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Effect of Intradialytic Lower Limb Resisted Exercise on Muscle Strength, Exercise Capacity and Quality of Life in Patients with Chronic Kidney Disease on Maintenance Hemodialysis: A Case Series

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ABSTRACT

Background: Chronic Kidney Disease (CKD) patients undergoing maintenance hemodialysis (MHD) are often physically deconditioned due to multiple factors such as uremic toxins, malnutrition, and physical inactivity. Which leads to muscle weakness, reduced exercise tolerance, and physical frailty. Hence, quality of life is significantly impaired. Intradialytic exercise, which involves physical activity during dialysis, can be a viable intervention to address these challenges.
Purpose: To evaluate the effect of intradialytic Lower Limb (LL) resisted exercise on muscle strength, exercise capacity, and quality of life in patients with CKD on MHD.
Method: 4 patients (3 male and 1 female, age 20-29 years) of CKD on MHD were on dialysis for more than 12 months and had no contraindications to exercise. Pre- and post-assessment were taken with 1- Repetition maximum (1-RM), 6-min Walk Test (6-MWT), Hand Grip Strength (HGS), Bioelectrical Impedance Analysis (BIA), and Kidney Disease and Quality of Life Instrument-36 (KDQOL-36). Patients performed a structured intradialytic exercise program during their hemodialysis, focused on lower limb strength using a weight cuff [Load- 65%-75% of 1-RM, Frequency- 2 times/week, 3-4 sets of 10-15 repetitions, Duration- 6 weeks].
Result: 6 weeks of intradialytic LL-resisted exercise resulted in notable improvement in muscle strength in terms of 1-RM, exercise capacity in terms of 6-MWT, and quality of life (KDQOL-36) in patients with CKD on MHD
Conclusion: This case series shows that intradialytic LL-resisted exercise is a promising intervention for improving muscle strength, exercise capacity, and Quality of Life (QoL) in patients with CKD on MHD.

Keywords: Intradialytic exercise, Muscle strength, Exercise capacity, Quality of life, CKD, Case series.

INTRODUCTION

According to the Kidney Disease Improving Global Outcomes (KDIGO) 2024 guidelines CKD is referred to as a reduction in kidney functions, as measured by a Glomerular Filtration Rate (GFR) of less than 60 mL/min/1.73 m^2 for at least three months, or kidney damage as determined by microalbuminuria, with health implications. CKD is classified based on **C**ause, **G**lomerular filtration rate, and **A**lbuminuria, Abbreviated as **CGA**. End-stage renal disease patients (classified as GFR <15 mL/min/1.73 m^2) are likely to require dialysis or kidney transplantation.[1]

Muscle wasting is prevalent among patients with CKD. 18% to 75% of adults with End-Stage Renal Disease (ESRD) undergoing maintenance dialysis showed some evidence of muscle wasting.[2,3] Numerous studies indicate that dialysis patients have lower muscle strength than healthy individuals, affecting both proximal and distal muscles, which is caused by a less active lifestyle and lower level of functional capacity compared to people with normal renal function.[4] This reduced skeletal muscle function is the result of metabolic impacts and muscle fiber size reduction.[5] Thereby, individuals with CKD or dialysis have a marked decline in muscular strength and exercise capacity when compared to healthy individuals in the same age group.[5,6] Along with that renal disease symptoms, extended dialysis vintage, and comorbidities can lead to low physical fitness and Health-Related Quality of Life (HRQOL) in MHD patients and ultimately they are going to be frail.[7]

According to the Renal Association Clinical Practice Guideline on Hemodialysis (HD), dialysis patients must participate in intradialytic exercise.[8,9] Intradialytic exercise has several advantages, including decreased patient load, ease of monitoring, time efficiency, and safety (under the supervision of dialysis staff). Since MHD patients have limited physical function, time, strength, and resources, intradialytic exercise is more appropriate.[10] Intradialytic exercise, usually done within the first 2 hours of HD treatment, is an effective non-pharmacological therapeutic option for HD patients and it can be used to improve the QoL for MHD patients.[8,9,11]

Resisted exercise is an activity that uses body weight or external resistance to enhance muscular strength, power, and endurance and can improve mobility, function, and independence.[12] Intradialytic resisted exercise, such as upper and lower extremity strengthening with weight cuffs or dumbbells can prevent or reverse muscle wasting and is an important part of comprehensive management for HD patients.[13,14] However, there was still insufficient evidence regarding the effects of intradialytic resistance exercises on people undergoing HD in the Indian population.

