Effect of twelve-week concurrent aerobic and resisted exercise training in non-dialysis day on functional capacity and quality of life in chronic kidney disease patients

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Abstract. – OBJECTIVE: Several researchers have evaluated the impact of exercise training on patients with chronic kidney disease (CKD). However, few studies have evaluated the impact of concurrent training (aerobic and resisted exercise) on non-dialysis days on the functional capacity and quality of life (QOL) of such patients. Our current study evaluated the effects of concurrent training on functional capacity and QOL of patients with CKD.

PATIENTS AND METHODS: Forty-three patients, aged ≥ 25 years, were recruited in this randomized study. They were divided into intervention and control groups (22 per group). The intervention group received concurrent aerobic and resistance exercises (three sessions per week for twelve weeks on alternative days). The control group continued their regular lifestyle practices and medical treatment without any exercise intervention. Before and after twelve weeks of training, the participant's functional capacity and quality of life (QOL) were measured.

RESULTS: Compared to the control group, the intervention group displayed a significant improvement in the distance walked in the 6-minute walk test and sit-to-stand test (STS1/s and STS-60) with *p*<0.001; furthermore, a significant improvement was observed in physical function, body pain, general health, role functioning/physical, vitality, and social functioning (*p*<0.05) of QOL assessed with the SF-36 questionnaire.

CONCLUSIONS: The twelve-week concurrent aerobic and resistance exercise training had a positive impact on functional capacity and QOL in CKD patients. Concurrent exercise training should be recommended as an interventional modality in physical therapy and rehabilitation protocols in CKD patients.

Key Words:

Aerobic exercise, Chronic kidney disease, Physical capacity, Psychological status, Quality of life.

Introduction

Chronic kidney disease (CKD) is recognized as a public health problem associated with increased mortality, decreased quality of life (QOL), increased healthcare costs, and hypertension. Diabetes and cardiovascular disease are associated with a greater vulnerability to developing CKD. Additionally, CKD has a complicated interrelationship with these diseases[1]. Malnutrition, anemia, sedentary lifestyle, a decrease in muscular strength, and a decrease in flexibility are all associated with disease progression and pose a significant challenge for CKD patients[2]. Several factors lead to the deterioration of the level of physical activity in CKD patients, including decreased muscle strength[3], increased co-morbidities[4], and deteriorated physiological status[5]. Furthermore, rehabilitation program with exercise therapy appears to be an important intervention to protect the population from chronic diseases, such as diabetes mellitus, CKD, and heart failure. Physical activity recommendations state that moderate-intensity aerobic physical activity for a minimum of 30 minutes, at least 5 days each week, confers substantial protection against chronic diseases. In this study, various types of exercise therapy interventions containing aerobic and strengthening

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exercises were investigated. The rehabilitation program usually lasts two or three times a week for about 45 minutes to an hour. The time ranges from 3 months to one year[6].

It was reported that aerobic endurance exercise training in patients with CKD showed improvements in physical functioning as well as QOL. Additionally, training, including resistance exercise, has been reported to enhance the power of the muscles and physical function in these types of patients. Also, exercise training improves cardiovascular risk factors, such as blood pressure and lipid profiles as well as dialysis efficacy[7,8]. Chronic kidney insufficiency is characterized by irreversible and progressive loss of kidney function; it is now a major public health concern because it is associated with high morbidity and mortality, frequently leading to disability and a reduction in life quality[9].

To improve activity levels in CKD patients, researchers have experimented with different types of interventions, including both in-center (intradialytic) and out-of-clinic (intradialytic) exercise programs. CKD patients were engaged in the prescribed exercise program on anon-dialysis day (e.g., walking). The intensity of these exercises varied based on patient comorbidities and other factors. Most of the published exercise plans for CKD patients to do on days when they do not have dialysis fall into three categories: walking programs at home, resistance training at a gym, and combined exercise plans that include aerobic, resistance, and/or educational components[10,11].

