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EXERCISE TRAINING IN PATIENTS WITH END-STAGE RENAL DISEASE ON HEMODIALYSIS: COMPARISON OF THREE REHABILITATION PROGRAMS

Erasmia Konstantinidou,[1] Georgia Koukouvou,[1] Evangelia Kouidi,[1] Asterios Deligiannis[1] and Achilleas Tourkantonis[2]

From the [1]Laboratory of Sports Medicine and the [2]A' Internal Medicine Clinic, Renal-Unit, Aristotle University of Thessaloniki, Thessaloniki, Greece

Functional capacity of end-stage renal disease patients is dramatically impaired. Although exercise training programs appear to have beneficial morphological, functional and psychosocial effects in end-stage renal disease patients on hemodialysis (HD), the adherence rate is high. The purpose of this study was to compare the effects of three modes of exercise training on aerobic capacity and to identify the most favourable, efficient and preferable to patients on HD with regard to functional improvements and participation rate in the programs. Fifty-eight volunteer patients were screened for low-risk status and selected from the dialysis population. The 48 patients who completed the study protocol were randomly assigned either to one of the three training groups or to a control group. Sixteen of them (Group A – mean age 46.4 ± 13.9 years) completed a 6-month supervised outpatient exercise renal rehabilitation program consisting of three weekly sessions of aerobic and strengthening training on the non-dialysis days; 10 (Group B – mean age 48.3 ± 12.1 years) completed a 6-month exercise program during HD; 10 (Group C – mean age 51.4 ± 12.5 years) followed an unsupervised moderate exercise program at home, and 12 patients (Group D – mean age 50.2 ± 7.9 years) were used as patient controls. The level of anemia, the medications and the HD prescription remained stable during the study. Fifteen sex- and age-matched sedentary individuals (Group E – mean age 46.9 ± 6.4 years) comprised a healthy control group for baseline data. All subjects at the beginning and end of the study underwent clinical examination, laboratory tests and a treadmill exercise test to fatigue endpoints with direct measurement of aerobic capacity. Group A had a higher dropout rate (24%) compared to groups B (17%) and C (17%). Peak oxygen consumption (VO_2 peak) increased by 43% ($p < 0.05$), anaerobic threshold (VO_2AT) by 37% ($p < 0.05$) and exercise time by 33% ($p < 0.05$) after training in Group A; by 24% ($p < 0.05$), 18% ($p < 0.05$) and 22% ($p < 0.05$), respectively, in B; and by 17% ($p < 0.05$), 8% ($p < 0.05$) and 14% ($p < 0.05$), respectively, in C; while both remained almost unchanged in Group D. These results demonstrate that intense exercise training on non-dialysis days is the most effective way of training, whereas exercise during HD is also effective and preferable.

Key words: hemodialysis, exercise training, aerobic capacity, compliance.

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Correspondence address: Evangelia Kouidi, 9 Mitropoulou Str, GR-546 42 Thessaloniki, Greece. E-mail: ekouidi@med.auth.gr

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INTRODUCTION

Patients with end-stage renal disease are characterized by severe functional limitations (1, 2). Although renal replacement treatment options, such as hemodialysis (HD) or peritoneal dialysis, reduce morbidity and mortality, end-stage renal disease patients still experience significantly low physical fitness, psychosocial problems and poor quality of life (3–5). Their cardiorespiratory capacity is reported to be dramatically low (1, 6, 7). The maximum oxygen consumption (VO_2 max) in end-stage renal disease patients on HD is reported to be from 15.0 to 21.0 ml/kg/min, values that are half of those reported for healthy sedentary subjects, which range from 35.0 to 40.0 ml/kg/min (7–9). Functional capacity is even lower in patients on HD with other coexisting medical problems, such as severe anemia, diabetes mellitus, cardiovascular disease, etc., which are the majority of general dialysis populations (3, 4, 7, 10).

