ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA DOI: 10.5336/healthsci.2024-104098

Effect of Calisthenic Exercise on Aerobic Capacity, Grip Strength and Quality of life of Patients Undergoing Haemodialysis: A Single-Blind Placebo-Controlled Randomized Trial

Hemodiyaliz Hastalarında Kalistenik Egzersizin Aerobik Kapasite, Kavrama Kuvveti ve Yaşam Kalitesi Üzerindeki Etkisi: Tek Kör Plasebo Kontrollü Randomize Çalışma

Nazan ÖZTÜRK[a], Ayşegül KAHRAMAN[b], Hakan AKDAM[c], Fatma ÜNVER[d]

[a]Aydın Adnan Menderes University Söke Vocational School of Health Services, Department of Health Care Services, Aydın, Türkiye
[b]Aydın Adnan Menderes University Nazilli Vocational School of Health Services, Department of Health Care Services, Aydın, Türkiye
[c]Aydın Adnan Menderes University Faculty of Medicine, Division of Nephrology, Aydın, Türkiye
[d]Pamukkale University Faculty of Physiotherapy and Rehabilitation, Department of Physiotherapy and Rehabilitation, Denizli, Türkiye

ABSTRACT Objective: Although hemodialysis (HD) has increased patients' life expectancy, physical limitations have emerged. As a result of adopting a physically inactive lifestyle, the aerobic capacity, overall health, and quality of life of this patient group are negatively affected. This study aims to fill the gap in understanding the specific benefits of different physical activities for this population. While the benefits of physical activity for HD patients are known, there is no consensus on which activity has what kind of effect. This randomized controlled trial aimed to demonstrate the effects of calisthenic exercise on aerobic capacity, grip strength, and quality of life in HD patients. **Material and Methods:** The study included 47 hemodialysis patients divided into control (n=23) and exercise (n=24) groups. Calisthenic exercise was given to the exercise group three times a week for eight weeks. The 6-Minute Walk Test (6MWT), the 30-Second Sit-and-Stand Test (30-SSST), a handgrip hand dynamometer and the Kidney Disease Quality of Life Questionnaire (KDQOL-SF) were used. **Results:** The 30-Second Sit-and-Stand Test (30-SSST) (p=0.008); clinical parameters, such as creatinine (p=0.04), albumin (p=0.003) and haemoglobin levels (p=0.019); Kidney Disease Quality of Life Questionnaire (KDQOL-SF) physical component subdimensions (p=0.01); symptoms and problems (p=0.042); effect of kidney disease (p=0.017) and total quality of life (p=0.021) increased in the exercise group. The 30-SSST (p=0.009) and KDQOL-SF physical component subdimensions (p=0.021) increased in the control group. **Conclusion:** Post-exercise measurements of the given parameters of patients undergoing HD that participated in the calisthenic exercise programme improved compared with pre-exercise measurements.

Keywords: Exercise; dialysis; quality of life

ÖZET Amaç: Hemodiyaliz (HD) tedavisi, hastaların yaşam beklentisini artırmış olsa da, fiziksel kısıtlamalar ortaya çıkmaktadır. Fiziksel olarak aktif olmayan bir yaşam tarzının benimsenmesi sonucunda, bu hasta grubunun aerobik kapasitesi, genel sağlık durumu ve yaşam kalitesi olumsuz etkilenmektedir. Bu çalışma, bu popülasyon için farklı fiziksel aktivitelerin spesifik faydalarını anlama konusundaki boşluğu doldurmayı amaçlamaktadır. Fiziksel aktivitenin HD hastaları için faydaları bilinmekte olsa da, hangi aktivitenin ne tür bir etki yarattığı konusunda bir fikir birliği yoktur. Bu randomize kontrollü çalışma, kalistenik egzersizin HD hastalarında aerobik kapasite, kavrama gücü ve yaşam kalitesi üzerindeki etkilerini göstermeyi hedeflemiştir. **Gereç ve Yöntemler:** Çalışmaya 47 hemodiyaliz hastası dahil edilmiştir ve hastalar kontrol (n=23) ve egzersiz (n=24) gruplarına ayrılmıştır. Egzersiz grubuna sekiz hafta boyunca haftada üç kez kalistenik egzersiz uygulanmıştır. Değerlendirmelerde 6 Dakika Yürüyüş Testi (6MWT), 30 Saniye Otur-Kalk Testi (30-SSST), el kavrama dinamometresi ve Böbrek Hastalığı Yaşam Kalitesi Anketi (KDQOL-SF) kullanılmıştır. **Bulgular:** Egzersiz grubunda 30-SSST (p=0.008); klinik parametreler, kreatinin (p=0.04), albumin (p=0.003) ve hemoglobin seviyeleri (p=0.019); KDQOL-SF fiziksel bileşen alt boyutları (p=0.01); semptomlar ve sorunlar (p=0.042); böbrek hastalığının etkisi (p=0.017) ve toplam yaşam kalitesi (p=0.021) artmıştır. Kontrol grubunda da 30-SSST (p=0.009) ve KDQOL-SF fiziksel bileşen alt boyutları (p=0.021) artış göstermiştir. **Sonuç:** Kalistenik egzersiz programına katılan hemodiyaliz (HD) hastalarının verilen parametrelerinin egzersiz sonrası ölçümleri, egzersiz öncesi ölçümlerle karşılaştırıldığında iyileşmiştir.

