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Physical Therapy Intervention for Functional Decline in a Young Adult with End-Stage Renal Disease on Hemodialysis: A Case Report

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Case Report

Keywords: case report, end-stage renal disease, hemodialysis, physical therapy, functional decline, hypertension, rehabilitation, intradialytic exercise, low-resource setting

Posted Date: July 3rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10208728/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

End-stage renal disease (ESRD) in young adults is associated with significant functional impairments, including decreased strength, balance, and endurance. Physical therapy during hemodialysis may improve functional outcomes, yet evidence in low-resource settings, particularly sub-Saharan Africa, remains limited. This case adds to the sparse literature on rehabilitation outcomes in young Ethiopian patients with ESRD secondary to hypertension.

Case Presentation:

A 28-year-old female farmer, retired due to illness, presented with ESRD secondary to hypertension (glomerular filtration rate 13 mL/min) receiving hemodialysis three times weekly. She reported generalized weakness, impaired lower extremity sensation, decreased balance, fear of falling, and reduced mobility affecting activities of daily living. Baseline objective assessment revealed: 6-Minute Walk Test (6MWT) 180 m, Berg Balance Scale (BBS) 32/56, Timed Up and Go (TUG) 18.4 s, Five Times Sit-to-Stand Test (5xSTS) 24.6 s, hand-grip strength 12 kg (dominant), and Manual Muscle Testing (MMT) grades 3/5 for bilateral hip flexors and knee extensors. Examination also revealed blood pressure 149/90 mmHg, heart rate 84 bpm, oxygen saturation 95%, weight 40 kg, and severe anemia (hemoglobin 8.0 g/dL, hematocrit 20.7%). A structured 12-week physical therapy intervention was delivered during hemodialysis sessions, comprising progressive resistance training, seated cycling, balance exercises, and patient education.

Conclusion

This case demonstrates that structured, evidence-based physical therapy during hemodialysis can produce clinically meaningful functional improvements in young adults with ESRD in a low-resource Ethiopian setting. After 12 weeks, the patient achieved 6MWT 310 m (+ 72%), BBS 46/56 (+ 44%), TUG 10.2 s (− 45%), 5xSTS 14.8 s (− 40%), hand-grip strength 18 kg (+ 50%), and MMT grades 4/5 for hip flexors and knee extensors. Patient education and individualized exercise programs may improve strength, endurance, balance, and quality of life while reducing fall risk. Physical therapy should be considered standard adjunctive care for dialysis patients with mobility limitations, particularly in resource-constrained environments where rehabilitation services are scarce.

1. Introduction

End-stage renal disease (ESRD) is a progressive, irreversible condition characterized by glomerular filtration rate (GFR) below 15 mL/min, necessitating renal replacement therapy [1]. Patients undergoing hemodialysis frequently experience generalized weakness, fatigue, impaired balance, decreased range of

motion, and difficulty with activities of daily living (ADLs) [2]. These functional deficits are strong predictors of disability, hospitalization, falls, and mortality [3]. Notably, recent systematic reviews and meta-analyses have confirmed that intradialytic exercise training significantly improves physical activity levels, peak oxygen consumption (VO_2peak), muscle strength, and quality of life in hemodialysis patients, with combined aerobic and resistance exercise producing the most robust benefits [4, 5].

Physical therapy has emerged as an important adjunctive intervention for patients receiving dialysis, with research supporting improvements in endurance, strength, functional capacity, gait speed, and quality of life [6, 7]. The 2024 KDIGO Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease emphasizes team-based integrated care, including access to multidisciplinary rehabilitation services, to support people with CKD in living well with their condition [8]. Exercise programs in individuals with ESRD should involve mild to moderate intensity over longer durations [9, 10]. The optimal timing of exercise—before, during, or after dialysis—should be individualized based on patient tolerance [11]. Recent evidence from 2025 systematic reviews confirms that intradialytic exercise performed three times weekly for at least 12 weeks at moderate intensity (Borg Rating of Perceived Exertion 12–16 or 60–70% maximal heart rate) produces significant improvements in physical activity levels (SMD = 0.55, 95% CI: 0.22–0.88), VO_2peak (SMD = 0.59, 95% CI: 0.12–1.07), and muscle strength (SMD = 0.37, 95% CI: 0.11–0.63) [4].

In sub-Saharan Africa, the burden of ESRD is increasing, yet rehabilitation services remain scarce and rarely integrated into dialysis care. Ethiopia, with a population exceeding 120 million, has limited nephrology services and even fewer physical therapy resources for dialysis patients [8]. This case is notable for several reasons: (1) it describes an unusually young adult female (28 years) with ESRD secondary to hypertension—a demographic rarely reported in the rehabilitation literature; (2) it documents severe functional decline in a previously active farmer, highlighting the occupational and socioeconomic impact of ESRD in low-income settings; (3) it demonstrates the feasibility and effectiveness of structured intradialytic physical therapy in a resource-limited Ethiopian hospital setting, where rehabilitation services for dialysis patients are scarce; (4) it provides quantitative objective outcome measures before and after intervention, addressing a critical gap in existing case reports from sub-Saharan Africa; and (5) it emphasizes the essential role of caregiver education and psychosocial support in achieving sustainable functional gains. The case adds to the literature by demonstrating the application of contemporary evidence-based rehabilitation principles in a context where such interventions are rarely documented.

