ORIGINAL RESEARCH

Effects of In-Center Resistance Training in End-Stage Renal Disease: A Pilot Study

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ABSTRACT

Background: Patients with end-stage renal disease are sedentary, frail, and have low functional ability (FA) compared to healthy age-matched controls. The purpose of this study was to examine the effects of an intradialytic, supervised, 8-week resistance training (RT) program on strength (ST), FA, and quality of life (QOL) in a sample of patients with end-stage renal disease.

Methods: Twenty hemodialysis patients were randomized to an exercise (E, n=12) or control (C, n=8) group. Patients randomized to E received intradialytic RT immediately before and during treatment, 3 d per week for 8 weeks. Patients randomized to C received usual care and no exercise. ST and FA were assessed at baseline and at 4 and 8 weeks with manual muscle testing and the Short Physical Performance Battery. QOL was assessed at baseline and 8 weeks with the 36-item Short Form Health Survey (SF-36). Mixed factorial ANOVAs were used to determine the effects of RT on ST, FA, and QOL.

Results: Significant interactions were found for ST for the right ($p=0.006$) and left ($p=0.008$) gastrocnemius, right quadriceps ($p=0.003$), right ($p=0.005$) and left ($p=0.004$) hamstrings, and right adductor ($p=0.020$). ST improved for E but not C across time ($p<0.05$). Significant time effects for FA were found for chair ($p=0.001$) and total ($p=0.008$) SPPB scores but were not different between groups ($p>0.05$). Similar effects were found for the physical performance component of the SF-36 ($p=0.023$).

Conclusion: A supervised 8-week, intradialytic RT program improved lower body ST in patients with end-stage renal disease; however, these improvements did not impact FA or QOL. *Journal of Clinical Exercise Physiology*. 2019;8(3):91–96.

Keywords: exercise, chronic kidney failure, muscular strength, physical function, quality of life

INTRODUCTION

The prevalence of end-stage renal disease (ESRD) in the United States increased by 73% between 1991 (183,372 cases) and 2014 (678,383 cases) with estimated medical expenditures currently exceeding $87 billion per year (1–3). Patients with ESRD tend to be sedentary, frail, and have low functional ability compared to healthy age-matched controls, due primarily to their poor muscle function (4–8). Exercise is recommended to improve muscle function in those with ESRD by improving muscular strength, gait speed, and overall physical function (4–6,8–11). However, exercise studies to date have tended to involve protocols on non-dialysis days because of the assumption that intradialytic exercise is overly fatiguing and burdensome during dialysis treatment (5). Recent evidence has since refuted such assumptions and

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demonstrated intradialytic exercise to not only be safe, but effective at reducing boredom during treatment (12), fueling the notion that exercise, in combination with other lifestyle therapies, should be integrated into the standard of care for dialysis patients (4,13).

Although intradialytic exercise appears to be safe and efficacious for reducing boredom during dialysis treatment, a majority of these programs have focused on the effects of aerobic exercise (12), which have revealed exercise to be more preferable for patients during the first half of dialysis treatment (14). Few studies, however, have focused on the effects of intradialytic resistance exercise (4,9,15,16); but those that have support its use with evidence of improved muscular strength and functional ability and reduced inflammation (4,9,16). Accordingly, because few studies have implemented intradialytic resistance exercise into the standard of care for patients on dialysis, an adequately powered clinical trial is warranted to examine whether these patients would benefit from resistance exercise because of their poor muscle function and limited functional ability.

Before conducting such a large-scale clinical trial, we first determined that a pilot investigation was warranted to examine the feasibility of conducting the larger trial under the supervision of clinical exercise physiologists. The aim of our pilot study was to examine the effects of a supervised, intradialytic, low-volume resistance training program on muscular strength, functional ability, and quality of life in a sample of patients with ESRD. We hypothesized that those randomized to the supervised resistance training program would improve muscular strength and that such improvements would enhance functional ability and quality of life compared to those randomized to usual care and no exercise.

METHODS

Subjects

A preliminary power analysis for each dependent variable was performed with G*Power (version 3.1) to detect a medium effect size with 80% power (17). We determined that a sample of 20 would yield 81% power to detect an effect size of $f = 0.30$. Twenty patients with ESRD receiving hemodialysis at the Fresenius Medical Care Centers in western Massachusetts were recruited and provided written informed consent. Patients were excluded if they: (a) were <18 years of age; (b) were engaging in physical activity at least 3 d per week and/or were accustomed to resistance exercise prior to enrollment; (c) were not medically cleared to perform resistance exercise before and during treatment; (d) were diagnosed with chronic kidney disease but were not receiving hemodialysis; and/or (e) were living with a significant musculoskeletal injury and/or functional limitation that would preclude and/or restrict their ability to perform resistance exercise.