Anahtar Kelimeler: Egzersiz; diyaliz; yaşam kalitesi

TO CITE THIS ARTICLE:
Öztürk N, Kahraman A, Akdam H, Ünver F. Effect of calisthenic exercise on aerobic capacity, grip strength and quality of life of patients undergoing haemodialysis: A single-blind placebo-controlled randomized trial. Turkiye Klinikleri J Health Sci. 2025;10(1):85-96.

Correspondence: Nazan ÖZTÜRK
Aydın Adnan Menderes University Söke Vocational School of Health Services, Department of Health Care Services, Aydın, Türkiye
E-mail: nazan.ozturk@adu.edu.tr

Peer review under responsibility of Turkiye Klinikleri Journal of Health Sciences.

Received: 25 May 2024 ***Received in revised form:*** 04 Oct 2024 ***Accepted:*** 16 Oct 2024 ***Available online***: 19 Dec 2024

Haemodialysis is a vital and common form of treatment for patients with chronic kidney disease.[1] Advanced age, concomitant diseases, uremic myopathy and neuropathy, altered protein catabolism, anaemia and dialysis can cause muscle symptoms, limiting dialysis patients' daily physical capacity and lowering their quality of life.[2] Due to inactivity during haemodialysis treatment and post-dialysis fatigue symptoms, patients' physical activity levels decrease, with a reduction of 17% on dialysis days compared with non-dialysis days.[3] Moreover, the limited engagement in physical activity among individuals undergoing haemodialysis can be attributed to various factors. These factors encompass patients' apprehension towards exercise, coupled with inadequacies in encouragement from nephrologists, nurses or healthcare providers.[2] Consequently, the adoption of a sedentary lifestyle within this patient demographic adversely impacts their aerobic capacity, walking ability, overall health and quality of life.[4] The main goals of renal patient management include maintaining functional capacity and providing adequate physical therapy to reduce dependency in performing daily activities.[2] As per the recommendations provided by the Kidney Disease Outcomes Quality Initiative Clinical Practice Guidelines, it is advisable to promote an elevation in the level of physical activity among individuals undergoing haemodialysis.[5] Research studies also emphasise that exercise serves as a supplementary and beneficial approach in the treatment of patients receiving haemodialysis.[6] In the literature, it has been shown that endurance exercises reduce blood pressure in patients undergoing haemodialysis, and resistance exercises improve walking and aerobic capacity, increase functional capacity, and improve quality of life.[7]

Despite evidence supporting the advantages of exercise for haemodialysis patients, there is a lack of agreement on the most effective exercise mode and intensity.[8] Low-intensity physical exercise programmes are suggested, because they may be more beneficial in patients undergoing haemodialysis due to their low exercise capacity. Additionally, the patient population undergoing haemodialysis is primarily elderly, and they may exhibit age-related fragility. In individuals undergoing haemodialysis, reduced physical activity significantly impacts their overall health and quality of life.[7,9] Although various low to moderate-intensity exercises exist, the specific suitability of calisthenic exercises within this unique patient population remains inadequately explored.[10] Given the prevalence of inactivity during haemodialysis treatments and post-dialysis fatigue, there is a critical need to assess the tolerance and effectiveness of calisthenics for these individuals. Calisthenics offer a low-impact, rhythmic, and equipment-free exercise method that may align well with the needs of this demographic. During haemodialysis treatment, exercise prescriptions created by physiotherapists with individual loading principles and rest intervals can play an active role in minimizing the symptoms experienced by individuals, and during this period, calisthenic exercises can be preferred because they can be planned rhythmically and specifically for the individual. However, the literature lacks studies specifically examining the feasibility and benefits of calisthenic exercises in haemodialysis patients. This randomized controlled trial investigates the effects of calisthenic exercise on aerobic capacity, grip strength, physiological parameters, and quality of life in patients undergoing haemodialysis, addressing the lack of consensus on exercise mode and intensity for this population.

There is a remarkable lack of randomised controlled studies in the literature demonstrating the effectiveness of exercises in patients undergoing haemodialysis.[10-12] No study has examined calisthenics in patients undergoing haemodialysis; however, few studies have focused on calisthenics among patients with renal transplants, and the present randomized controlled trial is carried out in the same line with subsequent research with different target populations.[13]

The aim of this study was to assess the effect of calisthenic exercise on aerobic capacity, grip strength, physiological parameters, and quality of life in patients undergoing haemodialysis.

Hypotheses

H0: Calisthenic exercise application in haemodialysis patients increases aerobic capacity.

H1: Calisthenic exercise application in haemodialysis patients increases muscle strength.

H2: Calisthenic exercise application in haemodialysis patients improves quality of life.

MATERIAL AND METHODS

This is a randomised single-blind placebo-controlled study. The study was conducted between March and September 2021.

STUDY POPULATION AND SAMPLING

From March to September 2021, 65 patients undergoing haemodialysis treatment were enrolled in this parallel, randomized, controlled trial at the dialysis centre of Aydın Adnan Menderes University Faculty of Medicine Research and Application Hospital/Türkiye.

This randomized controlled trial was conducted following the Declaration of Helsinki. The Consolidated Standards of Reporting Trials (CONSORT) guidelines are followed in its presentation. The Ethics Committee of the Faculty of Medicine of Aydın Adnan Menderes University in Türkiye approved the study (date: March 02, 2021, no: E-53043469-050.04.04-9332), and written informed consent was obtained from all patients in the trial.

The study population consisted of volunteers aged 18-60 years, undergoing maintenance haemodialysis for a minimum of three months, undergoing haemodialysis three times per week, exhibiting good cognitive function, and lacking regular exercise habits and physical disabilities. Cognitive levels were determined by applying the mini mental test. Participants must sign the informed consent form to participate in the study.