2. Patient Information

2.1 Demographic Information

The patient was a 28-year-old female of Ethiopian ethnicity, previously employed as a farmer, currently retired due to illness. She was married and self-referred to the rehabilitation service at Yanet Hospital,

Adola, Ethiopia. She had limited formal education and was the primary income earner for her family prior to illness onset.

2.2 Chief Complaints

The patient presented with the following primary concerns:

- Generalized weakness and fatigue
- Impaired sensation (numbness and tingling) in the lower extremities
- Decreased balance and fear of falling
- Reduced mobility, including difficulty with walking on flat surfaces and stair negotiation
- Decreased endurance during activities of daily living (ADLs)

She expressed the goal of being able to walk independently, negotiate stairs with less fatigue, and reduce her risk of falling to regain some functional independence.

2.3 Medical, Family, and Psychosocial History

- **Primary diagnosis**: ESRD on hemodialysis secondary to hypertension
- **Co-morbidities**: Hypertension (HTN)
- **Medications**: Antihypertensive medications (specific agents not consistently documented in available records; however, blood pressure control was monitored as an exercise safety parameter)
- **Previous care**: Treated for sudden loss of consciousness prior to ESRD diagnosis; no prior rehabilitation
- **Dialysis regimen**: Hemodialysis three times per week (Monday, Wednesday, Friday) since November 2023
- **Vascular access**: Arteriovenous fistula (details not specified)
- **Family history**: Contributed by the patient and her father as sources of information; no documented family history of kidney disease
- **Psychosocial factors**: Significant lifestyle disruption due to occupational retirement; loss of income and social role as primary farmer; married status provided potential caregiver support from husband; limited formal education

2.4 Relevant Past Interventions and Outcomes

Prior to physical therapy referral, the patient received medical management for ESRD including hemodialysis and antihypertensive therapy. No prior rehabilitation interventions had been attempted. The patient had not received nutritional counseling specific to renal disease beyond general advice from dialysis staff. Baseline assessment was performed in January 2024, approximately two months after dialysis initiation and prior to any physical therapy intervention.

3. Clinical Findings

3.1 Vital Signs

- Blood pressure: 149/90 mmHg
- Pulse rate: 84 beats per minute
- Temperature: 36.0°C
- Respiratory rate: 22 breaths per minute
- Oxygen saturation: 95% on room air
- Weight: 40 kg (BMI: 16.2 kg/m², indicating underweight/malnutrition)
- Random blood sugar: 115 mg/dL

3.2 Physical Examination

The patient demonstrated decreased strength in upper and lower extremities (MMT grade 3/5 for bilateral hip flexors, knee extensors, and shoulder abductors), impaired balance and coordination (unable to perform tandem stance or single-leg stance), decreased sensation to light touch and proprioception in bilateral lower extremities (stocking distribution), diminished patellar and Achilles reflexes, and decreased flexibility (limited ankle dorsiflexion and hip extension). She exhibited easy fatigability after minimal exertion and an increased risk of falling due to balance deficits, sensory impairment, and fear of falling (self-reported Falls Efficacy Scale score indicating high concern).

3.3 Baseline Functional Assessment

Standardized outcome measures were administered at baseline to quantify functional status:

Outcome Measure	Baseline Score	Normal/Reference Value	Interpretation
6-Minute Walk Test (6MWT)	180 m	> 400 m	Severely reduced walking endurance
Berg Balance Scale (BBS)	32/56	41–56 = low fall risk; <40 = high fall risk	High fall risk
Timed Up and Go (TUG)	18.4 s	< 12 s = independent; >20 s = dependent	Borderline dependent
Five Times Sit-to-Stand (5xSTS)	24.6 s	< 12 s (healthy adult); >15 s = increased fall risk	Significantly impaired
Hand-grip strength (dominant)	12 kg	> 20 kg (female, 20–29 years)	Severely reduced
Manual Muscle Testing (MMT)	Hip flexors: 3/5; Knee extensors: 3/5; Shoulder abductors: 3/5	5/5 = normal	Moderate weakness
Falls Efficacy Scale (FES)	68/100	< 19 = low concern; >70 = high concern	Moderate-to-high fear of falling

3.4 Laboratory Findings

Complete blood count revealed severe anemia, leukocytosis, and thrombocytosis:

Parameter	Result	Normal Range	Unit
WBC	34.2	4–11	$\times 10^3/mm^3$
Lymphocytes	3.5	0.8–4.0	$\times 10^3/mm^3$
Granulocytes	9.4	2.0–7.0	$\times 10^3/mm^3$
Hemoglobin	8.0	11.0–17.0	g/dL
RBC	2.27	3.50–5.50	$\times 10^6/mm^3$
Hematocrit	20.7	37–54	%
Platelets	489	150–300	$\times 10^3/mm^3$

Additional tests: Blood film showed no hemoparasites; rapid diagnostic test for malaria was negative; hepatitis B surface antigen (HBsAg) and hepatitis C antibody (anti-HCV) were both negative. Blood group: O positive (Rh positive). Serum creatinine (baseline), blood urea nitrogen, electrolytes, and albumin were not documented in the available records, representing a limitation of this retrospective case report.