Studies in the field of renal rehabilitation support the fact that exercise training in patients on HD is capable of ameliorating many of the morphological and functional disorders that accompany end-stage renal disease and improve physical fitness, behavioural characteristics, as well as their quality of life (5, 7, 9, 11). Patients on HD are usually exercised on the non-dialysis days in a rehabilitation center under the instructions of specialized physical education teachers or physiotherapists and the supervision of a physician (8, 9, 12). Despite the helpful and beneficial effects of exercise training in patients on HD, compliance with regular supervised exercise of off-dialysis days remains poor (13–15).

Alternatives to exercise on off-dialysis days are exercise training during the HD sessions and training at home (14–16). These methods have certain advantages, no transportation is required, more free time, etc., while they seem to improve compliance to regular exercise. However, there are few data regarding the outcome measurements, which are essential when evaluating the effectiveness of physical rehabilitation programs. The aim of this study was to compare the effects of these three

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modes of exercise training on cardiorespiratory fitness and to identify those most favourable, efficient and preferable to patients on HD with regard to functional improvement and participation rate in the programs.

MATERIALS AND METHODS

Study population

From the 120 end-stage renal disease patients in the maintenance hemodialysis program at the Renal Unit of AHEPA Hospital, 58 without any exclusion criteria (Table I) volunteered to participate in the study. Their ages ranged from 21 to 65 years. They had all been undergoing regular HD with an artificial kidney for at least 6 months, three sessions a week, 4 h each session. After the initial screening, the patients were randomized into four groups: In Group A, 21 patients on HD participated in a 6-month outpatient supervised exercise training program on the non-dialysis days. In Group B, 12 patients followed a 6-month supervised exercise training program during their hemodialysis sessions. In Group C, 12 patients followed a moderate unsupervised exercise training program for 6 months at home. The proportions between exercised groups were unequal for practical reasons (number of pieces of equipment, trainers, etc.). In Group D, 13 patients were included who continued their usual lifestyle ("patient" controls). Also included were 15 sex- and age-matched volunteer healthy controls for normal baseline data (Group E) with sedentary lifestyle, and not engaged in any regular work or leisure time activity. Informed consent was obtained from all patients according to guidelines approved by the Aristotle University Ethics Committee.

Study design

A baseline physical assessment, resting ECG, echocardiogram, spirometry and spiroergometric study during graded treadmill exercise testing, as well as blood tests were carried out on each patient, 24 h after an uncomplicated and effective hemodialysis session, as well as on the healthy controls. After a 6-month period the same measurements were repeated only in the four groups of patients.

To exclude any impact of the changes in the status of anemia on the aerobic capacity of patients, we tried to keep the hemoglobin/haematocrit level stable for all renal patients (optimum level Hb/Hct ratio was considered 11/33) throughout the study by increasing or decreasing the dose of erythropoietin, whenever necessary. Forty-one of the patients were receiving erythropoietin regularly. All patients were also on stable medical therapy during the study. Moreover, dialysis procedure was kept stable throughout the 6-month period program (by using the same model of filter and a constant composition of the dialysis solution, and by keeping the HD session time constant throughout this period).

Cardiopulmonary exercise test

Cardiorespiratory responses to graded exercise were measured during treadmill tests to peak or symptom-limited effort at the beginning and end of the study. A modified Bruce treadmill testing protocol was used. It begins with a 3-min stage of walking at 1.5 mph at 0% grade. Thereafter, the grade is incremented 3.3% every 3 min and the speed remains unchanged until the treadmill reaches 10% grade. Afterwards, the speed and grade increase progressively according to the Bruce protocol. During the tests the ECG of each individual was monitored and recorded every 3 min. At the same time points, blood pressure was measured by mercury sphygmomanometry. Subjects were exercised until volitional exhaustion. End points for the tests were symptoms, target heart rate, severe hypertension or hypotension, >2.5 mm ST segment shift in ECG or severe arrhythmias. During the exercise test, expired gases were analysed on a breath-by-breath basis using a spiroergometer device (Cosmed b^2) calibrated to the manufacturer's specifications prior to each test. The b^2 system has fast analyzers (O_2 analyser: response time <120 ms, CO_2 analyser: response time <150 ms) that procure accurate results even when a high respiratory frequency is achieved. VO_2 peak was considered as the highest VO_2 obtained, characterized by a plateau of oxygen uptake despite further increases in work rate (steady state). Ventilatory anaerobic threshold (VAT) was determined as the intercept of the two slopes on a VCO_2 vs VO_2 graph referred to an incremental test selected by the software defines the VO_2 above which VCO_2 increases faster than VO_2 without hyperventilation.