In a systematic review of 29 clinical trials, it was shown that the patients' physical condition significantly improved following exposure to aerobic training. Resistance training makes people with advanced CKD stronger and better able to do daily tasks. This is shown by increases in the peak torque of the quadriceps muscle, the distance walked in a 6-minute walk test, the maximum walking speed, and better performance in a sit-to-stand test[12-14].

The 6-minute walk test (6MWT) was used to measure functional capacity based on the recommendations of the American Thoracic Society and since it is a simple and inexpensive option for CKD patients[15]. The sit-to-stand test is a good way to measure the strength of the lower limbs, and it has already been proven in people with CKD[16].

Assessment of QOL, using a generic Short-form 36 questionnaire (SF-36), considered a physical component of SF-36 valid to assess physical performance in patients with CKD on hemodialysis, which included physical functioning (PF), role functioning/physical (RP), bodily pain (BP), general health (GH), vitality (VT), and social functioning (SF)[17-20].

Patients and Methods

This study was implemented to evaluate the effectiveness of combined exercise training on non-dialysis days on the functional capacity and QOL of CKD patients on regular hemodialysis. Using two groups (intervention and control), pre-test and post-test designs were employed to determine the effectiveness of combined exercise training on functional capacity and QOL among CKD patients. The intervention group was assigned to combined aerobic and resistance exercise, and the control group received the usual care. The inclusion criteria were being over the age of 25 years, being a part of the hospital's hemodialysis program, receiving a medical prescription for the practice of physical activity, and signing the informed consent. Patients complaining of recent myocardial infarction, unstable angina, uncontrolled arrhythmias, hypertension, diabetes, and neurological or musculoskeletal disorders were excluded from the study.

Study Design

This randomized controlled trial was implemented between January and June 2020 in the outpatient physiotherapy clinic. The study's ethical clearance was obtained from the institutional ethics committee before commencing the study based on the consolidated standards of reporting trials, CONSORT checklist (No.: RHPT/020/057)[21].

Participants

Fifty patients suffering from CKD participated in this study. Age over 25 years, participation in the hemodialysis program, receipt of a medical prescription for physical activity, and willingness to sign an informed consent form were the inclusion criteria. Patients complaining of recent myocardial infarction, unstable angina, uncontrolled arrhythmias, hypertension, diabetes, and neurological or musculoskeletal disorders were excluded from the study. The patients were allocated into one of two groups: the intervention group (IG), which underwent combined aerobic and resistance exercise; and the control group (CG), which did not receive any special intervention except the usual medical care. The flowchart of the study is detailed in Figure 1.