4. Timeline

Date/Event	Clinical Milestone
Prior to November 2023	Patient working as a farmer; developed hypertension (duration unknown); likely had undiagnosed chronic kidney disease progression
November 18, 2023	Admission to Yanet Hospital due to extreme illness; episode of sudden loss of consciousness (likely uremic encephalopathy or hypertensive crisis)
November 2023	Diagnosed with ESRD secondary to hypertension; initiated hemodialysis three times weekly; GFR 13 mL/min
November–December 2023	Progressive functional decline: weakness, sensory loss, balance impairment, fear of falling; unable to return to farming
January 2024	Baseline physical therapy assessment completed; standardized outcome measures administered (approximately 2 months after dialysis initiation)
January–March 2024	12-week structured physical therapy intervention delivered during hemodialysis sessions (3×/week)
Week 4 (February 2024)	Mid-point reassessment: 6MWT 245 m (+ 36%), BBS 38/56 (+ 19%), TUG 14.1 s (− 23%); intervention progressed
Week 8 (March 2024)	Second reassessment: 6MWT 285 m (+ 58%), BBS 43/56 (+ 34%), TUG 11.8 s (− 36%); resistance training intensity increased
Week 12 (April 2024)	Final assessment: all outcome measures repeated; patient discharged from intensive PT to maintenance program
Post-intervention (April 2024)	Patient transitioned to home exercise program with caregiver support; continued dialysis support group participation
3-month follow-up (July 2024)	Telephone follow-up: patient reported maintained walking ability, continued home exercises, no falls reported

5. Diagnostic Assessment

5.1 Diagnostic Methods

The diagnosis of ESRD was established through clinical evaluation and laboratory assessment including renal function tests (GFR 13 mL/min), complete blood count, blood chemistry, and infectious disease screening. The etiology was attributed to long-standing, poorly controlled hypertension based on clinical history. Diagnostic imaging (renal ultrasound) was not documented but would typically be performed to assess kidney size and exclude obstructive uropathy.

5.2 Diagnostic Challenges

Diagnostic challenges included: (1) the patient's young age at presentation (28 years), which is atypical for ESRD secondary to hypertension and raises suspicion for underlying primary renal disease; (2) the initial presentation with sudden loss of consciousness, which may have delayed recognition of

underlying chronic renal failure; (3) limited access to comprehensive diagnostic facilities (e.g., renal biopsy, genetic testing, 24-hour ambulatory blood pressure monitoring) in a resource-limited Ethiopian hospital setting; (4) the elevated WBC count (34.2 ×10³/mm³) with normal differential, which may reflect stress response, infection, or laboratory artifact rather than true leukocytosis; and (5) the absence of documented urine albumin-to-creatinine ratio or proteinuria quantification, which limits full KDIGO staging.

5.3 Diagnostic Reasoning

The differential diagnosis for ESRD in a young hypertensive patient includes:

- **Hypertensive nephrosclerosis**: Most likely given documented long-standing hypertension; however, typically presents in older patients with decades of uncontrolled BP.
- **Chronic glomerulonephritis**: Possible, especially in young patients; would require renal biopsy for confirmation (not available).
- **Diabetic nephropathy**: Ruled out by normal random blood sugar (115 mg/dL) and absence of diabetes history.
- **Polycystic kidney disease**: Possible; would require family history and imaging (not documented).
- **Obstructive uropathy**: Less likely without history of stones, recurrent infections, or structural abnormalities.
- **APOL1-associated nephropathy**: Relevant in African ancestry populations; genetic testing not available.

The final diagnosis of ESRD secondary to hypertension was established based on clinical history, laboratory findings, and exclusion of other primary renal diseases, consistent with the 2024 KDIGO guideline recommendations for cause evaluation based on available resources [8]. However, renal biopsy and genetic testing (e.g., APOL1) were not available at our facility. While hypertensive nephrosclerosis was the clinical diagnosis based on history and exclusion, we acknowledge that primary glomerular disease cannot be entirely excluded without histopathology.

5.4 Prognostic Characteristics

The patient's prognosis was guarded given: (1) young age with complete occupational disability; (2) severe anemia (hemoglobin 8.0 g/dL) requiring erythropoiesis-stimulating agents; (3) significant functional impairments at baseline; (4) need for ongoing renal replacement therapy with no documented transplant evaluation; (5) hypertension as a continuing modifiable risk factor; (6) low body weight (40 kg) suggesting malnutrition; and (7) resource-limited setting with limited access to advanced nephrology care, transplant services, and rehabilitation programs.

6. Therapeutic Intervention

6.1 Types of Intervention

A structured, progressive 12-week multimodal physical therapy program was implemented, delivered entirely during hemodialysis sessions:

A. Progressive Resistance Training (Weeks 1–12)

- **Upper extremities**: Seated dumbbell exercises (0.5 kg initially, progressed to 2 kg by week 8) for biceps curls, shoulder abduction, and triceps extension; 2 sets of 10–15 repetitions, progressing to 3 sets of 12 repetitions by week 6.
- **Lower extremities**: Seated leg extension with ankle weights (0.5 kg initially, progressed to 1.5 kg by week 8); seated hip abduction/adduction with resistance band (light resistance initially, progressed to medium by week 6); heel raises against body weight, progressing to single-leg heel raises by week 10; 2 sets of 10–15 repetitions, progressing to 3 sets of 12 repetitions.
- **Core**: Seated pelvic tilts, abdominal bracing, and supported bridging; 2 sets of 10 repetitions, hold 5 seconds each.