The study excluded participants who had experienced neurological impairment (e.g., cerebrovascular accident or Guillain-Barré syndrome), those with musculoskeletal limitations that precluded exercise, individuals with central and peripheral nervous system diseases, those with advanced heart failure, unstable angina pectoris, chronic liver failure, or a history of cardiovascular events within the previous 12 months.[13]

Participants were selected using a simple and stratified randomization method. The control and exercise groups were formed at random. In this study, the confidence interval and power were set at 95%, and the effect size was determined to be 0.746 based on the results of the reference study.[14] The case intervention group ratio was 1:1. In accordance with the aforementioned values, the sample size was calculated in the presence of a two-sided hypothesis in the a priori power analysis according to the t-test using the r. G*Power program (G-Power version 3.1.9.2, Heinrich Heine University, Düsseldorf, Germany). The calculated sample size was determined to be 46, comprising the intervention (n=23) and placebo control (n=23) groups. With 95% confidence interval and 80% theoretical power, 46 patients were included. In the present study, no limitations existed in the exercise and control groups; therefore, all haemodialysis patients who met the inclusion criteria were included in the study. The Consolidated Standards of Reporting Trials flowchart of the study (Figure 1) shows that the study was conducted with 24 patients undergoing haemodialysis in the exercise group and 23 patients undergoing haemodialysis in the control group, following the application of the exclusion criteria.

DATA COLLECTION TOOLS

Data were collected using the Patient Information Form, 6-Minute Walk Test (6MWT), 30-Second Sit-and-Stand Test (30-SSST), hand grip strength measurement, Kidney Disease Quality of Life Questionnaire (KDQOL-SF) and the physiological evaluation form.

Patient Information Form

The Patient Information Form, created by the researcher according to the literature, is divided into two sections. The first section includes questions about the patients' socio-demographic characteristics and the second section includes questions about the disease's characteristics.

6MWT

The 6MWT was administered to the patients prior to dialysis. The walking track was built along the dialysis unit corridor. A 30-m walking track was built. The 30-m course's beginning and ending points were marked with a thick, visible line. One lap was defined as a total walking distance of 60 m (30 m in each direction). Individuals were given 6 min to commute this distance. The total distance walked by the patient in 6 min was measured in metres and recorded.[15]

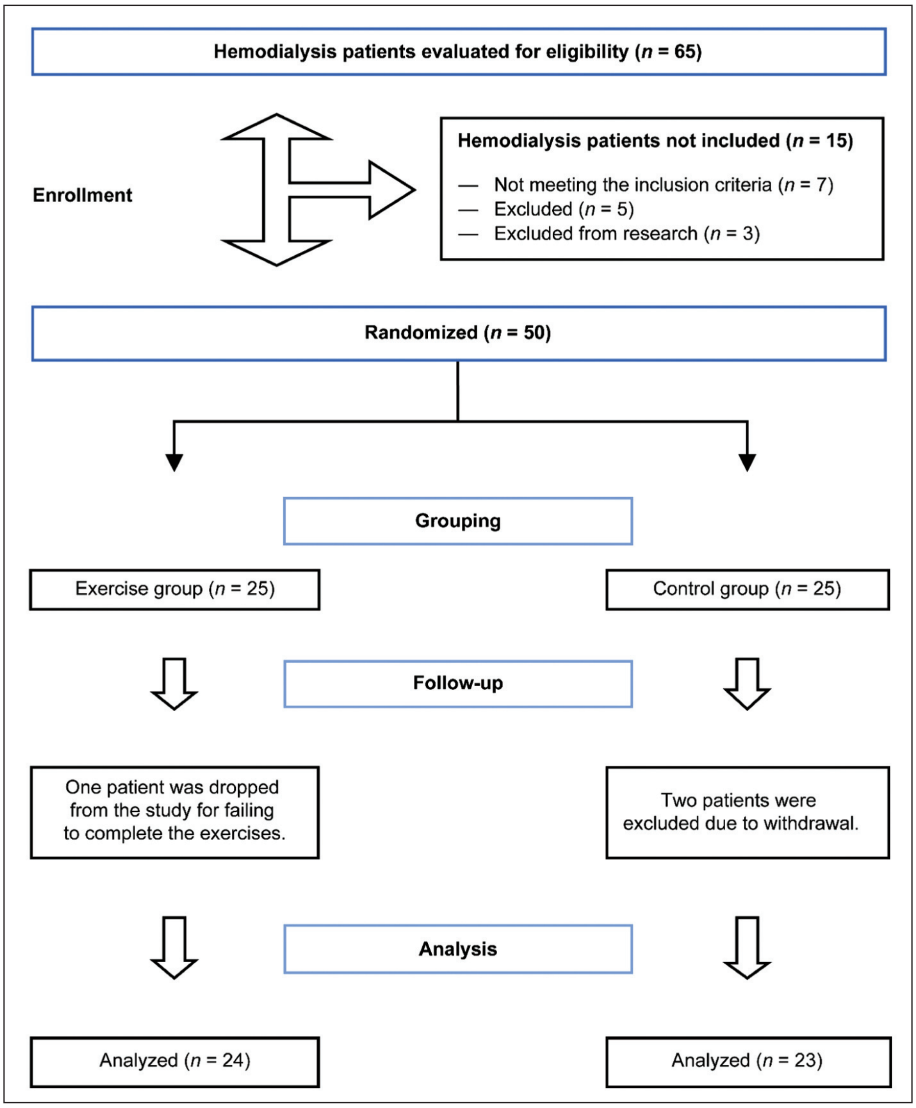

FIGURE 1: Consolidated Standards of Reporting Trials flowchart.