Data analysis: To access exercise performance we chose from the spiroergometric study to analyse: heart rate at peak exercise (HRmax), total exercise time, pulmonary ventilation (VE), peak oxygen uptake (VO_2 peak), anaerobic threshold (VO_2AT) and respiratory exchange ratio (RER).

To measure lactic acid, blood samples were taken from the right ear before and 4 min after the end of the exercise test. Lactic acid measurement was carried out in a photometer (Dr Lange LP 400 model). Before each measurement calibration of the photometer was carried out according to the operating instructions.

Exercise rehabilitation programs

The patients who were included in Group A followed a 6-month outpatient exercise rehabilitation program in the Sports Medicine Laboratory's rehabilitation center under the supervision of a sports physician and the responsibility of two physical education teachers specialized in this field. The training sessions were performed 3 times a week, 60 min each approximately, on the non-dialysis days. The patients were divided into subgroups, each consisting of three or four persons, in order to keep a high frequency of patient–therapist contact. They were divided according to dialysis days, as well as age and sex, in order to have the same fitness level and social interests. Each training session consisted of a 10-min warm up on a cycle-ergometer or treadmill, a 30-min intermittent aerobic exercise program, including calisthenics, steps and flexibility exercises and a 10-min cool down period. After the first 2 months of training, a 10-min stretching and low-weight resistance program was added to the program. The intensity of exercise was prescribed on an individual basis, so that during the first 2 months the heart rate remained within the 60–70% of the HRmax achieved during the initial maximal exercise test. Therefore, there was a continuous monitoring of the cardiac rhythm of each patient with a specific telemetric device. Blood pressure was also measured every 15 min. After the first 3 months the younger patients were playing basketball and football once a week, whereas the older patients were swimming in a pool.

The patients who were included in Group B followed a 6-month exercise rehabilitation program during their HD treatment in the Renal Unit under the supervision of the physician and the responsibility of two physical education teachers specialized in this field. The training sessions were performed 3 times a week, 60 min each time during the first 2 hours of their HD sessions. The subjects prescribed target HR for training sessions corresponded to approximately 70% of HRmax achieved during the maximum exercise test. Their HR during training was monitored continuously. The blood pressure was also measured every 15 min. The exercise routine consisted of a combination of exercise training, 30 min with a bed bicycle ergometer and 30 min exercises for strength and flexibility. The cycling exercise session were divided into three parts. The first 5 min consisted of warm-up, the second period of training at the desired workload (active cycling), and the last 5 min of cool-down. The exercise session consisted of sets of repetitions using therabands and weights only for training the lower

Table I. *Contraindications for including patients in the study*

1. Unstable hypertension
2. Congestive heart failure (grade >II according to NYHA)
3. Cardiac arrhythmias (≥III according to Lown)
4. Recent myocardial infarction or unstable angina
5. Persistent hyperkalemia before dialysis
6. Diabetes mellitus
7. Active liver disease
8. Bone disease that puts the patient at risk of a fracture
9. Arthritic or orthopedic problems limiting exercise
10. Peripheral vascular disease
11. Undisciplined patients

Table II. *Baseline clinical features of patients and controls who participated in the study (mean ± SD)*