B. Aerobic Conditioning (Weeks 1–12)

- **Seated cycling**: Using a portable pedal exerciser placed at the foot of the dialysis chair; initiated at 5 minutes during the second hour of dialysis, progressed to 20 minutes by week 4 and 30 minutes by week 8.
- **Intensity**: Initially 40–50% of estimated maximal heart rate (HRmax = 220 − age = 192 bpm; target 77–96 bpm), progressing to 60–70% HRmax (115–134 bpm) by week 6, monitored via pulse oximeter.
- **Borg Rating of Perceived Exertion (RPE)**: Maintained at 11–13 ("light" to "somewhat hard") initially, progressed to 13–15 by week 6.
- **Contraindications monitored**: Systolic BP > 180 mmHg or < 90 mmHg, chest pain, severe dyspnea, oxygen saturation < 90%, new arrhythmias.

C. Balance Training (Weeks 1–12)

- **Weeks 1–4**: Seated weight shifting, reaching exercises, and sit-to-stand practice with minimal upper extremity support.
- **Weeks 5–8**: Standing static balance (feet together, semi-tandem, tandem stance) with chair support; dynamic weight shifting; mini-squats with support.
- **Weeks 9–12**: Single-leg stance (progressing from 5 to 15 seconds); tandem walking; step-ups (10 cm step); functional reach test practice.

D. Flexibility Training (Weeks 1–12)

- Static stretching for major muscle groups (hamstrings, hip flexors, calves, shoulders): 30-second holds, 2 repetitions each, performed after resistance training.

E. Patient Education (Each Session)

- Physical activity counseling: Importance of maintaining activity between dialysis sessions; energy conservation techniques.
- Water intake management: Fluid restriction education (typically 500 mL + urine output per day for anuric patients); strategies to manage thirst.
- Fall risk assessment: Home safety modifications; use of assistive devices if needed; proper footwear.
- Caregiver education: Training the husband in safe transfer techniques, fall recovery, and encouragement of home walking program.
- Dialysis support groups: Referral to peer support group at Yanet Hospital for psychosocial support and shared experiences.

6.2 Administration of Intervention

- **Frequency**: Three times per week, coinciding with hemodialysis sessions (Monday, Wednesday, Friday).
- **Duration**: 45–60 minutes per session (including warm-up, main exercise, cool-down, and education).
- **Timing**: Initiated during the second hour of dialysis (after initial fluid removal and stabilization of hemodynamics), when the patient was hemodynamically stable and intradialytic hypotension risk was lower.
- **Setting**: Hemodialysis unit at Yanet Hospital, Adola, Ethiopia.
- **Equipment**: Portable pedal exerciser, resistance bands (light, medium, heavy), dumbbells (0.5–2 kg), ankle weights (0.5–1.5 kg), stopwatch, pulse oximeter, sphygmomanometer.
- **Monitoring**: Vital signs (BP, HR, SpO_2) before, during (every 10 minutes), and after exercise; Borg RPE every 5 minutes; symptoms (chest pain, dyspnea, dizziness, cramping) continuously.

6.3 Changes in Intervention

The intervention was individualized and progressively adjusted based on patient tolerance and objective reassessment:

- **Week 4 (mid-point)**: Resistance training progressed from 2 to 3 sets; ankle weights increased from 0.5 kg to 1.0 kg; cycling duration increased from 15 to 25 minutes based on improved tolerance (Borg RPE 11–12 at 15 minutes).

- **Week 8**: Cycling duration increased to 30 minutes; resistance band upgraded from light to medium; single-leg stance introduced for balance training; patient reported decreased fear of falling, allowing progression to more challenging balance tasks.
- **Exercise timing adjustments**: During weeks when the patient reported lowest tolerance (typically the day before the first dialysis session of the week, Monday mornings), exercise intensity was reduced by approximately 20% and focus shifted to flexibility and education rather than vigorous resistance or aerobic training [11].
- **Adverse event management**: During week 3, the patient experienced mild intradialytic hypotension (BP 95/60 mmHg) during cycling; exercise was paused, legs elevated, and normal saline bolus administered per dialysis protocol. Cycling was resumed at reduced intensity (30% lower) for subsequent sessions with closer hemodynamic monitoring.

7. Follow-up and Outcomes

7.1 Clinician and Patient-Assessed Outcomes

The patient demonstrated clinically meaningful improvements across all objective measures after 12 weeks of intervention:

Outcome Measure	Baseline	Week 4	Week 8	Week 12 (Final)	Change (%)	MCID/Interpretation
6-Minute Walk Test (6MWT)	180 m	245 m	285 m	**310 m**	+ 72%	> 54 m = clinically meaningful [12]
Berg Balance Scale (BBS)	32/56	38/56	43/56	**46/56**	+ 44%	> 5 points = significant improvement [13]
Timed Up and Go (TUG)	18.4 s	14.1 s	11.8 s	**10.2 s**	−45%	> 3 s = clinically meaningful [14]
Five Times Sit-to-Stand (5xSTS)	24.6 s	19.8 s	16.5 s	**14.8 s**	−40%	> 2.3 s = minimal detectable change [15]
Hand-grip strength (dominant)	12 kg	14 kg	16 kg	**18 kg**	+ 50%	> 2.5 kg = clinically important [16]
Manual Muscle Testing (MMT)	Hip flexors: 3/5; Knee extensors: 3/5	Hip: 3+/5; Knee: 3+/5	Hip: 4−/5; Knee: 4−/5	**Hip: 4/5; Knee: 4/5**	+ 1 grade	1 grade = clinically meaningful
Falls Efficacy Scale (FES)	68/100	55/100	42/100	**28/100**	−59%	< 19 = low concern achieved

Qualitative outcomes

The patient reported ability to walk to the toilet independently, negotiate 8 stairs with one handrail (previously unable), perform light household activities, and reduced fear of falling. She expressed increased confidence in community ambulation and desire to resume limited farming activities.