CASE SERIES DESCRIPTION

This case series was carried out at a tertiary care hospital in Ahmedabad between May and July 2024. It focuses on patients who had intradialytic exercise.

Participants: A total of 4 patients (3 males, 1 female) aged 20-29 years, right side dominancy with CKD stage 5 requiring maintenance hemodialysis via brachiocephalic Arteriovenous Fistula (AVF) were on dialysis for more than 12 months and had no history of any active infection, cardiovascular disease, musculoskeletal injury or neurological condition.

Outcome measures: The following outcomes were assessed at baseline and after the 6 weeks of intervention. Muscle strength was assessed via 1-RM of quadriceps muscles, while peripheral muscle strength was assessed via HGS of non-AVF hand. Exercise capacity was evaluated using the 6-MWT. Health-related quality of life was measured using the KDQOL-36. BIA analyzed body composition with the use of the Inbody Mass 270 machine.

Intervention: Patients performed a structured intradialytic LL-resisted exercise program according to Frequency, Intensity, Time, and Type (FITT) recommendations given in American College of Sports Medicine (ACSM) guidelines (10th edition) for individuals with kidney disease [15] during their HD. Exercises were performed in the first half of the HD. Patients remained in a supine lying position on the dialysis bed, and exercises were performed on both lower limbs using a weight cuff. The strengthening exercises were focused on the lower limb muscles. Exercise includes heel slide, last-degree extension of the knee, Straight Leg Raise (SLR), hip abduction, and adduction. A summary of the protocol is mentioned in ***Table 1.***

In India, commonly dialysis is performed in bed with patients lying down in a supine position. Utmost care is taken to look after the flow of dialysis. We took extra care to prevent restriction of flow while performing the exercises in the supine position. Hence no such position was kept which restricted the flow during the dialysis phase and there were no adverse events or complications noted while performing the exercise regimen during dialysis.

Table 1. Detailed Intervention

TIME	INTERVENTION
Week 1-2	• **Resisted exercise** of the bilateral lower limb with weight cuffs • **Frequency:** 2 times/week • **Intensity:** 65% of 1-RM • **Repetition:** Minimum-10, Maximum-15 • **Set:** Minimum-3, Maximum-4 • **Time:** 15-20 minutes (1:1 work-to-rest ratio maintained during each set of exercise)
Week 3-4	• **Resisted exercise** of the bilateral lower limb with weight cuffs • **Frequency:** 2 times/week • **Intensity:** 70% of 1-RM • **Repetition:** Minimum-10, Maximum-15 • **Set:** Minimum-3, Maximum-4 • **Time:** 15-25 minutes (1:1 work-to-rest ratio maintained during each set of exercise)
Week 5-6	• **Resisted exercise** of the bilateral lower limb with weight cuffs • **Frequency:** 2 times/week • **Intensity:** 75% of 1-RM • **Repetition:** Minimum-10, Maximum-15 • **Set:** Minimum-3, Maximum-4 • **Time:** 15-30 minutes (1:1 work-to-rest ratio maintained during each set of exercise)

Figure 1: Heel slide exercise

Figure 2: Last-degree extension of knee

Figure 3: Straight Leg Raise (SLR)

Figure 4: Hip abduction and adduction

RESULT

The demographic details and anthropometric measurements of four patients are summarized in ***Table 2.*** Three males and one female, aged from 20 to 29 years, diagnosed with CKD on MHD undergoing HD via brachiocephalic AVF, performed intradialytic LL-resisted exercise twice a week for six weeks. By the end of six weeks, patients demonstrated notable improvement in various measures. 1-RM for the right and left quadriceps muscles were increased, with the dominant (right) side of all patients showing greater improvement than the left following rehabilitation, as seen in ***Figure 5.***

Specifically, 6- MWT showed a significant improvement in the distance covered by all four patients ***(see Figure 6).***

Additionally, hand grip strength also improved which suggests that there is an increased peripheral muscle strength ***(see Figure 7).*** Furthermore, the body composition analysis of skeletal muscle mass in the lower limbs showed some improvement ***(see Figure 8).***