Resistance Exercise

Upon enrollment, patients were randomized to intradialytic resistance exercise (E) or control (C). Patients randomized to E received supervised resistance training before and during treatment and included 8 to 10 exercises performed at moderate intensity (rating of perceived exertion [RPE] 3 to 5 on a 1 to 10 scale) (17), for 1 set of 10 to 15 repetitions, 3 d per week for 8 weeks. Patients randomized to C received usual dialysis care and no exercise until completing the study. Prior to beginning the resistance exercise intervention, patients completed a baseline orientation session to determine the initial workload of subsequent exercise sessions. Resistance exercise performed before dialysis was completed in the waiting room with ankle weights and Therabands (Model 2022-C, Theraband, Akron, Ohio), and included the following progressive exercises that were contraindicated to perform during dialysis treatment: bicep curls, anterior and lateral shoulder raises, seated rows, triceps extensions, and sit-to-stand exercises. Exercise performed during treatment was completed with similar modalities but included the following progressive exercises that were deemed appropriate and safe to perform during dialysis treatment: bent leg raises, leg extensions, calf raises, hip adduction squeezes, hip abductions, chin tucks, scapular retractions, and core strengthening exercises, which were progressed when an RPE of 2 was perceived (18).

Measurement of Muscular Strength

Strength was measured as the peak force generated in pounds (lb) and was assessed at baseline and at 4 and 8 weeks with the Lafayette Manual Muscle Testing (MMT) System (Model 01165, Lafayette, Indiana). The Lafayette MMT System is an ergonomic handheld device used for objectively quantifying muscle strength. Muscular strength was measured with the MMT as the clinician applied force to the limb and overcame (or “breaks”) the patient’s resistance. The muscles assessed with the MMT included the right and left biceps brachii, deltoids, quadriceps, hamstrings, gastrocnemius, and abductor and adductor muscles.

Measurement of Functional Ability

Functional measures were assessed at baseline and at 4 and 8 weeks with the Short Physical Performance Battery (SPPB). The SPPB is an objective assessment tool for evaluating lower extremity function in older adults, and includes a 3- or 4-meter gait speed test, a single and repeated chair stand test, and a feet-together, semi-tandem, and tandem balance test. Each functional assessment was scored and summed on a 0 to 4 scale with higher scores indicating better functional outcomes. The total SPPB score was computed as the sum of the composite score for each measure.

Measurement of Quality of Life

Quality of life measures were assessed at baseline and at 8 weeks with the Short Form (36) Health Survey (SF-36) (19). The SF-36 is a 36-item patient-reported health status survey that uses an 8-scale profile to compute a weighted composite score for physical and mental health. The weighted composite of each scale, which includes sections on vitality, physical functioning, bodily pain, general health perceptions, physical role functioning, emotional role functioning, social role functioning, and mental health, was then transformed into a 0 to 100 scale with higher scores indicating better physical or mental health perceptions.

Statistical Analysis

Descriptive statistics were computed as means ± standard deviations for all variables, unless otherwise noted. Mixed factorial analyses of variance (ANOVAs) with repeated measures were used to determine whether the effects of resistance exercise training differed from control for all measurements. Post-hoc pairwise comparisons and simple effects tests were performed with multiple comparison adjustments to protect the familywise error rate at $P<0.05$. All analyses were performed using the Statistical Package for the Social Sciences (SPSS, Armonk, New York) 24.0.

RESULTS

Patient Characteristics

The sample included 20 (E=12, C=8) male (n=11) and female (n=9) hemodialysis patients who, on average, were middle-aged (57.5±13.3 y), obese (body mass index [BMI]: 32.7±8.5 kg·m^{-2}), and ethnically mixed (Table 1). Physical characteristics at baseline were similar between E and C groups ($P>0.05$).

TABLE 1. Mean physical characteristics (±SD) of the total sample and by group.

Characteristic	Total (n=20)	Exercise (n=12)	Control (n=8)
Age (y)	57.5±13.3	60.8±13.1	52.6±12.9
Height (in)	68.0±3.8	68.3±3.8	67.4±3.9
Weight (lb)	213.2±52.1	213.6±50.8	212.6±57.6
BMI (Kg·m^{-2})	32.7±8.4	32.5±8.5	33.0±9.2
Sex (%)			
Male	55.0	58.3	50.0
Female	45.0	41.7	50.0
Race (%)			
Black	40.0	41.7	37.5
White	30.0	33.3	25.0
Hispanic	30.0	25.0	37.5

Muscular Strength

Significant group × time interactions were found for muscular strength of the right gastrocnemius ($P=0.006$), left gastrocnemius ($P=0.008$), right quadriceps ($P=0.003$), right hamstrings ($P=0.005$), left hamstrings ($P=0.004$), and right adductor ($P=0.02$). Simple effects tests revealed MMT values to increase for the E but not C group over time ($P<0.05$). No other group by time interactions or main effects were found for any of the other muscles measured at any time point (Table 2).