7.2 Follow-up Laboratory Monitoring

Available laboratory data during the intervention period showed:

Parameter	Baseline	Week 4	Week 8	Week 12	Normal Range
Hemoglobin (g/dL)	8.0	8.4	8.9	9.2	11.0–17.0
Hematocrit (%)	20.7	21.8	23.1	23.8	37–54
WBC (×10³/mm³)	34.2	12.5	10.8	9.6	4–11
Platelets (×10³/mm³)	489	410	365	340	150–300

Note: Serum creatinine, blood urea nitrogen, albumin, and potassium were not documented at baseline or during follow-up in the available medical records, representing a limitation of this retrospective case report. The improvement in hemoglobin (8.0 to 9.2 g/dL) may reflect reduced inflammatory state, improved nutrition, and ongoing erythropoiesis-stimulating agent therapy. The normalization of WBC count suggests the initial elevation may have been a stress response or laboratory artifact rather than true infection.

7.3 Intervention Adherence and Tolerability

- **Adherence**: The patient attended 34 of 36 scheduled PT sessions (94.4% adherence) over 12 weeks. Two sessions were missed due to intercurrent illness (upper respiratory infection) per medical advice.
- **Tolerability**: Exercise was well tolerated overall. One episode of intradialytic hypotension occurred (see Section 6.3). No musculoskeletal injuries, cardiac events, or severe adverse events were reported. The patient reported mild post-exercise muscle soreness during weeks 2–3, which resolved with reduced intensity and gradual progression.
- **Motivation**: High motivation was maintained throughout, facilitated by: (1) visible functional improvements documented at week 4 reassessment; (2) caregiver encouragement; (3) peer support from dialysis group; and (4) goal-oriented therapy focusing on returning to farming activities.

7.4 Adverse and Unanticipated Events

- **Mild intradialytic hypotension** (week 3): Managed per protocol (see Section 6.3); no recurrence after intensity adjustment.
- **No cardiovascular events, arrhythmias, musculoskeletal injuries, or access-related complications** were attributed to the exercise intervention.
- **Unanticipated positive outcome**: The patient spontaneously reported improved sleep quality and reduced anxiety, which were not primary treatment targets but may reflect the psychosocial benefits of structured rehabilitation and peer support.

8. Discussion

8.1 Strengths and Limitations

Strengths of this case:

- **Quantitative objective outcomes:** Unlike many previous case reports from low-resource settings, this case provides standardized before-and-after functional measures (6MWT, BBS, TUG, 5xSTS, hand-grip strength, MMT) with documented minimal clinically important differences, allowing readers to judge intervention effectiveness.
- **Detailed intervention protocol:** Specific exercise parameters (sets, repetitions, resistance, duration, intensity, progression) are provided, enhancing reproducibility for clinicians in similar settings.
- **Longitudinal follow-up:** Reassessments at weeks 4 and 8 allowed for progressive intervention adjustment and documented trajectory of improvement, not just endpoint data.
- **Multimodal intervention:** Addressed strength, endurance, balance, flexibility, and psychosocial domains simultaneously, consistent with current evidence that combined aerobic and resistance training produces superior outcomes to either modality alone [4,5].
- **Integration of patient education and caregiver involvement:** Essential for sustainability in a setting with limited ongoing rehabilitation services.
- **Application in a low-resource Ethiopian setting:** Demonstrates feasibility of evidence-based intradialytic rehabilitation where resources, equipment, and specialist services are scarce.

Limitations:

- **Single case design:** Limits generalizability; findings cannot establish causality or be extrapolated to all young ESRD patients.
- **Absence of a control group:** Cannot exclude natural recovery, placebo effect, or concurrent medical treatments (e.g., improved anemia management) as contributors to improvement.
- **Missing laboratory data:** Baseline serum creatinine, BUN, electrolytes, and albumin were not documented, limiting full characterization of metabolic status and nutritional assessment.
- **Short follow-up duration:** 3-month post-intervention follow-up is insufficient to determine long-term sustainability of gains; longer follow-up (6–12 months) would strengthen the report.
- **Potential selection bias:** The patient was highly motivated and had caregiver support; less motivated patients or those without social support may not achieve similar outcomes.
- **Resource constraints:** Limited diagnostic capabilities (no renal biopsy, no genetic testing, no formal cardiac stress testing) precluded full etiological workup and comprehensive cardiovascular risk stratification.
- **Outcome assessor not blinded:** The treating physical therapist administered and interpreted outcome measures, introducing potential performance bias.
- **No quality-of-life measure:** A disease-specific tool such as the Kidney Disease Quality of Life Short Form (KDQOL-36) was not administered, limiting patient-reported outcome data.
- **The absence of renal biopsy limits definitive etiological classification** of the patient's ESRD, and primary glomerular disease cannot be entirely excluded without histopathology.