In terms of HRQOL, improvement was found in four domains (Symptoms/problem list, effects of kidney disease, physical composite, and mental composite) and no improvement was found in the domain of burden of kidney disease by KDQOL-36 ***(Table 3).***

Table 2. Basic characteristics

Demographic details	P1	P2	P3	P4
Age (years)	20	22	29	20
Gender	Male	Male	Male	Female
Dialysis vintage (years)	4	1.2	4	3
Height (cm)	167	168	158	157
Weight (kg)	48	49.8	37.9	33.7
BMI (kg/m^2)	17.2	17.66	15.16	13.7

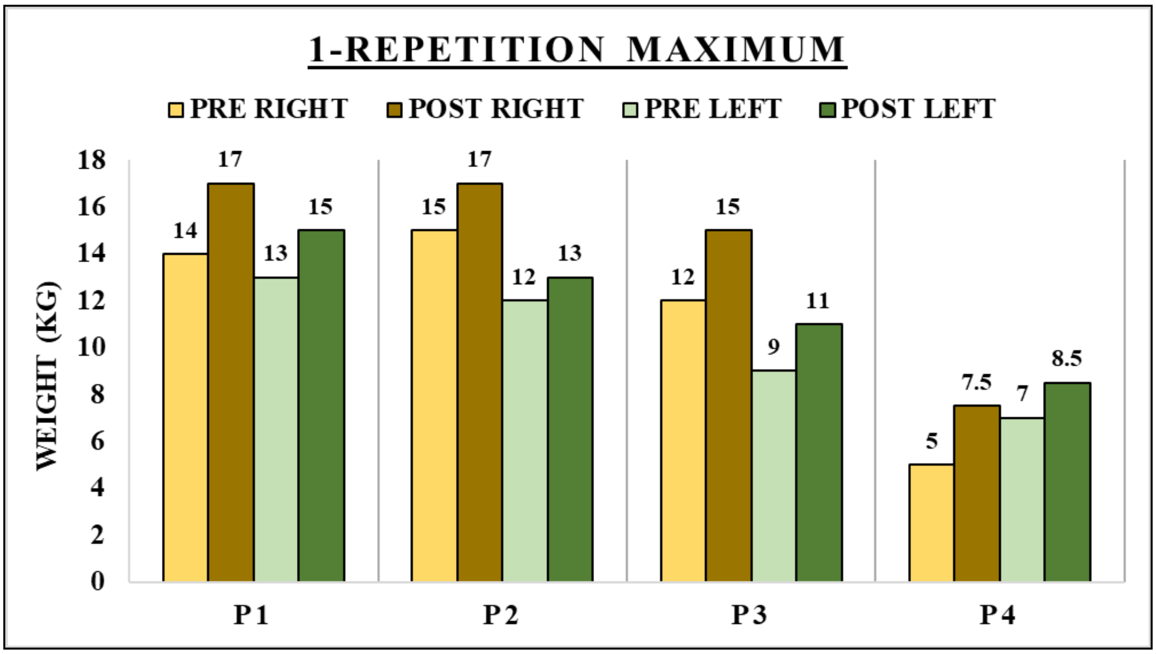

Figure 5: Graph illustrating the progression of 1-repetition maximum of the quadriceps muscle