Functional Ability

A significant group by time interaction was found for the 4-meter gait speed test ($P=0.026$). Simple effects tests revealed gait speed to improve for C but not E over time ($P<0.05$). Significant main effects were also found for time with the SPPB chair ($P=0.001$) and total score ($P=0.008$). No other group by time or main effects were found for any of the other SPPB variables measured (Table 3).

Quality of Life

Significant main effects were found for time with the physical composite score of the SF-36 ($P=0.023$), but this finding was not different between groups ($P>0.05$). Mental composite scores for the SF-36 were not different between groups or across time ($P>0.05$).

DISCUSSION

The primary aim of our pilot study was to determine the effects of a supervised, intradialytic, low-volume resistance training program on muscular strength, functional ability, and quality of life in a sample of patients with ESRD. We found the resistance exercise intervention led to significant strength gains in lower extremity musculature, which surprisingly did not translate into improvements in functional ability or quality of life. The finding of increased lower body muscular strength is consistent with previously reported findings that have employed resistance training protocols similar to ours and that involved populations similar to the patients recruited in our pilot study (5,8,9). Moreover, our program was designed with the intention of targeting both upper and lower body musculature, but interestingly, we did not find any changes in upper body muscular strength. This finding was unexpected given that the patients performed contraindicated exercises to intradialytic resistance training before receiving dialysis treatment. This finding might be attributed to an insufficient exercise stimulus that was inadequate to elicit a resistance training adaptation in the upper extremities.

To date, most previous intradialytic resistance training studies have employed protocols that were longer in duration (4,5,8,9) than the 8-week intervention employed in our pilot investigation. However, similar to Ribeiro et al. (20), who employed an 8-week multi-set resistance training intervention among 15 patients with chronic kidney disease, we determined that significant strength gains are possible after only 8 weeks of single set resistance training (20,21). In addition to implementing an intervention of shorter duration, we prescribed a lower exercise intensity and volume than previous studies reported in the literature (4,8,9,20). We prescribed a moderately intense resistance training program for 1 set at 8 to 12 repetitions to meet the minimum FITT ExRx recommended by the American College of Sports Medicine (21), which differs from previous researchers who have employed multi-set interventions at 60% to 70% of a patient's one-repetition maximum (8,9). Our findings therefore demonstrate that patients with ESRD may benefit from

TABLE 2. Mean Manual Muscle Testing (±SD) changes in pounds across time by group.

	Exercise			Control			*P*
	Baseline	4-wk	8-wk	Baseline	4-wk	8-wk	
Biceps							
R	29.0±19.4	34.9±15.8	37.4±16.5	26.6±13.3	33.2±17.7	28.1±22.1	0.125
L	28.7±21.4	29.2±16.2	33.9±15.5	29.9±11.1	32.2±11.4	28.2±16.0	0.865
Shoulder							
R	29.7±16.5	30.9±15.5	32.5±13.2	29.8±16.7	29.5±13.2	27.1±14.2	0.951
L	28.4±17.1	28.8±16.6	32.0±11.4	28.8±6	25.5±6.5	27.2±9.1	0.455
Calf							
R	23.4±11.3	31.7±14.8	32.6±9.8	40.6±18.9	32.3±13.4	38.4±12.7	0.006**
L	22.4±11.7	29.4±11.1	36.0±12.8	34.8±19.9	29.3±11.8	31.7±9.5	0.008*
Quadriceps							
R	28.0±15.7	33.4±10.4	39.3±14.8	33.4±7.5	35.7±14.7	30.3±12.8	0.003**
L	28.2±18.1	33.4±9.8	36.3±12.7	34.5±14.8	33.3±14.2	31.9±17.6	0.589
Hamstrings							
R	21.5±11.0	34.5±11.9	32.2±7.7	29.4±12.4	29.1±11.8	27.5±8.4	0.005**
L	21.6±9.4	32.0±11.0	31.0±8.8	31.5±16.8	27.7±13.8	30.7±12.5	0.004**
Adductors							
R	21.7±9.9	25.0±8.3	27.2±8.3	28.5±13.3	24.1±10.8	24.4±6.6	0.020**
L	22.9±10.9	23.2±8.0	27.0±7.0	24.8±17.3	21.9±10.0	21.1±7.7	0.637
Abductors							
R	28.7±14.0	34.9±16.2	35.5±17.6	32.4±16.4	32.6±17.5	33.1±10.6	0.235
L	26.3±13.9	36.8±16.8	35.6±15.5	30.5±13.1	29.4±16.8	29.1±13.1	0.193

*indicates a significant main effect.
**indicates a significant interaction.

improvements in lower body muscular strength with exercise stimuli that are lower than what previous researchers have used.