Groups	A	B	C	D	E
Subjects ($n = 63$)	16	10	10	12	15
Male/female	11/5	8/2	8/2	4/8	8/7
Age (years)	46.4 ± 13.9	48.3 ± 12.1	51.4 ± 12.5	50.2 ± 7.9	46.9 ± 6.4
Height (cm)	166 ± 12	167 ± 9	166 ± 6	164 ± 8	171 ± 10
Weight (kg)	65.4 ± 12.4	65.1 ± 11.2	64.4 ± 12.5	64.7 ± 11.6	76.0 ± 10.9*
Months on hemodialysis	78 ± 62	72 ± 66	62 ± 37	79 ± 86	–
Hypertension ($n = 30$)	10	6	6	8	–
Coronary artery disease ($n = 13$)	4	3	3	3	–

* $p < 0.05$ between groups E and A, B, C, D.

limbs. Increasing the repetitions, the sets, the theraband resistance and then applying weights round the limb increased the workload.

The 10 patients who were included in Group C followed an unsupervised moderate exercise training program at home. These patients were supplied with a mobile cycle-ergometer and were given instructions regarding the performance of simple exercises. According to this exercise program the patients had to cycle at least 5 times a week, 30 min each time, at a heart rate of 50–60% of the maximal heart rate each had reached during the baseline treadmill test. After that, they performed simple flexibility and muscular extension exercises. We kept close contact with these patients, visiting them monthly at their home, to answer any questions they had, to become familiar with their course and to modify the exercise program, if necessary.

Statistical methods

All data are expressed as mean values ± SD. Changes of variables within the groups at the start and end of the study were evaluated using the Wilcoxon signed rank test. The Mann-Whitney U test was used to compare the results between groups. For statistical analysis, the SSPS 7.0 for Windows was used (Statistical Package for the Social Sciences, Chicago, Illinois, USA). A p-value <0.05 was regarded as statistically significant.

RESULTS

There were no musculoskeletal, cardiovascular or other complications related to the exercise programs. However, during the study 5 patients from Group A, 1 from Group B, 2 from C voluntarily withdrew, while 1 patient from Group B and 1 from D died of causes unrelated to exercise. Finally, 48 patients on HD completed the entire study; Group A consisted of 16 patients (11 men and 5 women), Group B of 10 patients (8 men and 2 women), Group C of 10 patients (8 men and 2 women) and Group D of 12 patients (4 men and 8 women). Group A had the highest dropout rate (23.8%) and the reasons were lack of time, transportation difficulties and medical reasons unrelated to

Table III. *Cardiorespiratory capacity data of the subjects at the beginning and end of the study (mean ± SD)*

	A	B	C	D	E
HR max (bpm)					
Before	139 ± 22	141 ± 14	139 ± 7	140 ± 12	179 ± 11$^{\infty}$
After	146 ± 20$	144 ± 3.0	142 ± 10	139 ± 12	
Exercise time (min)					
Before	16.0 ± 3.7	15.8 ± 3.2	16.3 ± 2.8	16.0 ± 3.1	26.8 ± 4.1$^{\infty}$
After	21.2 ± 3.6*$	19.2 ± 3.0*†	18.6 ± 3.3*§	16.1 ± 3.1# + II	
VE max (l/min)					
Before	42.1 ± 14.1	40.9 ± 12.4	42.9 ± 8.2	35.4 ± 11.5	90.0 ± 20.1$^{\infty}$
After	59.2 ± 15.7*$	45.8 ± 11.2*†	44.3 ± 8.6§	34.9 ± 9.0# + II	
VO_2peak (ml/kg/min)					
Before	16.6 ± 6.2	16.3 ± 5.2	16.2 ± 5.0	16.3 ± 4.7	42.4 ± 9.8$^{\infty}$
After	23.7 ± 7.7*$	20.2 ± 5.7*†	19.0 ± 5.3*§	15.8 ± 4.8# + II	
VO_2AT (ml/kg/min)					
Before	14.9 ± 3.6	14.1 ± 3.4	14.2 ± 3.8	14.7 ± 3.1	39.4 ± 8.7$^{\infty}$
After	20.4 ± 6.2*$	16.7 ± 5.1*†	15.9 ± 5.6*§	14.3 ± 4.2# + II	
RER					
Before	0.97 ± 0.05	0.97 ± 0.06	0.96 ± 0.05	0.97 ± 0.06	1.01 ± 0.07
After	0.99 ± 0.07	0.98 ± 0.06	0.98 ± 0.06	0.97 ± 0.06	
Lactic acid (mmol/l)					
Before	8.1 ± 2.3	8.6 ± 1.7	8.5 ± 1.7	8.9 ± 1.9	11.5 ± 1.1$^{\infty}$
After	6.9 ± 3.0*$	8.0 ± 1.9	8.4 ± 2.2	9.0 ± 2.3#	