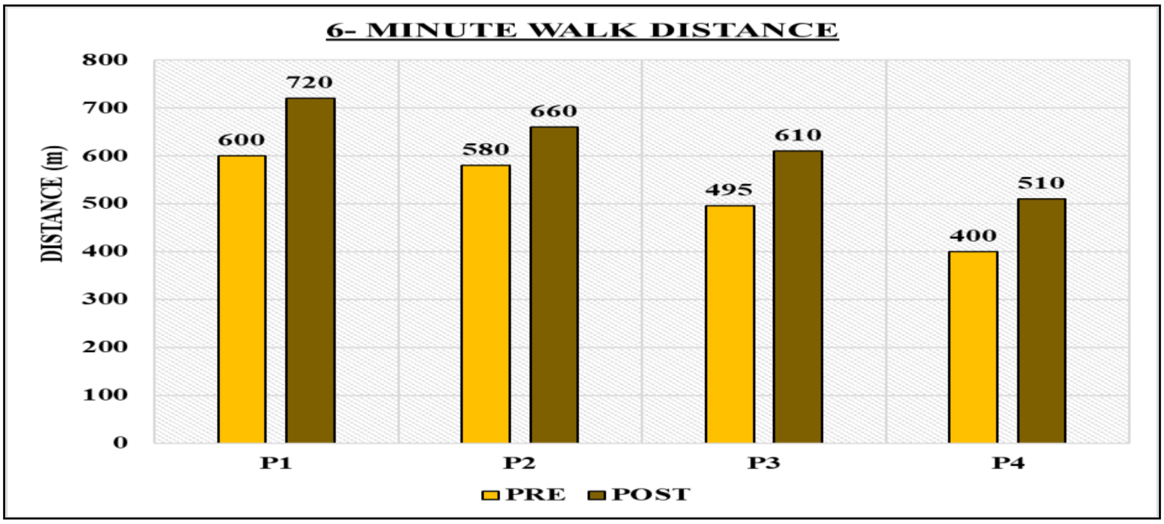

Figure 6: Graph illustrating the progression of 6-minute Walk Distance (6-MWD)