We used the SPPB to estimate the functional ability of patients recruited in our pilot study. The SPPB is a tool designed to quantify physical performance and decline over time and has been shown to be a predictor of disability risk in community-dwelling older adults (4,19). The SPPB has also been used to predict mortality, nursing home admission, health care reliance, and functional decline of routine activities of daily living among older populations (4). We found a significant group × time interaction in the 4-meter gait speed test, but unexpectedly measured that patients randomized to C outperformed patients randomized to E. This finding may be attributed to age-related differences in muscle function between groups (E: 60.8±13.1 vs C: 52.6±12.9 y) as we found both groups improved similarly with chair and SPPB total scores over time. In addition to a potential age-related difference in our SPPB findings, a possible learning effect could have existed due to the nature of repeated measure testing. Future studies should therefore expand upon our pilot study by matching patient groups by clinical sample features such as age, and by including appropriate and more comprehensive orientation sessions to familiarize patients with testing procedures.

Similar to our SPPB findings, we neglected to find statistically significant differences in physical or mental quality of life between groups, which is consistent with previously reported literature by DePaul et al. (10), who implemented a 12-week resistance training program in 38 ESRD patients. Similar to the theory proposed by DePaul et al., we concur that the lack of improvement we found in health-related quality of life may be caused by either an insensitivity of the SF-36 to our 8-week intervention and/or a function of the general inconsistencies of quality of life outcomes in patients with ESRD (10). Furthermore, because our sample was small, our inability to identify statistically significant differences in quality of life outcomes was not surprising.

Our pilot study is not without limitation. We recruited a sample of 20 patients with ESRD that may have been underpowered to detect statistical differences in the many outcome variables reported. A larger sample size may have allowed us to perform more advanced statistical procedures (e.g., MANOVA), which would reduce the familywise error rate of

TABLE 3. Mean SPPB (±SD) changes across time by group.

	Exercise			Control			P
	Baseline	4-wk	8-wk	Baseline	4-wk	8-wk	
Total Balance Score	2.3±1.4	2.6±0.9	3.1±1.0	3.3±1.2	3.4±1.1	3.1±1.5	0.360
Total Gait Speed Score	1.3±0.5	1.2±0.4	1.2±0.4	1.0±0.0	1.1±0.4	1.4±0.5	0.026**
Total Chair Stand Scores	1.0±1.2	1.5±1.4	1.9±1.7	1.8±1.3	2.3±1.6	2.4±1.7	0.001*
Total SPPB Score	4.6±2.4	5.3±2.3	6.2±2.2	6.1±2.4	6.6±2.9	6.8±3.6	0.008*

SPPB=Short Physical Performance Battery
*indicates a significant main effect.
**indicates a significant interaction.

multiple comparison testing. However, given the challenges of conducting large-scale clinical trials in nephrology (22) coupled with the many benefits of resistance exercise for the betterment of health, we feel our sample is justified given the exploratory nature of our study. Another limitation of the study was the potential variation in manual muscle testing measurement ability between study administrators. To mediate this potential limitation, we assigned the same test administrator for each patient throughout the study. A practical advantage of using the Lafayette device is its portability, accuracy, and adaptability within the confines of dialysis centers. Finally, we assessed quality of life with a valid and reliable health survey that was limited by self-report and possible variation in patient values or the presence of adverse events that may have influenced the perceived health status and quality of life of participants throughout the intervention.

In conclusion, a low-volume, supervised, in-center, 8-week resistance training program was found to improve lower body strength in patients with ESRD receiving hemodialysis. However, our observed strength improvements did not translate into meaningful changes in functional ability or quality of life (21). Our findings suggest that intradialytic exercise programs can be feasibly implemented but likely need to be prescribed at longer and more stimulating volumes and durations to augment clinical changes in physical function and quality of life. Future research studies should expand upon and replicate our preliminary findings by recruiting larger samples of patients with ESRD receiving supervised exercise for durations longer than 8 weeks and should assess both quantitative and qualitative outcomes germane to patient safety (e.g., adverse events), efficacy, and longevity with more objective measurements. Our findings, albeit preliminary, add to the call for inclusion of physical activity and exercise as non-pharmacological therapy in conjunction with traditional standard-of-care therapies for ESRD.

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