30-SSST

The 30-SSST was used to assess the patients' dynamic balance, physical fitness and levels of lower extremity neuromuscular function. The individual began the test by sitting in a chair without arms, with their back upright, feet on the ground and arms crossed across their chest. The patients were asked to stand up and sit back for 30 s. The total number of sit-and-stands performed in 30 s was recorded.[16]

Hand Grip Strength Measurement

Hand grip strength was assessed using a digital dynamometer (Takei 5401, TKK5401, Takei Scientific Instruments Co., LTD, Tokyo, Japan). Participants were seated in a chair and instructed to grip a dynamometer with their elbows close to their body, bent at a 90-degree angle, and their wrists in a neutral position. Then the patient was instructed to squeeze the device as forcefully as possible. The grip strength test was performed twice for both hands. A 10-second rest was allowed between trials. The mean value of the four measurements was calculated as the participant's grip strength.[17]

KDQOL-SF

The KDQOL-SF scale is used to monitor patients with end-stage renal disease and evaluates various treatment effects and well-being based on the patient's self-report. The questionnaire contains 36 items divided into five dimensions: kidney disease burden, symptoms and problems, kidney disease effect and physical and mental components. Each dimension's score ranges from 0 to 100. A higher score on the health-related quality of life questionnaire indicates that the participant perceives a higher level of well-being and satisfaction with their overall health and life circumstances. Yildirim et al. established Turkish validity and reliability, and the Cronbach's α coefficient was reported as 0.84-0.91. The Cronbach's α coefficient of the scale in this study was 0.83 in the exercise group and 0.77 in the control group before the application and 0.72 in the exercise group and 0.83 in the control group after the application.[18]

Physiological Parameters Registration Form

A number of physiological changes are expected in exercisers as a result of both acute and chronic adaptation. The physiological evaluation form, which the researcher prepared based on the literature, includes information on blood parameters [blood urea nitrogen (BUN), creatinine, albumin, cholesterol, haemoglobin and haematocrit]. In our study, the results of the biochemistry laboratory were used to determine the blood profiles of the programme's participants.

All measurements and assessments in our study were taken before the study (pre-test) and 8 weeks after the study (post-test).

INTERVENTION

Exercise Group

The research physiotherapist informed patients undergoing haemodialysis in the exercise group about calisthenic exercise prior to the study. The exercises were performed in the dialysis unit with the assistance of a research physiotherapist. The exercise flow and weekly progress were described. The participants were subjected to a 40- to 50-min exercise programme 3 days a week for 8 weeks. Warm-up and breathing exercises were performed before starting the calisthenic exercises. The exercise programme included warm-up, spine lateral flexion, spine twisting, neck rotation, neck flexion and extension, trunk flexion and extension, trunk lateral flexion, arm circles and strengthening exercises, such as sit-ups/crunches and push-ups. The intensity of the exercises was calibrated each week. The application severity was also set at a level of 4-6 on the modified Borg scale. Patients were given time to rest between exercises based on their tolerance.[19] The recommended number of repetitions for calisthenic exercises is as follows: 10-15 in the initial two weeks, 15-20 in the subsequent two weeks, and 25-30 in the final four weeks. It was proposed that the exercises be performed in a rhythmic manner, that the more challenging ones be identified, and that they be supported by a chair or wall if necessary. Patients were asked to keep an exercise diary, and weekly phone calls were made to ensure that their motivation was maintained. Every other week, they were checked in the dialysis unit to make sure they were doing the exercises correctly. Those who experienced one session of disruption in the flow of their exercises were given a recovery period, and their final tests were calculated with this time in mind. Those who did not exercise for two consecutive sessions were excluded from the study.[13]

Control Group

The control group was briefed about the importance of physical activity; however, the patients were not followed up like the exercise group. They were advised to continue their normal daily work and take regular walks. They continued their current medical treatment.[20]

DATA ANALYSIS

Statistical analysis was performed with SPSS 25.0 (IBM, USA). Continuous variables are presented using mean±standard deviation, and categorical variables are presented using number and percentage. Normal distribution was assessed using the Shapiro-Wilk test. In instances where parametric test assumptions were established for independent group comparisons, an independent samples t-test was employed. In cases where parametric test assumptions were not met, the Mann-Whitney U test was used. In cases where parametric test conditions were satisfied for intragroup comparisons, paired samples t-test was used. In cases where parametric test conditions were not met, the Wilcoxon-Signed Rank test was used. Chi square test was used for categorical variables.

Cohen's d effect size was used for effect size examinations. Statistical significance was determined as p<0.05.

RESULTS

Patients were randomly assigned to one of two groups: 24 patients in the exercise group (eight females and 16 males) and 23 patients in the control group (eight females and 15 males). In terms of age, gender, marital status, education status, living and socioeconomic status, primary kidney disease type, type and duration of dialysis and with similar characteristics, no statistical difference was found between the groups (p>0.05, Table 1).

A significant difference was observed between the exercise and control groups only in the post-test in the 30-SSST (p=0.032) and 6MWT (p=0.009). The exercise group's post-test values were significantly higher than the control group. While no difference was found in the 6MWT used to evaluate the patients' in-group exercise capacity (p>0.05), the changes in the 30-SSST showed a statistically significant increase in the exercise (p=0.008) and control (p=0.009) groups. No significant difference was found between the exercise and control groups in the hand grip strength assessments (p>0.05, Table 2).