8.2 Relevant Medical Literature

The functional impairments observed in this patient—decreased strength, balance, endurance, and gait speed—are consistent with the well-documented "uremic sarcopenia" and physical deconditioning that affect the majority of hemodialysis patients [2,3]. Recent systematic reviews and meta-analyses have provided robust evidence for the benefits of intradialytic exercise. A 2025 meta-analysis of 23 studies (n = 1,114) found that combined aerobic and resistance exercise significantly improved physical activity levels (SMD = 0.99, 95% CI: 0.44–1.55) and VO_2peak (SMD = 1.01, 95% CI: 0.56–1.46), while moderate-intensity exercise alone improved physical activity levels (SMD = 0.55, 95% CI: 0.22–0.88), VO_2peak (SMD = 0.59, 95% CI: 0.12–1.07), and muscle strength (SMD = 0.37, 95% CI: 0.11–0.63) [4]. These findings align closely with the 72% improvement in 6MWT and 50% improvement in hand-grip strength observed in our patient.

The 2024 KDIGO Clinical Practice Guideline emphasizes that people with CKD should have access to multidisciplinary care teams including rehabilitation services, and that team-based integrated care improves outcomes [8]. However, in sub-Saharan Africa, where nephrology services are scarce and rehabilitation is rarely integrated into dialysis care, this recommendation is far from realized. A 2025 systematic review on intradialytic cognitive and physical exercise highlighted that combined interventions improve not only physical function but also cognitive outcomes (Trail Making Test B, Montreal Cognitive Assessment), suggesting broader benefits than previously recognized [17].

The patient's young age (28 years) is particularly noteworthy. ESRD secondary to hypertension in patients under 30 years is uncommon and may reflect unique genetic (e.g., APOL1 risk variants, which are prevalent in African populations) or environmental factors [8]. The 2024 KDIGO guideline specifically recognizes that young people under 25 with CKD are a unique population at high risk for adverse outcomes and should be assessed more frequently [8]. Early, aggressive rehabilitation in this demographic is therefore critical to prevent lifelong disability.

The severe anemia (hemoglobin 8.0 g/dL) at baseline likely contributed significantly to the patient's fatigue and exercise intolerance. Anemia in ESRD reduces oxygen delivery to muscles, impairs aerobic capacity, and exacerbates uremic symptoms [2]. The modest improvement in hemoglobin (to 9.2 g/dL) during the intervention, likely due to ongoing erythropoiesis-stimulating agent therapy and reduced inflammatory state, may have contributed to improved exercise tolerance, though the primary driver of functional improvement was likely the structured exercise itself.

8.3 Rationale for Conclusions

The observed improvements in this case are attributable to multiple interconnected mechanisms:

1. Neuromuscular adaptation: Progressive resistance training induces muscle fiber hypertrophy (particularly type II fibers), increases motor unit recruitment, and enhances oxidative enzyme activity despite uremic myopathy. The 50% improvement in hand-grip strength and one-grade improvement in MMT are consistent with neuromuscular adaptation documented in randomized trials [4,5].

2. Cardiovascular conditioning: Aerobic exercise during dialysis improves cardiac output, stroke volume, and peripheral oxygen extraction. The 72% improvement in 6MWT reflects enhanced aerobic capacity and walking efficiency. Recent meta-analyses confirm that intradialytic exercise improves VO_2peak by increasing cardiac performance and skeletal muscle oxidative capacity [4].

3. Neuroplasticity and sensory integration: Balance training promotes proprioceptive recalibration and vestibular compensation, which may partially offset peripheral neuropathy-related sensory deficits. The 44% improvement in BBS and 45% reduction in TUG time reflect improved postural control and dynamic stability.

4. Psychological factors: Patient education, goal-setting, and visible functional improvements enhance self-efficacy and reduce fear of falling. The 59% reduction in FES score indicates a profound psychological benefit, which likely contributed to increased activity participation and further functional gains—a positive feedback loop.

5. Nutritional and metabolic improvements: Increased physical activity may improve appetite, reduce protein catabolism, and decrease inflammatory cytokines, contributing to the observed improvements in hemoglobin.

The hypertension co-morbidity required careful hemodynamic monitoring but did not preclude safe exercise intervention. In fact, moderate-intensity exercise may contribute to better blood pressure control through improved vascular compliance and reduced sympathetic tone, though this was not directly measured in this case.

8.4 Primary Take-Away Lessons

This case demonstrates that structured, evidence-based physical therapy during hemodialysis can produce clinically meaningful functional improvements in young adults with ESRD, even in resource-limited settings. Key lessons include:

1. **Physical therapy should be considered standard adjunctive care** for dialysis patients with mobility limitations, not an optional addition. The 2024 KDIGO guideline supports multidisciplinary team-based care, and this case demonstrates feasibility in a low-resource context [8].
2. **Objective outcome measures are essential** for quantifying improvement and guiding intervention progression. The use of 6MWT, BBS, TUG, and 5xSTS provided clear evidence of effectiveness and should be standard practice in all dialysis rehabilitation programs.
3. **Patient education and caregiver involvement are essential components** of sustainable rehabilitation, particularly in settings where long-term supervised therapy is unavailable. Training the husband in safe transfer techniques and home exercise ensured continuity of care.
4. **Exercise intensity and timing must be individualized** based on dialysis schedule and patient tolerance. The patient's lowest tolerance on Monday mornings necessitated intensity modulation, consistent with evidence that exercise timing should be personalized [11].