HR = heart rate, VE = ventilation, VO_2peak = peak oxygen consumption, VO_2AT = anaerobic threshold, RER = respiratory exchange ratio.

* $p < 0.05$ between the baseline and the follow-up values, † $p < 0.05$ between groups A and B, § $p < 0.05$ between groups A and C, # $p < 0.05$ between groups A and D, + $p < 0.05$ between groups B and D, II $p < 0.05$ between groups C and D, $ $p < 0.05$ between groups E and A, ∞ $p < 0.05$ between group E and the other four groups.

exercise. The dropout rate in both Groups B and C was 16.7% and the reason for withdrawal was an acute illness.

The clinical features of the five groups that completed the study are presented in Table II. Of the 48 patients on HD who lasted the study, 42 were hypertensives controlled on medication, 13 suffered from stable coronary artery disease with no clinical manifestations and 5 had heart failure $\leq$ class II of NYHA. Allocation of the above patients in the four groups was balanced. There was no difference between patient groups regarding age, clinical and biochemical data. The mean Hb/Hct level of all patients was $10.8 \pm 0.8/33.0 \pm 0.9$ and by design it remained constant during the study.

Cardiopulmonary exercise testing results

In 42 out of 48 patients the baseline treadmill tests were discontinued because of leg fatigue and the remainder because of shortness of breath or exhaustion. After the 6-month training program the repeated exercise test was discontinued because of leg fatigue in only 2 out of the 16 patients in Group A and in 3 patients in Groups B and C.

There were no significant differences in the main measured parameters of the cardiorespiratory capacity among groups on baseline maximal treadmill testing. The healthy individuals in Group E achieved a longer exercise time on the treadmill by 68% ($p < 0.05$), a higher peak heart rate by 29% ($p < 0.05$), VE max by 114% ($p < 0.05$), as well as a higher VO_2peak by 155% ($p < 0.05$), VO_2AT by 164% ($p < 0.05$) and blood lactate by 42% ($p < 0.05$) in comparison with Group A. Similar differences were found between Group E and other patient groups.

Means for treadmill duration, VE, VO_2 peak, VO_2AT, RER and lactic acid at the start and end of the study are given in Table III. The exercise time on treadmill increased by 33% ($p < 0.05$) in Group A, by 22% ($p < 0.05$) in Group B and by 14% in Group C ($p < 0.05$). After 6 months' training, VEmax increased by 41% ($p < 0.05$) in Group A and by 12% ($p < 0.05$) in B; VO_2 peak by 43% ($p < 0.05$) in Group A, by 24% ($p < 0.05$) in B and 17% ($p < 0.05$) in C and VO_2AT by 37% ($p < 0.05$) in Group A, by 18% ($p < 0.05$) in B and 8% ($p < 0.05$) in C. The measurements of Group D were not significantly changed after the 6 months. Bar graphs depicting the mean changes after training in treadmill duration and VO_2 peak for each exercised group are shown in Fig. 1.