In our study, no significant difference in blood values was found between the exercise and control groups (p>0.05). Within-group analyses revealed that there was no significant difference in BUN, total cholesterol and haematocrit values (p>0.05) in the exercise group; however, a significant increase in creatinine (p=0.04), albumin (p=0.003) and haemoglobin (p=0.019) values. Additionally, the difference in haemoglobin values obtained in the pre-test and post-test showed a significant difference between the two groups. The exercise group experienced significantly higher change than that the control group (Table 3).

TABLE 1: Comparison of socio-demographic and clinical characteristics of patients (n=47).

		Groups control (n=23)	Exercise (n=24)	Total (n=47)	p value
Sex	Female	8 (34.8%)	8 (33.3%)	16 (34%)	0.91[a]
	Male	15 (65.2%)	16 (66.7%)	31 (66%)	
Age (yr, $\overline{X}$±SD)		55 (44-64)	51 (37-60)		0.286[b]
Marital status	Single	6 (26.1%)	6 (25%)	12 (25.5%)	0.22[a]
	Married	15 (65.2%)	18 (75%)	33 (70.2%)	
	Divorced	2 (8.7%)	0 (0%)	2 (4.3%)	
Education level	None	4 (17.4%)	2 (8.3%)	6 (12.8%)	0.415[a]
	Primary school	8 (34.8%)	7 (29.2%)	15 (31.9%)	
	Secondary school	4 (17.4%)	2 (8.3%)	6 (12.8%)	
	High school	6 (26.1%)	9 (37.5%)	15 (31.9%)	
	Other	1 (4.3%)	4 (16.7%)	5 (10.6%)	
Living status	Alone	3 (13%)	1 (4.2%)	4 (8.5%)	0.348[a]
	With family	20 (87%)	23 (95.8%)	43 (91.5%)	
Socioeconomic status	Low	3 (13%)	3 (12.5%)	6 (12.8%)	0.998[a]
	Moderate	19 (82.6%)	20 (83.3%)	39 (83%)	
	High	1 (4.3%)	1 (4.2%)	2 (4.3%)	
Primary kidney disease	Diabetic nephropathy	8 (40%)	9 (37.5%)	17 (38.6%)	0.713[a]
	Hypertensive nephropathy	6 (30%)	8 (33.3%)	14 (31.8%)	
	Glomerulonephritis	0 (0%)	1 (4.2%)	1 (2.3%)	
	Other	6 (30%)	6 (25%)	12 (27.3%)	
Dialysis treatment type	Haemodialysis	14 (60.9%)	10 (41.7%)	24 (51.1%)	0.246[a]
	Home haemodialysis	2 (8.7%)	6 (25%)	8 (17%)	
	Hemodiafiltration	7 (30.4%)	8 (33.3%)	15 (31.9%)	
Dialysis time (month, $\overline{X}$±SD)		36 (30-84)	39 (13.5-84)		0.797[b]

[a]χ^2 test; [b]Mann-Whitney U test; SD: Standard deviation.

TABLE 2: Comparison of 30-Second Sit-and-Stand Test, 6-Minute Walk Test distance, grip strength in the exercise and control groups.

		Exercise group (n=24)		Control group (n=23)		
		X̄±SD	Med (IQR)	X̄±SD	Med (IQR)	p (ES)
30-Second Sit-and Stand Test (s)	Pretest	10.96±2.46	11.5 (9.25-13)	9.83±2.64	10 (8-12)	0.11[c] (-0.233)
	Post-test	12.17±2.41	13 (10.25-13)	10.61±2.41	11 (9-12)	0.032[d,*] (-0.647)
	Difference	-1.21±2.04	-1 (-2-0)	-0.78±1.81	-1 (-2-0)	0.454[c] (0.22)
	p (ES)	0.008[a,*] (-0.592)		0.05[a,*] (-0.433)		
6-Minute Walk Test (m)	Pretest	237.29±83.26	235 (185-270)	203.26±66.14	200 (150-260)	0.129[c] (-0.451)
	Post-test	240.83±73.78	250 (205-280)	185.22±74.4	190 (140-260)	0.009[d,*] (-0.383)
	Difference	-3.54±49.97	-15 (-30-25)	18.04±57.08	0 (-10-30)	0.116[d] (-0.229)
	p (ES)	0.732[a] (-0.071)		0.323[b] (-0.206)		
Right Hand Grip Test (kg)	Pretest	22.03±9.75	21.9 (15.25-29.08)	20.65±10.34	20.2 (13.8-27.3)	0.64[c] (-0.137)
	Post-test	22.34±10.83	19.6 (14.25-31.38)	20.23±10.62	18.9 (10.4-26.8)	0.503[c] (-0.197)
	Difference	-0.31±4.67	0.05 (-3.28-3.7)	0.42±3.99	1 (-2.2-3)	0.568[c] (0.168)
	p (ES)	0.749[a] (-0.066)		0.618[a] (0.106)		
Left Hand Grip Test (kg)	Pretest	19.75±7.84	17.7 (13.83-23.03)	18.27±11.35	18.5 (10.5-23.8)	0.537[d] (-0.09)
	Post-test	18.49±9.02	13.5 (11.68-24.55)	16.77±10.13	14.2 (10.3-21.7)	0.4[d] (-0.123)
	Difference	1.26±5.09	1.55 (-1.55-3.18)	1.5±5.39	1.6 (-1.9-4.9)	0.84[d] (-0.029)
	p (ES)	0.055[b] (-0.391)		0.197[a] (0.278)		

*p<0.05 (statistically significant); [a]Paired sample t-test; [b]Wilcoxon-signed rank test; [c]Independent sample t-test; [d]Mann-Whitney U test; ES: Effect size; SD: Standard deviation.