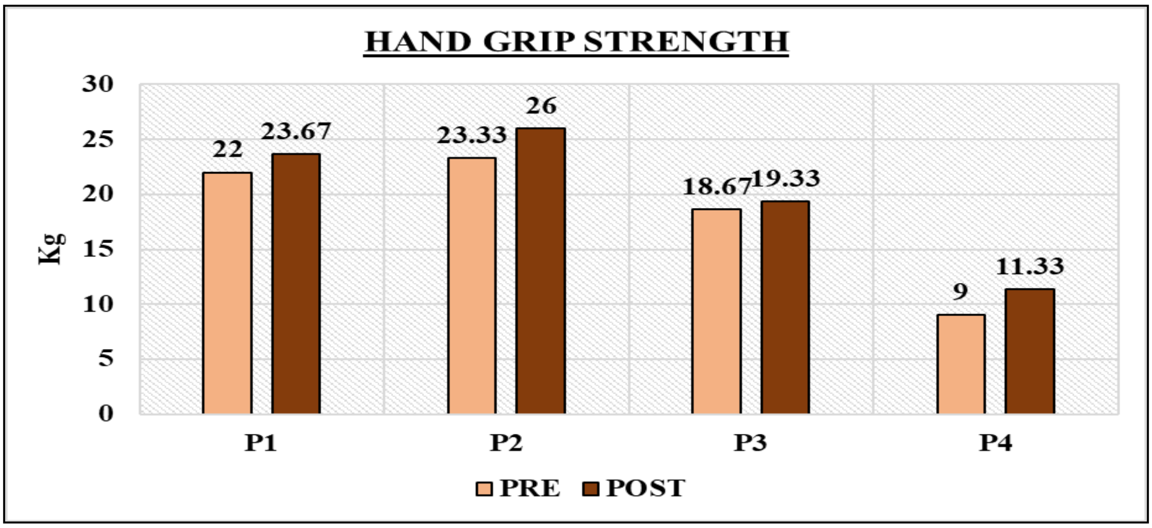

Figure 7: Graph illustrating the progression of hand grip strength

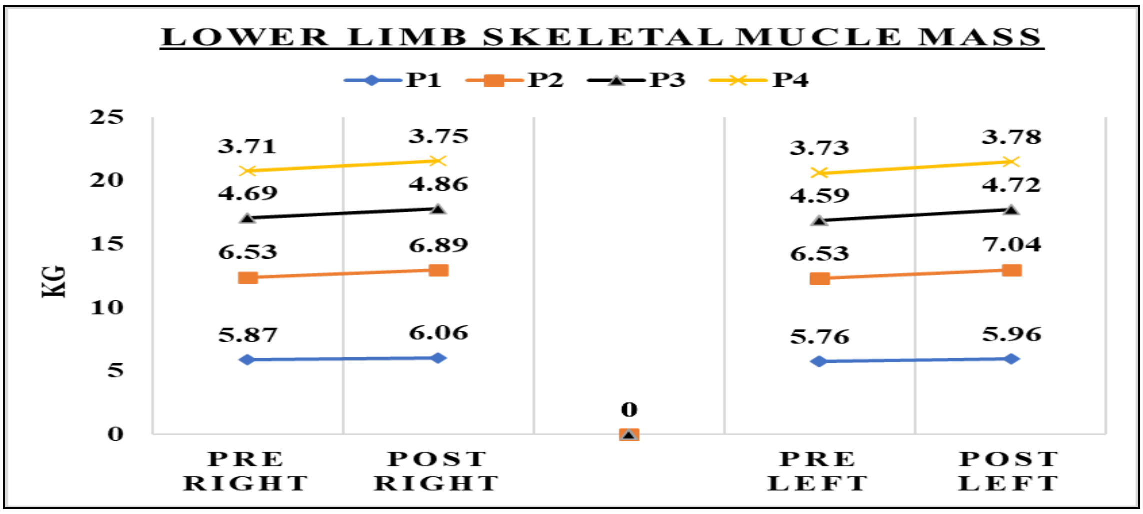

Figure 8: Graph illustrating the progression of lower limb skeletal muscle mass

Table 3. KDQOL-36

	P1		P2		P3		P4	
	PRE	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*
Symptom/problem list	87.50	95.83	81.25	95.83	81.25	89.58	70.83	93.75
Effects of kidney disease	87.50	90.63	81.25	84.38	84.38	78.13	75.00	93.75
Burden of kidney disease	50.00	50.00	12.50	12.50	37.50	37.50	6.25	6.25
SF-12 Physical Health Composite	27.45	53.54	37.98	48.03	53.54	54.63	35.60	46.60
SF-12 Mental Health Composite	57.91	64.88	43.56	47.75	45.88	56.88	48.39	57.83

DISCUSSION

Frailty causes a reduction in both physiological and cognitive health, resulting in symptoms like weight loss, fatigue, poor physical activity, weakness, and slow-speed walking. Frail patients have a lower quality of life and are at a higher risk of hospitalization, infection, cardiovascular events, dialysis problems, and mortality. Generally, CKD-associated uremia, hormonal imbalance, metabolic disturbances, and impaired energy utilization- a condition known as protein-energy wasting (PEW)- cause muscular proteolysis and sarcopenia in dialysis patients. This condition causes excessive intramuscular collagen deposition and atrophy of type I and II skeletal muscle fibers, all of which contribute to fatigue, low levels of physical function, and stiffness in the muscles (Gordon Chun-Kau Chan et.al.).[16]

Fernanda et al. investigated the association between lower limb muscular strength and frailty in the elderly, and the findings show that poor lower limb muscle strength is connected with a higher risk of frailty. [17]

While studying physiological abnormalities of skeletal muscle in dialysis patients, H. Fahal et al. found that most dialysis patients had quadriceps muscle weakness in their study. The nutritional status was found to be the most significant predictor of both abnormal muscular tension and loss of muscle strength in that study. [18]

Frailty can be assessed using handgrip strength, the KDQOL-36 Item Short Survey Form (KDQOL-SF36), and the Short Physical Performance Battery (SPPB, which focuses on lower-limb functions).[16] 6-MWT is a valid method for assessing exercise capacity and determining V̇O2peak in HD patients.[19] Meanwhile, the Inbody 270 machine is a valid and reliable instrument for body composition analysis.[20]

Regular exercise improves cardiovascular fitness, mobility, strength, and physiological reserves for dealing with stress and preventing frailty. Exercise treatment improves muscle strength and endurance by decreasing inflammation, boosting anabolism, and improving oxidative capacity. Exercise can reduce inflammatory reactions in adipocytes, reduce bone loss, and improve cardiac remodelling, making it effective for reducing frailty, enhancing physical function, and ultimately improving the quality of life.[16]

Intradialytic exercise has been shown to benefit HD patients in studies. These people should be treated less like "patients" and encouraged to take a more active part in their health as they negotiate the barriers of end-stage kidney disease. Thus, Intradialytic Exercise is Medicine for Hemodialysis Patients (Parker K et.al).[11] To prevent hypotensive episodes, exercise should normally be done during the first half of dialysis, while some patients may use late dialysis exercises to counteract a hypotensive response.[15]

The appropriate dose of resistance exercises for HD has yet to be established. International health organizations and the KDOQI recommend regular exercise training for HD patients to reduce the risk of cardiovascular complications. Exercise programs should be designed and delivered by qualified personnel and tailored to patient needs (K/DOQI Workgroup; Smart et al.).[21,22]

The findings of this case series suggest that intradialytic LL-resisted exercise can have positive effects on muscle strength, exercise capacity, and quality of life in individuals with CKD on MHD. The improvements in handgrip and quadriceps strength suggest that moderate-intensity LL-resisted exercise during dialysis can have a positive effect on muscle strength and functional capacity. This is crucial, as muscle wasting and weakness are common in CKD in MHD patients, contributing to frailty and decreased functional independence.