5. **Combined aerobic and resistance training is superior** to either modality alone for improving multiple functional domains, consistent with 2025 meta-analytic evidence [4,5].
6. **Even in resource-limited settings, evidence-based rehabilitation can improve functional outcomes** using low-cost, portable equipment (resistance bands, pedal exercisers, ankle weights). This is particularly relevant for sub-Saharan Africa, where dialysis programs are expanding but rehabilitation services remain scarce.
7. **Early referral to physical therapy may prevent further functional decline** and improve quality of life. This patient was referred within 2 months of dialysis initiation, which likely contributed to her excellent response.
8. **Young ESRD patients require special attention:** The 2024 KDIGO guideline recognizes young adults with CKD as a high-risk population [8]. Early, aggressive rehabilitation in this group is critical to prevent lifelong disability and preserve occupational and social functioning.

Declarations

9. Patient Perspective

"Before starting physical therapy, I was very afraid. I could not walk properly, and I was always worried that I would fall down. My legs felt numb, and even simple things like climbing stairs or walking to the toilet were exhausting. I felt like my life had stopped because I could not work on my farm anymore. I was only 28 years old, but I felt like an old woman. I would cry at night because I thought I would never be able to take care of my family again.

When the physical therapist started working with me during my dialysis sessions, I was not sure if it would help. The first week was difficult—I was tired, and my muscles were sore. But slowly, I started to feel stronger. The therapist always explained what we were doing and why, which made me feel involved in my own care. My husband also learned how to help me at home, which made me feel safer. I learned how to manage my water intake better, and I joined a support group where I met other patients like me. Talking to them made me feel less alone.

After about one month, I noticed I could walk farther without stopping. After two months, I could climb the stairs at my house with only one hand on the railing. Now, after three months, I can walk to the market with confidence, and I am not as scared of falling. I can do light housework, and I am planning to try some light farming activities again. I still need dialysis three times a week, but I do not feel as weak as before. Physical therapy gave me hope that I can still improve, even with kidney disease. I would tell other dialysis patients to try physical therapy—it really made a difference for me. I am grateful to the therapist and the hospital for giving me my life back."

10. Informed Consent

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. The patient was informed that all identifying information would be de-identified to protect confidentiality. A copy of the written consent is available for review by the Editorial Office upon request.

Declarations

Ethical approval: Ethical approval is not required at our institution for anonymous case reports. All procedures were performed in accordance with the ethical standards of the institutional and national research committees and with the 1964 Helsinki Declaration and its later amendments.

Conflict of interest: The author declares that there is no conflict of interest regarding the publication of this article.

Funding: None.

Authors' contributions: Biruk Getiso Awata conceived the case report, conducted the clinical assessment and physical therapy intervention, collected and analyzed the patient data, drafted the initial manuscript, and approved the final version for submission. The author takes full responsibility for the integrity of the work and the accuracy of the reported information.

Acknowledgments: I would like to express my sincere gratitude to the nursing and medical staff of the hemodialysis unit at Yanet Hospital for their cooperation and support during the rehabilitation sessions. Special thanks to the patient's family members, particularly her husband, for their dedication to caregiver education and their encouragement throughout the treatment process. I also acknowledge the patient for her willingness to participate in physical therapy, her perseverance during challenging sessions, and for sharing her experience to benefit others in similar circumstances. I thank the hospital administration for facilitating access to the dialysis unit for rehabilitation services.

Data availability: The data supporting this case report are available from the corresponding author upon reasonable request, subject to ethical and institutional approval.