TABLE 3: Comparison of blood values in the exercise and control groups.

		Exercise group (n=24)		Control group (n=23)		
Blood values		X̄±SD	Med (IQR)	X̄±SD	Med (IQR)	p (ES)
BUN (g/dL)	Pretest	97.96±23.53	100.5 (78.5-119.5)	96.57±25.27	86 (77-119)	0.846[c](-0.057)
	Post-test	100.06±24.53	102 (82-122)	93.81±32.29	96 (79-122)	0.458[c](-0.219)
	Difference	-2.1±33.61	-1 (-26.75-20.59)	2.75±40.38	-10 (-18-28.54)	0.941[d](-0.011)
	p (ES)	0.762[a] (-0.063)		0.843[b] (-0.041)		
Creatinine (g/dL)	Pretest	8.27±2.28	8.31 (6.46-9.59)	8.1±2.2	8.23 (6.2-9.56)	0.873[d] (-0.023)
	Post-test	6.6±2.74	7.09 (5.2-8.59)	7.98±2.16	8.27 (6-9.22)	0.128[d] (-0.222)
	Difference	1.67±3.16	0.19 (-0.17-3.93)	0.13±1.67	0.2 (-0.85-1.16)	0.297[d] (-0.152)
	p (ES)	0.04[b,*](-0.42)		0.456[b](-0.155)		
Albumin (g/dL)	Pretest	3.62±0.45	3.57 (3.25-4.02)	3.53±0.43	3.51 (3.37-3.74)	0.48[c](-0.208)
	Post-test	3.89±0.35	4.03 (3.55-4.14)	3.67±0.52	3.72 (3.58-3.96)	0.115[d](-0.23)
	Difference	-0.27±0.4	-0.33 (-0.51- -0.04)	-0.13±0.39	-0.15 (-0.44-0.09)	0.278[d](-0.158)
	p (ES)	0.003[a,*](-0.674)		0.068[b](-0.381)		
Total cholesterol (g/dL)	Pretest	175.83±52.46	167 (135-193)	157.3±38.49	152 (133-174)	0.208[d](-0.183)
	Post-test	170.3±54.91	158 (132-190)	152.16±48.29	157 (130-179)	0.629[d](-0.07)
	Difference	5.39±25.23	0 (-6-19)	5.15±45.91	0 (-13-10)	0.588[d](-0.079)
	p (ES)	0.293[b](-0.215)		0.926[b](-0.019)		
Haemoglobin (g/dL)	Pretest	10.6±2.02	11 (8.83-11.58)	11.2±1.19	11.4 (10.3-11.8)	0.222[c](0.362)
	Post-test	11.42±1.93	11.55 (10.58-12.38)	11.12±1.19	11.3 (10.2-11.9)	0.287[d](-0.155)
	Difference	-0.82±1.58	-0.6 (-1.08- -0.2)	0.08±1.24	-0.1 (-0.5-1.1)	0.037[c,*](0.628)
	p (ES)	0.019[a,*](-0.516)		0.765[a](0.063)		
Haematocrit (%)	Pretest	33.28±6.48	34.1 (28.5-36.55)	35.57±3.66	34.9 (33.5-38.2)	0.142[c](0.438)
	Post-test	34.81±5.75	35.45 (32.93-37.43)	34.83±3.85	35 (31.1-37.9)	0.823[d](-0.033)
	Difference	-1.53±4.83	-1 (-2.75-0.85)	0.74±4.05	0.8 (-1.3-3.5)	0.083[d](-0.253)
	p (ES)	0.11[b](-0.326)		0.388[a](0.184)		

*p<0.05 (statistically significant); aPaired sample t-test; bWilcoxon-signed rank test; cIndependent sample t-test; dMann-Whitney U test; ES: Effect size.

TABLE 4: Comparison of KDQOL-SF in the exercise and control groups.