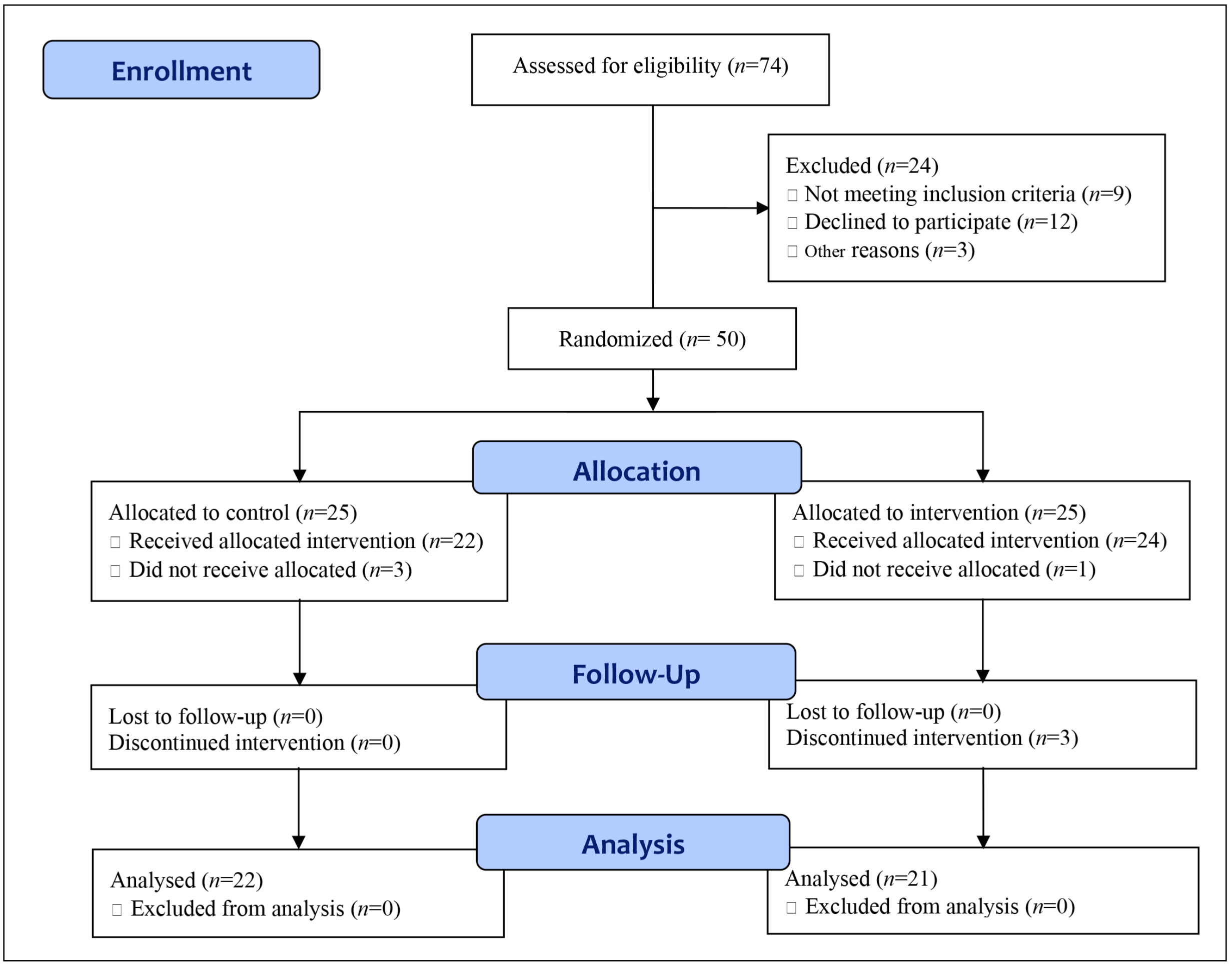

Figure 1. The flowchart of the study.

During data collection, four patients (two each in IG and CG) discontinued the intervention due to social factors. In the IG, the follow-up of three patients was discontinued due to unstable health conditions. Patients underwent two testing sessions before intervention (initial assessment) and immediately after the twelve-week intervention period (final assessment). The exercise sessions were conducted on non-dialysis days, 18-24 h after a dialysis treatment.

Sample Size Calculation and Randomization

The G-power program was used to determine the sample size in which (power= 80%, α= 0.05, and an effect size of 0.05). Coin toss randomization was used to minimize bias across the intervention and control groups. Allocation concealment was ensured by using invisible and sealed envelopes. As previously mentioned, patients were randomized into IG and CG.

Intervention

Patients assigned to the IG received training three times per week for 12 weeks. Each session consisted of an initial warm-up, aerobic exercise (AE), and resistance exercises on a non-dialysis day. The warm-up was performed for 10 minutes, progressing from isolated mobilizing to gross mobilizing exercises. The AEs were performed on a treadmill or by cycling for 20 minutes at a moderate intensity (70-80% HRmax). The rest was taken if required. The intensity of exercise was continuously monitored throughout each session using heart rate telemetry (Polar Team; Polar Electro) and with the rating of perceived exertion at 12-14 ("somewhat hard").

Dynamic closed- and open-chain resistance exercises were performed by the patients. The quadriceps muscles and hamstrings were trained at a multi-gym. Patients started at 50% of their initial one-repetition maximum (1-RM) with

Table I. Demographic characteristics.