In this case series marked improvement in quadriceps muscle strength was observed as measured by a 1-RM average of 2.63 kg in the right leg and 1.63 kg in the left leg, after six weeks of intervention. Ribeiro et al. suggest that low-intensity RE, 3 times a week, with 40% of the maximum force, is an adjuvant therapy to complement medical and dietary treatment in terminal CKD patients. Additionally, quadriceps muscle strength (assessed by manual strength testing) was improved in that study.[23] In another study in patients undergoing 12 weeks of intradialytic training, statistically significant improvements in muscle strength of the quadriceps and biceps were observed, improving physical function and vitality and the QoL domains.[24]

We saw marked improvement in peripheral muscle strength in terms of HGS, which was an average of 1.83 kg after 6 weeks of intervention. Zhang et al. did a systematic review and meta-analysis on the effects of intradialytic resistance exercises on physical performance, nutrient intake, and quality of life among hemodialysis people. In that fourteen studies of 594 people were included, compared with control groups and they found that intradialytic resistance exercises significantly improved grip strength as well as other outcomes such as physical performance including a 6-min walk test, and sit-to-stand 30. However, no significant improvements were found in nutrient intakes such as dietary protein intake and quality of life.[25]

The increase in exercise capacity, as measured by the 6MWT, supports the notion that exercise during dialysis not only improves strength but also enhances endurance and overall physical fitness. A significant improvement was found in exercise capacity in terms of 6-MWD which average increased up to 106.25 meters. Likewise, Martins do Valle F et. al. conducted 12 weeks randomized clinical trial to examine the effects of intradialytic resistance training on physical activity in daily life, muscle strength, physical capacity, and quality of life in hemodialysis patients. They observed that the intradialytic exercise program improved the patient's physical capacity, dialysis efficacy, and quality of life.[14] The mechanism behind improvement is that exercise training lowers blood pressure and enhances aerobic capacity, heart rate variability, muscle function, and quality of life in patients with chronic kidney disease. [15]

In our four patients, the body composition analysis of skeletal muscle mass in the lower limbs pointed out minor improvement. A 12-week randomized pilot study on intradialytic resistance training to improve lean mass gain and functional capacity in HD patients was carried out by Lorena Cristina Curado Lopes et al. They came across that high-load intradialytic resisted exercise improved lean leg mass and quality of life more than moderate-load intradialytic resisted exercise.[26]

Moreover, the improvement in HRQOL, particularly found in four domains (Symptoms/problem list, effects of kidney disease, physical composite, and mental composite) and no improvement found in the domain of burden of kidney disease by KDQOL-36, highlight the broader benefits of intradialytic exercise beyond physical fitness, which can be critical in managing the symptoms and emotional distress associated with CKD.

Furthermore, these findings are consistent with previous research indicating that exercise during dialysis can benefit both physical and mental health in this group of individuals. Its impact on QoL was much higher than expected based on the amount of effort, evaluation time, and simplicity.[23]

LIMITATION AND FUTURE RECOMMENDATIONS

The study's limitations highlight areas that need further research. First, it's a single center and small case series. To address this, future studies could employ a randomized controlled trial design with a bigger and more diverse sample size in various institutes. This would offer more robust evidence for the efficacy of intradialytic rehabilitation in CKD on MHD patients. The short duration (6 weeks) does not allow for an evaluation of the long-term effects of intradialytic LL-resisted exercise. To address this, future research should focus on longer-term rehabilitation. Furthermore, the patient's nutritional status was not considered during rehabilitation, despite its acknowledged importance in overall health and recovery. Including nutritional assessments and interventions in future rehabilitation regimens may provide a more holistic approach to patient care. These efforts, which target both physical function and nutritional demands, have the potential to improve treatment outcomes and promote long-term well-being in affected persons.

CONCLUSION

This case series demonstrates that intradialytic LL-resisted exercise can be an effective method for improving muscle strength, exercise capacity, and quality of life in patients with CKD on MHD. The intervention is feasible, safe, and beneficial and, it shows great potential as an important component of comprehensive therapy in this patient population. Larger, randomized trials are required to confirm these findings and evaluate their long-term effects.

Declaration by Authors

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