [19].

The use of functional tests (6MWT test and sit-to-stand-to-sit test) in our study is useful in HD patient because they are easy to carry out and can be performed specifically by Egyptian patients with a low capacity and who may not be able to undergo laboratory tests (ergometry).

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

In our study, in the sit-to-stand-to-sit 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 closer to that of the study by Levendoglu *et al.* [1], which was carried out on 20 patients with renal failure on HD, 14 of whom completed the study. The patients underwent a 12-week exercise program of 90 min/day, 3 days a week. Walking capacity and functional mobility were evaluated pretraining and post-training. The score of the sit-to-stand-to-sit test was 24.6 ± 3.9 at the beginning of the exercise program. After the completion of the exercise program, it was 20.4 ± 3.9 (with 16.9% improvement).

The 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. There is high significant difference ($P < 0.1$) in the distance before and after the exercise training program.

However, other studies demonstrated lesser or no change in 6MWT performance in patients undergoing HD. Fitts *et al.* [12] found an 8% increase in the distance walked, as compared with the baseline distances, in the 6MWT among patients who participated in an 8-week home program and an 8-week intradialytic exercise program.

The increase in 6MWT performance is most likely not due to a learning effect, because learning effects in the 6MWT have been primarily shown with repeat measures on the same day. In the current study, each patient performed the test only once at baselines and once at 12 weeks. It is highly unlikely that a learning effect persists for 12 weeks and no data have been

published as regards the repeatability beyond 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 show that the quality of life improved after the exercise training program and that there is a high statistical significance in the first four scales of the KDQOL-36 questionnaire before and after exercise (the symptoms and problems scale improved from 67.50 ± 12.46 to 73.09 ± 10.50 with $P < 0.001$; the effect of kidney disease on daily life scale improved from 63.02 ± 15.49 to 70.83 ± 13.54 with $P < 0.001$; the burden of kidney disease scale improved from 35.42 ± 10.55 to 44.16 ± 8.83 with $P < 0.001$; and the physical component scale improved from 41.71 ± 10.93 to 43.94 ± 8.47 with $P < 0.001$).

There was statistically significant improvement in the mental component scale, which improved from 50.39 ± 7.79 before exercise to 54.12 ± 4.84 after exercise ($P < 0.05$).

A previous study [21] identified improvements only in the 36-item short form health survey physical function scores following a 6-month rehabilitation program, and when compared with controls, no change in other physical component scale scores could be identified.

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

Similar to the findings of our study, Bennett *et al.* [23] found that the development of a structured exercise program can improve the quality of life, physical functioning, phosphorus levels, and urea clearances of dialysis patients.

Regular physical activity increases physical fitness as well as the quality of life. The results of our study shows 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 $P < 0.001$]. And there was statistically significance improvement regarding mental component scale (MCS) which improved from (50.39 ± 7.79) before exercise to (54.12 ± 4.84) after it with $P < 0.05$.

Other authors [24] have reported significant improvement in the mental component summary (mental component scale).

Johansen *et al.* [25] performed a study by employing SF-36, and found correlations between physical function scales and all physical performance measurements in the patients. Similar to our study, one study [26] concluded that the development of a structured exercise program can improve quality of life, physical functioning, phosphorus levels and urea clearances of dialysis patients. Other authors [27] reported significant improvement in the mental component summary (MCS).

Conclusion

The results of our study indicate that appropriate application of an exercise program can improve the functional mobility and quality of life, as well as increase the work capacity in long-term maintenance HD patients.

Our analysis indicates that health-related quality of life 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

There are no conflicts of interest.

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ان المرضى الذين يعانون من مرحلة متأخرة في القصور الكلوي ويتم علاجهم عن طريق الغسيل الكلوي وجد أنهم غير قادرين على العمل، كما أنهم يعانون من كثير من المشكلات النفسية و البدنية، ومن هنا كان هذا البحث.

الهدف من البحث:

تقييم مدى تأثير ممارسة برنامج منظم من التمرينات الرياضية على القدرة على العمل و على الوظيفة الحركية وعلى كفاءة الحياة في المرضى الذين يعانون من مرض الفشل الكلوي ويخضعون للعلاج بواسطة الغسيل الدموي المستمر.

المرضى و طرق البحث:

تمت الدراسة على ثلاثين مريضا يعانون من مرض الفشل الكلوي في مرحلته الأخيرة و التي تتطلب العلاج بواسطة الغسيل الكلوي المنتظم. كما تم اختيار مجموعة ضابطه تتكون من خمسة عشر شخصا صحيا مماثلين للمرضى فى السن والجنس الذين اجريت الدراسة وذلك لمقارنة الوظائف التنفسية.

خضع المرضى للتالى:

أولا: اختبار قياس أقصى قدرة على ممارسة التمارين قبل بدء البرنامج التدريبي باسبوع وبعد نهاية الاسبوع.

ثانيا: قياس اللياقة البدنية، و تم ذلك من خلال اختبارين هما:

- إختبار الجلوس ثم الوقوف ثم الجلوس

- إختبار السير لمدة ستة دقائق

ثالثا: قياس كفاءة الحياة ، وذلك من خلال استجاب يتكون من (36) بندا.

رابعا: تم إدخال المريض في برنامج منظم للتدريب لمدة ثلاثة اشهر.

نتائج البحث:

كان هناك تحسن إحصائي واضح في كل من القدرة على العمل و إختبارات اللياقة البدنية بعد إنتهاء برنامج التدريب. كما وجد أيضا أن هناك تحسن إحصائي واضح في مقاييس كفاءة الحياة المختلفة و لذلك لابد من إعتبار برنامج التدريب المنظم من أهم طرق تحسين الوظيفة الحركية وزياده قدره على العمل لمرضى الغسيل الدموي لما له من تأثير على الناحية النفسية و البيولوجية و البدنية.

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