	Intervention group (*n*=21)	Control group (*n*=22)	*p*-value
Age, years	53.6 ± 17.8	48.7 ± 18.5	0.381
Gender, M/F	7/14	6/16	0.665
BMI, Kg/m^2	29.5 ± 5.2	28.8 ± 4.9	0.651
Duration of CKD, m	28.6 ± 7.3	26.9 ± 7.8	0.465
Co morbid conditions			
Essential hypertension	11 (52.38%)	14 (63.6%)	0.454
Diabetes	9 (42.8%)	6 (27.2%)	0.284
ischemic heart disease	1 (4.7%)	2 (9.09%)	0.557
peripheral artery disease	0	0	1.000
Education level, n (%)			
No formal education	2 (9.5%)	4 (18.2%)	0.413
Primary or middle school	11 (52.38%)	13 (59.1%)	0.938
Secondary education or more	8 (38.1%)	5 (22.7%)	0.273

BMI: body mass index; CKD: chronic kidney disease.

5 repetitions for each exercise and later progressed to three sets of 8 repetitions at 70% of their 1-RM according to the patient Borg scale of exertion; training loads were increased when patients could comfortably complete three sets with good form. The training resistance was adjusted according to the newly achieved one-repetition maximum (1-RM).

Initial Assessment and Outcome Measures

Patients were assessed for age (y), gender, duration of CKD (m), co-morbidity, education level, height (m), weight (kg), body mass index (BMI, kg/m^2). On the first visit, they also underwent the 6-minute walk test (6MWT) and sit-to-stand test and completed the general health, physical function, body pain, role functioning/physical, vitality, and social functioning domains of the medical outcomes SF-36 questionnaire[19,20]. The STS-10 assesses time in seconds to consecutively complete 10 repetitions of sitting down on and getting up from a chair, whereas the STS-60 measures the number of repetitions achieved in 60 seconds. The STS-10 was carried out first, and STS-60 was performed after a 15-minutes recovery period. During the STS-10, patients were instructed to perform the task as fast as possible, starting and finishing at the sitting position. Patients were also allowed a trial before beginning the test[22,23].

The 6MWT was carried out in a 20-meter line along the passageway; the tape was placed every 2 meters. Patients were instructed to walk the longest possible distance in 6 minutes continuously, turning around at the final mark without stopping, and covering as much as they could. They were further instructed to walk as far as they could for 6 minutes without running or jogging. The covered distance in meters was measured at the end of the test for analysis[24].

Statistical Analysis

Demographic and baseline characteristics were calculated and compared between the intervention and control groups. The collected data was assessed for normality using the Kolmogorov-Smirnov test. For the normally distributed data, the differences between groups were assessed *via* an unpaired *t*-test, and the changes within groups were assessed by a paired *t*-test. For the non-normally distributed data, Mann-Whitney U and Chi-square tests were performed. All data were analyzed using SPSS for Windows (V.25, IBM Corp., Armonk, NY, USA). The significance level was set at $p<0.05$.

Results

As displayed in Table I, no significant difference was detected between the intervention and control groups regarding demographic characteristics involving gender, age, body mass index (BMI), duration of CKD, and education levels ($p>0.05$).

Concerning the baseline data of the outcome measures, no statistical differences were detected between the intervention and control groups (6 MWT, $p=0.167$, STS1, $p=0.681$, STS60, $p=0.892$, QOL-physical function, $p=0.375$, QOL-body pain, $p=0.638$, QOL-general health, $p=0.551$, QOL-role functioning/physical $p=0.169$, QOL-vitality, $p=0.056$, and QOL-social functioning, $p=0.725$). However, at 12-week post-intervention,

Table II. Baseline and 12-week differences between and within groups.