		Exercise group (n=24)		Control group (n=23)		
KDQOL-SF		**X̄±SD**	**Med (IQR)**	**X̄±SD**	**Med (IQR)**	**p (ES)**
Physical component	Pretest	43.81±10.77	44.62 (34.78-53.54)	41.6±12.5	39.26 (33.46-53.6)	0.519[c](-0.189)
	Post-test	49.46±9.44	53.36 (44.59-56.05)	46.41±11.56	52.18 (38.7-55.08)	0.344[d](-0.138)
	Difference	-5.65±9.8	-4.33 (-12.42-1.04)	-4.81±9.25	-3.12 (-9.08-0)	0.763[c](0.088)
	p (ES)	0.01[a,*](-0.577)		0.021[a,*](-0.52)		
Mental component	Pretest	44.28±9.54	43.4 (39.92-50.53)	46.7±9.77	45.22 (40.87-55.57)	0.394[c](0.251)
	Post-test	47.19±6.75	48.34 (40.46-52.38)	47.35±8.67	49.02 (41.51-54.48)	0.945[c](0.02)
	Difference	-2.91±8.69	-3.19 (-8.91-3.5)	-0.64±7.97	0 (-6.9-5.16)	0.357[c](0.272)
	p (ES)	0.114[a](-0.335)		0.702[a](-0.081)		
Burden of kidney disease	Pretest	41.41±24.58	40.63 (20.31-62.5)	42.12±30.92	37.5 (18.75-62.5)	0.93[c](0.026)
	Post-test	45.05±28.91	43.75 (20.31-71.88)	44.02±31.22	37.5 (25-75)	0.907[c](-0.034)
	Difference	-3.65±20.01	0 (-18.75-10.94)	-1.9±25.17	0 (-12.5-6.25)	0.872[d](-0.023)
	p (ES)	0.381[a](-0.182)		0.775[b](-0.06)		
Symptoms and problems	Pretest	82.99±14.07	86.46 (69.27-95.83)	81.43±17.03	87.5 (70.83-95.83)	1[d](0)
	Post-test	87.15±11.78	89.59 (83.33-95.83)	83.24±19.4	91.67 (72.92-100)	1[d](0)
	Difference	-4.17±9.5	-2.08 (-10.42-2.09)	-1.81±13.21	0 (-8.33-2.08)	0.485[c](0.205)
	p (ES)	0.042[a,*](-0.439)		0.518[a](-0.137)		
Effects of kidney disease	Pretest	75±19.5	75 (64.85-90.63)	75.68±19.94	84.38 (56.25-90.63)	0.856[d](-0.027)
	Post-test	84.64±18.61	92.19 (73.44-96.88)	81.39±20.15	87.5 (59.38-100)	0.821[d](-0.033)
	Difference	-9.63±18.34	-9.38 (-20.31-0)	-5.71±16.66	-3.12 (-9.37-0)	0.177[d](-0.197)
	p (ES)	0.017[a,*](-0.525)		0.209[b](-0.262)		
Total quality of life score	Pretest	60.86±14.47	61.07 (49.27-75.62)	60.85±16.13	61.46 (51.78-76.96)	0.998[c](-0.001)
	Post-test	66.29±13.53	67.76 (56.3-77.35)	63.88±17.54	65.89 (51.78-78.91)	0.6[c](-0.154)
	Difference	-5.43±9.83	-6.65 (-10.14-0.51)	-3.04±11.52	-0.15 (-9.56-1.91)	0.446[c](0.224)
	p (ES)	0.013[a,*](-0.553)		0.219[a](-0.264)		

*p<0.05 (statistically significant); aPaired sample t-test; bWilcoxon-signed rank test; cIndependent sample t-test; dMann-Whitney U test; KDQOL-SF: Kidney Disease Quality of Life Questionnaire; ES: Effect size.

In terms of KDQOL-SF scores, we found no statistically significant difference between groups. In intragroup tests, a statistically significant increase was found between the exercise group's physical component (p=0.01), symptoms and problems (p=0.042), effect of kidney disease (p=0.017) and total quality of life scores (p=0.013). Only the physical component (p=0.021) subdimension was found to be significant in within-group evaluation of the control group (Table 4).

DISCUSSION

This randomized controlled study aims to find out the effect of calisthenic exercise training on aerobic capacity, muscle strength and quality of life in patients undergoing haemodialysis. We found that calisthenic exercise improved blood parameters, such as creatinine, albumin and haemoglobin levels; symptoms and problems; effect of kidney disease subdomain scores; and the total score of the KDQOL-SF. There was a difference in the sit-and-stand test and the physical component of the KDQOL-SF in both the exercise and control groups. Changes in 6MWT, 30-SSST and haemoglobin levels were observed when groups were compared.

Similar to our study, a meta-analysis study has found that exercise increased the 6MWT distance in patients undergoing haemodialysis.[21] Furthermore, Vogiatzaki et al. (via 6 months of aerobic exercise) and Esteve Simo et al. (via a combined resistance exercise programme) reported significant improvements in 6MWT and walking distance in patients undergoing haemodialysis.[2,22] However, there are studies in the literature showing that exercise has no effect on physical performance in patients undergoing haemodialysis. This is hypothesized to be due to the patients' high pre-intervention 6MWT test values and the fact that the exercise programmes are not appropriate for the individuals' functionality.[23]

In our study, the increase in the 6MWT indicates that calisthenic exercises increase aerobic capacity in haemodialysis patients. Increased aerobic capacity is important because it can improve dialysis patients' autonomy, personal independence and social life.

Poor performance in the 30-SSST may indicate physical impairment and decreased exercise capacity in patients undergoing haemodialysis.[24] The 30-SSST in patients undergoing haemodialysis performing calisthenic exercise yielded results that is consistent with other study in the literature.[25]

Unlike in the literature, both groups improved on the 30-SSST in our study. We believe that it increased in the group that did not receive exercise because sitting and standing are part of daily life activities. A review of the literature reveals that exercise has been shown to improve the 30-SSST in patients undergoing haemodialysis. This has been demonstrated to positively impact their daily living activities and exercise capacities.

Dong et al. (in a 12-week exercise programme in which participants used their own body weight and elastic balls) found a statistically significant difference in grip strength.[26] However, no change was observed. Similar to the present results, Rosa et al. found no significant difference in grip strength.[27] We posit that this result is due to the fact that the patients in our study did not want to squeeze the handgrip due to their arteriovenous fistulas and there were no grasping exercises in the calisthenic exercises. In this case, it is proposed that further research be conducted to assess the efficacy, safety and applicability of upper extremity exercises.