At the end of the rehabilitation program, Group A had a longer exercise time by 10% ($p < 0.05$) in comparison with Group B, by 14% ($p < 0.05$) with C and by 32% with Group D ($p < 0.05$), higher VEmax levels by 29% ($p < 0.05$), 34% ($p < 0.05$) and 70% ($p < 0.05$), VO_2 peak by 17% ($p < 0.05$), 25% ($p < 0.05$) and 50% ($p < 0.05$) and VO_2AT by 22% ($p < 0.05$), 28% ($p < 0.05$) and 43% ($p < 0.05$), respectively. Moreover, Group A had a lower blood lactate concentration after the exercise test by 23% ($p < 0.05$) in comparison with D. In spite of these improvements in all exercise performance parameters, the values in Group A remained lower compared to the baseline healthy control values (Group E). Groups B and C had higher exercise time on treadmill by 19% ($p < 0.05$) and 16% ($p < 0.05$), respectively, VE max by 31% ($p < 0.05$) and 27% ($p < 0.05$), VO_2 peak by 28% ($p < 0.05$) and 20% ($p < 0.05$) and VO_2AT by 17% ($p < 0.05$) and 11% ($p < 0.05$) in comparison with non-trained Group D.

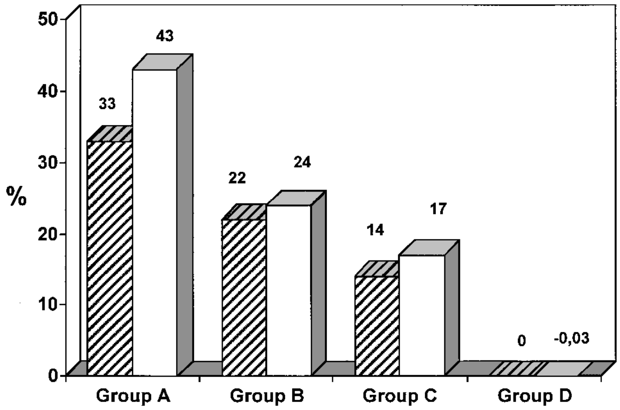

Fig. 1. Percentage changes in exercise time (ET) and VO2 peak during treadmill testing in patient groups at the end of the study (▨ = ET; □ = VO_2 peak).

DISCUSSION

The baseline level of VO_2max of our patients was markedly impaired and approximately almost one-third of the values of our sedentary healthy individuals. Their endurance and cardiorespiratory fitness were relative to patients with such severe chronic diseases as heart failure, chronic obstructive pulmonary disease or diabetes mellitus (17–19). A poor level of cardiorespiratory fitness in patients on HD has also been reported in previous studies (1, 2, 6). A combination of factors is responsible for this reduction in aerobic capacity, both central and peripheral, including cardiac dysfunction, anemia, cardiac autonomic nervous system abnormalities, metabolic disturbances, defect of muscle oxidative metabolism and skeletal muscle atrophy, as a main result of uremic myopathy and neuropathy, inactivity, etc. (10, 20, 21).

The average exercise performance on the treadmill was very low, and 88% of the tests in our patients were terminated because of leg fatigue, suggesting that peripheral factors are most important in exercising limitations in patients on HD (21, 22). Diesel et al. reported a positive relationship between VO_2max and isokinetic muscle strength (22). Kouidi et al., too, reported that impaired exercise capacity in patients on HD was associated with marked muscular atrophy, mainly type II, and reduction in muscle strength and peripheral nerve conduction velocity (21).

The results of this study indicate that all three different approaches to exercise training in patients on HD have beneficial effects on their cardiorespiratory capacity. Significant improvements were found in VO_2max and exercise duration on the treadmill. Increases in VO_2max between 20% and 40% have also been reported after exercise training lasting 3 to 12 months

(8, 9, 13). Although the changes resulting from any approach of training were statistically significant, clinically an aerobic capacity of 20–23 ml/kg/min remains low compared to age-predicted levels, indicating that there are still limitations to exercise.