Variables	Intervention group (*n*=21)	Control group (*n*=22)	*p*-value
6 MWT			
Baseline	338.4 ± 21.8	329.5 ± 19.7	0.167
12-week	370.3 ± 18.6	334.2 ± 19.4	<0.0001
p-value	<0.0001	0.397	
STS1/s			
Baseline	31.8 ± 3.5	32.2 ± 2.8	0.681
12-week	27.8 ± 1.5	30.8 ± 2.5	<0.0001
p-value	<0.0001	0.087	
STS 60			
Baseline	21.1 ± 2.7	21.2 ± 2.1	0.892
12-week	26.76 ± 2.3	22.1 ± 1.2	<0.0001
p-value	<0.0001	0.082	
QOL-Physical function			
Baseline	68.7 ± 6.4	67.3 ± 3.5	0.375
12-week	75.7 ± 8.3	69.2 ± 4.7	0.003
p-value	0.0026	0.113	
QOL-Body pain			
Baseline	70.86 ± 5.8	70.1 ± 4.7	0.638
12-week	76.83 ± 4.2	72.07 ± 5.5	0.003
p-value	0.0002	0.188	
QOL-General health			
Baseline	59.42 ± 4.4	60.2 ± 4.1	0.551
12-week	67.4 ± 5.7	62.1 ± 4.5	0.002
p-value	<0.0001	0.273	
QOL-Role functioning/physical			
Baseline	63.3 ± 5.7	61.4 ± 3.12	0.169
12-week	68.2 ± 4.8	62.36 ± 3.67	<0.0001
p-value	0.005	0.358	
QOL-Vitality			
Baseline	64.23 ± 4.84	63.54 ± 2.79	0.0566
12-week	70.95 ± 4.35	64.90 ± 2.34	<0.0001
p-value	0.0002	0.0867	
QOL-Social functioning			
Baseline	64.9 ± 4.7	65.40 ± 4.63	0.7250
12-week	70.8 ± 3.94	66.9 ± 4.27	0.0031
p-value	<0.0001	0.2709	

Significant difference at $p<0.05$; 6 MWT: six-minute walk test; STS: sit to stand test; QOL: quality of life

a significant difference was detected between the intervention and control groups (6 MWT, STS1, and STS60, $p<0.0001$, QOL-physical function, $p=0.003$, QOL-body pain, $p=0.003$, QOL-general health, $p=0.002$, QOL-role functioning/physical, $p<0.0001$, QOL-vitality, $p<0.0001$, and QOL-social functioning, $p=0.0031$) in favor of the intervention group (Table II).

Analyzing the changes in the intervention group, significant changes were observed after 12-week intervention (6 MWT, STS1, STS60, QOL-general health, $p<0.0001$, QOL-physical function, $p=0.0026$, QOL-body pain, $p=0.0002$, QOL-role functioning/physical, $p=0.005$, QOL-vitality, $p=0.0002$, and QOL-social functioning, $p<0.0001$), while the control group showed non-significant changes in all outcome measures ($p>0.05$) as displayed in Table II.

Discussion

In the present study, patients with CKD who performed a combined aerobic and resisted exercise on a non-dialysis day exhibited positive effects in the functional capacity and QOL parameters. Studies[25,26] have shown that preserving the physical capacity and integrating rehabilitation in the treatment of these patients results in several benefits in addition to reducing the disease's negative impact on functional capacity and life quality.

The main findings were that a combined aerobic-resistance training program improves physical capacity and life quality in CKD patients. Indeed, this exercise program decreased the total time of STS-10 and improved the repetition number of the STS-60, and the total distance covered during 6MWT. Similarly, it had a beneficial effect on physical function, body pain, and general health of life quality assessed with the SF-36 questionnaire.

Functional capacity in CKD patients can be assessed by several tests. The 6MWT is one of the most important tests that were used in the previous studies[27] because it can be validated at a low cost and easily applied. In our study, 6MWT was adopted with no difficulties. Regarding the baseline data of the mean 6MWT distance of our patients, no statistical differences were detected between the intervention and control groups. After the 12-week period, the 6MWT distance was significantly improved in the IG compared to the CG and showed that the combined aerobic-resistance program increased physical functioning in CKD patients. These results align with previous reports on exercise in CKD patients. Frih et al[28] showed that after 4 months of the exercise training program (combined endurance-resistance), the distance covered in 6MWTincreased significantly by 15.94%. Furthermore, Reboredo et al[29] showed that after three months of exercise training (aerobic) performed in14 CKD patients, the 6MWT distance increased significantly by 9%. Another study undertaken by Parsons et al[30] proved that after five months of exercise training (endurance), 13 CKD patients were associated with an increase of the 6MWT distance by 14%.