Regular physical exercise improves dialysis patients' quality of life.[7,12] A meta-analysis of 21 studies revealed that exercise training enhanced the physical component subdimension of dialysis patients' quality of life by an average of 43%.[14] Aytar Tığlı and Yakut also observed an improvement in the exercise group's social function subdimension.[13]

In our study, improvements in the physical component and symptoms and effects of kidney disease subdimensions of the KDQOL-SF and overall quality of life were observed in the exercise group. The mental component and burden of kidney disease subdimensions of quality of life remained unchanged. Dialysis can lead to psychosocial problems by affecting individuals' self-perception, mental states, social relationships, roles and professional lives. Many patients are unable to continue working at their previous levels of competence, their family life and roles change and their reliance on their spouse grows. All of these changes affect all aspects of dialysis patients' social, economic and psychological lives and may cause them to see themselves as a burden.[28] We believed that our study's evaluation period was insufficient to demonstrate the effect on the mental component and the burden of kidney disease. Therefore, we believe that studies with a longer evaluation period will be able to demonstrate the effects of exercise on both the mental component and the burden of kidney disease. Unlike previous research, we found an increase in the physical component subdimension of the control group in our study. There are many factors that have a negative impact on dialysis patients' physical capacity. One of these is the presence of anaemia due to insufficient erythropoietin production.[29] In our study, the exercise group's haemoglobin levels increased significantly, while the pre-test and post-test haemoglobin levels of the patients in the control group were within the normal range for dialysis patients. We believe that this situation has a positive effect on the physical capacities of the patients in the control and exercise groups. In conclusion, calisthenic exercises performed as a regular physical activity are a preferable practice for improving the quality of life in haemodialysis patients.

In studies comparing the blood parameters of patients who exercised and patients who did not exercise during dialysis, it was found that patients who exercised had a significant improvement in serum phosphate levels compared with patients who did not exercise, but there was no change in albumin and calcium levels.[30] The creatinine and albumin levels of the exercise group increased statistically significantly in the present study. We believe that the elevated creatinine level caused by muscle destruction indicated the presence of increased muscle mass as a result of exercise. In addition, the albumin value, which is a nutritional parameter, indicated that the patients' quality of life had improved. Regular, long-term and moderate-intensity aerobic exercise lowers lipids, such as total cholesterol, low-density lipoprotein cholesterol and triglycerides, which are risk factors for coronary artery disease and raises high-density lipoprotein levels.[31] However, in our study, we found that the calisthenic exercise programme had no effect on the patients' total cholesterol levels. We believe that this result is due to the fact that our study was only 8 weeks long. We believe that long-term exercise programmes can produce more positive lipid profile results.

There were some limitations to this study. First, the findings may not be fully generalisable owing to its single-centre design. Our findings suggest that studies with longer-term and more multicentre interventions are required. This study included elderly patients with relatively good physical function, but excluded patients who could not walk independently. Further research is needed to determine the effect of exercise therapy on elderly patients with poor physical function. The lack of a sham exercise control activity, due to the single site nature of the study, is a further limitation. In addition, outcome assessors were blinded to group allocation, although participants could not be blinded to the intervention. Another limitation of our study is that physical activity level was not assessed in this study.

The principal strength of our study is that by enhancing physical functionality, the quality of life, which is a crucial consideration in the context of these devices, can be sustained.

In our study, post-exercise measurements of patients undergoing haemodialysis who participated in the calisthenic exercise programme improved when compared with pre-exercise measurements.

Calisthenic exercises have several advantages, including the fact that they are simple, can be done at home and do not require any equipment. Because of the significant benefits it provides to patients, it will be beneficial to develop simple individual exercise programmes for patients in dialysis units under the supervision of a multidisciplinary team comprised physiotherapists and dialysis personnel. Additionally, studies with a larger sample group can be conducted by varying the content, intensity and duration of the calisthenic exercises. Furthermore, we believe that comparative studies with various types of exercise are required.

PRACTICAL APPLICATIONS

This study highlights the importance of calisthenic exercise in patients undergoing haemodialysis treatment. It demonstrates the positive effects of calisthenic exercise on aerobic capacity, grip strength and quality of life in the exercise group. Patients who participated in the exercise programme showed improvement in the mentioned parameters. Thus, it is clear that exercise is important for such patients; however, it is unclear which types of exercises are effective. Results show that participation in physical activity and regular exercise can improve the quality of life of patients undergoing haemodialysis treatment. Thus, participation of patients undergoing haemodialysis in daily activities will increase, and the social isolation they experience will decrease. Therefore, it is crucial for health professionals working in haemodialysis units recommend regular physical activities, such as calisthenic exercise, to patients.

CONCLUSION

Considering the positive effects of calisthenic exercise on haemodialysis patients, it is important that patients are encouraged to participate in physical activities such as calisthenic exercise and that these activities are continuous.

Acknowledgments

We would like to express our sincere appreciation to all those who helped us complete this report. We thank the haemodialysis unit staff, patients, and their relatives.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that pro-

vides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Nazan Öztürk, Ayşegül Kahraman; **Design:** Nazan Öztürk, Ayşegül Kahraman, Fatma Ünver; **Control/Supervision:** Fatma Ünver, Hakan Akdam; **Data Collection and/or Processing:** Nazan Öztürk, Ayşegül Kahraman; **Analysis and/or Interpretation:** Nazan Öztürk, Ayşegül Kahraman; **Literature Review:** Nazan Öztürk; **Writing the Article:** Nazan Öztürk, Fatma Ünver, Ayşegül Kahraman; **Critical Review:** Fatma Ünver, Hakan Akdam; **References and Fundings:** Ayşegül Kahraman.*

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