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Figures

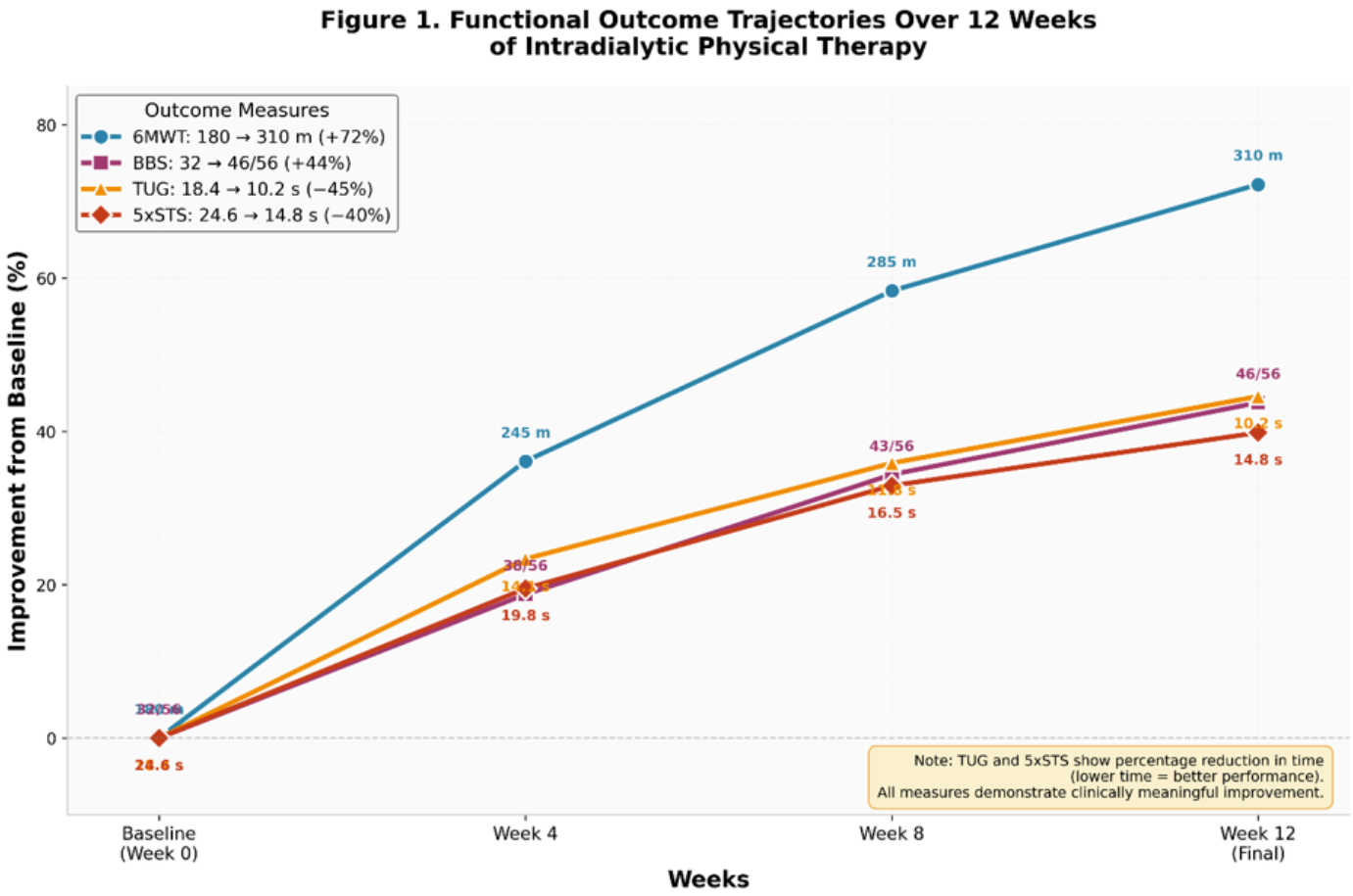


Figure 1

Functional Outcome Trajectories Over 12 Weeks

Legend: Progression of key functional outcome measures from baseline through 12 weeks of intradialytic physical therapy intervention. All measures demonstrate clinically meaningful improvements, with the most pronounced gains observed in the first 8 weeks.

Figure 2. 12-Week Progressive Intradialytic Exercise Protocol

Equipment: Portable pedal exerciser | Resistance bands (light/medium/heavy) | Dumbbells (0.5–2.0 kg) | Ankle weights (0.5–1.5 kg) | Pulse oximeter | Sphygmomanometer

Parameter	Phase 1 Weeks 1-4	Phase 2 Weeks 5-8	Phase 3 Weeks 9-12
Aerobic: Seated Cycling	5–15 min 40–50% HRmax Borg RPE 11–13	20–25 min 60–70% HRmax Borg RPE 13–14	25–30 min 60–70% HRmax Borg RPE 13–15
Resistance: Upper Extremities	2 sets × 10–15 reps 0.5 kg dumbbells	3 sets × 12 reps 1.0 kg dumbbells	3 sets × 12 reps 2.0 kg dumbbells
Resistance: Lower Extremities	2 sets × 10–15 reps 0.5 kg ankle weights	3 sets × 12 reps 1.0 kg ankle weights	3 sets × 12 reps 1.5 kg ankle weights
Balance Training	Seated weight shifting Sit-to-stand practice (assisted)	Standing static balance Tandem stance (supported) Dynamic weight shifting	Single-leg stance Tandem walking Step-ups (10 cm step)
Flexibility	Static stretches 30-sec holds, 2 reps Major muscle groups	Static stretches 30-sec holds, 2 reps Major muscle groups	Static stretches 30-sec holds, 3 reps Major muscle groups
Frequency	3 sessions/week (Monday / Wednesday / Friday)	3 sessions/week (Monday / Wednesday / Friday)	3 sessions/week (Monday / Wednesday / Friday)
Session Duration	45–50 minutes (incl. warm-up & cool-down)	50–55 minutes (incl. warm-up & cool-down)	55–60 minutes (incl. warm-up & cool-down)
Timing	2nd hour of hemodialysis session	2nd hour of hemodialysis session	2nd hour of hemodialysis session

MONITORING PARAMETERS

- Vital Signs: BP, HR, SpO_2 recorded before exercise, every 10 min during, and after exercise
- Borg RPE: Recorded every 5 minutes during aerobic exercise
- Target HR: Phase 1 = 77–96 bpm | Phase 2–3 = 115–134 bpm (HRmax = 220 − 28 = 192 bpm)
- Safety Contraindications: SBP >180 or <90 mmHg | SpO_2 <90% | Chest pain | Severe dyspnea | New arrhythmias
- Intensity Modulation: Reduce by 20% on days with lowest tolerance (typically Monday mornings)

Figure 2

Intervention Protocol Summary

Legend: Overview of the 12-week progressive intervention protocol, including resistance training (upper and lower extremity), aerobic conditioning (seated cycling), balance training, flexibility, and patient education components. Progression parameters are indicated for each phase.

Supplementary Files

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