The STS-10 and STS-60 were performed to measure lower limb muscle capacity force; it was used for people with renal disease. It is a simple, inexpensive, reproducible, and rapid test. The STS-60 has been found to be a valid measure of lower limb muscle endurance. As previously mentioned, the STS-10 was performed first; then, the STS-60 was applied after a recovery period of 15 minutes. The STS-10 measures the time (in seconds) that is required to complete 10 repetitions of sitting down on and getting up from a chair consecutively, whereas the STS-60 count the number of repetitions in 60 seconds[31-33].

In our study, there was a significant increase in the number of repetitions of the sit-to-stand test (STS-60) and a decrease in the time of STS-10 in the intervention group. Compared to the control group, these results go on hand with the study undertaken by Frih et al[28] who studied the impact of an exercise training program (combined endurance-resistance) on the physiological and psychological outcomes for hemodialysis patients. The results showed a significant improvement in physical performance during the sit-to-stand-to-sit tests (STS-10: −16.2%; STS-60: +23.43%)[30].

Moreover, the study done by Tomich et al[34] investigated the effects of exercise training on the functional capacity and life quality of chronic kidney disease patients. Using the sit-to-stand test, the results showed that there was a significant increase of 24% in the distance walked in the 6-minute walk test (p=0.007) and of 47% in the number of repetitions during the sit-to-stand test (p= 0.002).

The SF-36 questionnaire was used to evaluate the self-reported domains of health status[20]. This questionnaire consists of 36 items compiled into 8 scales: physical functioning, role functioning/physical, bodily pain, general health, vitality, social functioning, role functioning/emotional, and mental health. The physical component scale (PCS) includes all dimensions[19].

Several authors, such as Valderrábano et al[35], de Jonge et al[36], and Perlman et al[37] have approved that CKD has a negative effect on the life quality of patients. According to an evaluation done in a Brazilian public hospital by Silveira et al[38], the health-related life quality of CKD patients decreased in all groups of different ages, especially regarding physical aspects.

Regarding health-related life quality results, our study revealed that a significant improvement in IG was observed after the 12-week intervention (QOL-general health, QOL-physical function, QOL-body pain, QOL-role functioning/physical, QOL-vitality, and QOL-social functioning), while the control group showed non-significant changes in all outcome measures. These findings are aligned with the results of other authors on the effect of physical training on CKD patients[39,40].

The study done by Frih et al[28] approved that physical component scores of the SF-36 questionnaire improved in IG compared with CG (p=0.003). On the other hand, a prior study did not observe any significant changes in any of the HRQoL subscale after 8 weeks of exercise training (aerobic and resistance) during hemodialysis[41]. It may be due to isolating each modality and a limited number of patients in each group which led to a decrease in the statistical power of the study, and the lack of patient blinding. These findings are in accordance with some previous studies[42], but in our study, we had significant improvement in the HRQoL subscale because we included a good number of patients and ensured patient blinding.

Also, a one-group repeated-measures study undertaken by Parsons et al[30], proved that the distance walked on the 6MWT increased by 14% at both weeks 10 and 20 ($p<0.05$), and no changes were noted in the KDQOL scores. They explained that this was perhaps related to a ceiling effect on the selected instruments (KDQOL, SF-36).

Our study aimed to document the positive effects of combined training (aerobic and resisted exercise) on functional capacity and QOL in CKD patients since the aims of health care are not only for life expectancy but also to help persons to live better. Given the positive results obtained in our study, it is a justified collection of data with a satisfied sample of patients and for an extended period to increase the evidence of the impact of physical therapy exercise training on functional capacity and life quality.

Conclusions

Patients with CKD have physical changes that predispose them to a sedentary lifestyle. Twelve-week aerobic and resistance exercise training improved functional capacity and QOL in CKD patients. Concurrent exercise training should be recommended as an interventional modality in physical therapy and rehabilitation protocols in CKD patients.

Conflict of Interest

No potential conflict of interest was reported.

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Informed Consent

Each patient has signed a written informed consent before starting the study program.

Data Availability

The authors declare that all relevant data supporting the findings of this study are available within the article.

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