The favourable effects of exercise training on cardiorespiratory capacity were more pronounced in the patients who were exercised in an outpatient supervised rehabilitation program than the other two exercised groups. That is because this program included a variety of exercises, some intensive, and the workload of each session might have been higher, as supervision could result in a greater dose of exercise being applied. The supervised exercise program applied included a combination of aerobic and strengthening exercises and also sports activities. That may be a reason why our patients reached the value of 24 ml/kg/min in VO_2max after 6 months' training, while Goldberg's patient reached the same level of peak VO_2 after aerobic training lasting 12 months (9).

Despite improvements in cardiorespiratory capacity, participation in the outpatient program was limited. It is difficult to persuade end-stage renal disease patients to attain a supervised outpatient exercise program. The dropout rate was found to be high, approximately 24%, for reasons such as transportation difficulties, lack of time in the non-dialysis days programs, changes in medical status, etc. Shalom et al. showed that 40% of the population on HD could not participate in a renal rehabilitation program mainly because of distance between residence and the exercise-training center (13). An additional 31% could not participate because of poor health and another 21% did not volunteer (13). Williams et al. reported that main factors affecting adherence of patients on HD to an outpatient exercise programme were lack of time (33%), lack of energy (25%), too much trouble (17%), depression (17%) and high morbidity (15).

Exercise training during HD has the advantage of greater applicability, as the dropout rate was lower. It provided a more convenient and time-efficient model for training in patients on HD. It did not involve any extra time, because patients were in the hospital three times per week anyway. Painter et al. reported that compliance with an exercise training during HD was greater than 75% during the second 3 months (14).

Moreover, exercise training during HD was technically feasible and effective, as the cardiorespiratory capacity of our patients was significantly improved. Similar beneficial effects of training during dialysis on aerobic capacity have also been reported previously (16, 23). Painter et al. supported that patients cycling during HD for 6 months reached a reported value in VO_2max of 25 ml/kg/min, which is indeed high compared to our results, although the percentage of improvement was similar (14). The difference is that the patients of this study started with higher pre-training values of aerobic capacity (19.6 ml/kg/min) compared to the patients participating in our study (16.3 ml/kg/min).

Training at home is also an alternative, because dropout rate was also low (17%), the same as exercise during HD. However, such programs could not be supervised at all and so it was difficult to ensure compliance with exercise. Moreover, the improvement in cardiorespiratory capacity was not as high compared to the other two modes of training. The difference in response was more likely due to the fact that those in the supervised setting exercised longer and harder. Moreover, it depends on the willingness and mood of the patients whether they are exercised or not. In a recent paper by Painter et al., greater benefits were obtained from independent home exercise compared to cycling during HD (20). However, Painter's study was a crossover study and patients were asked to participate sequentially in each 2-month intervention. The home independent exercise was applied first and therefore the functional improvements from the initial 2 months training were more pronounced compared to cycling during HD, which followed.

Additionally to cardiorespiratory capacity improvements, significant beneficial effects of the three modes of training were found on muscle strength, psychological status and quality of life (5, 16, 21). The results seemed to be more pronounced in patients who participated in an outpatient program on the non-dialysis days compared to those who trained during dialysis or at home (unpublished data).

In conclusion, adherence to an exercise program may have a powerful effect on the clinical outcome of change in the cardiorespiratory capacity of patients on HD. It is suggested that the amount of exercise plays a significant role in attaining health-related benefits and therefore exercise on non-dialysis days is the most effective way of training. However, exercise during HD is also more applicable and preferable from the point of view of the patients. Exercise during HD is therefore highly recommended to those who are unable to participate in a supervised non-dialysis program because of lack of time or transportation problems. It is noteworthy that unsupervised home training was shown to be effective and safe, despite generally less control of frequency and intensity of exercise. Thus, every patient on HD not having medical contraindication to exercise should be encouraged to participate in any exercise training program.

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