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Effectiveness of Intradialytic Leg Exercise on Fatigue and Activities of Daily Living Among Hemodialysis Patients: A Quasi-Experimental Study

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ABSTRACT

Background: *Fatigue is among the most prevalent and debilitating symptoms experienced by patients undergoing hemodialysis, significantly compromising their activities of daily living (ADL) and overall quality of life. Intradialytic exercise has been proposed as a safe, cost-effective non-pharmacological intervention; however, evidence regarding the simultaneous impact on both fatigue and ADL in the Indian clinical context remains limited.* ***Objectives:*** *To evaluate the effectiveness of intradialytic leg exercise on fatigue and ADL among hemodialysis patients and to determine the correlation between fatigue and ADL after the intervention.* ***Methods:*** *A quasi-experimental, non-randomized control group design was employed. Fifty-four adult hemodialysis patients from selected hospital, Lucknow, India, were allocated to experimental (n = 27) and control (n = 27) groups via purposive sampling. The intervention consisted of structured intradialytic leg exercises (stretching, flexion, extension, and rotation) performed during the first hour of each dialysis session for 30 minutes, twice weekly over two weeks. Fatigue was assessed using the Functional Assessment of Chronic Illness Therapy–Fatigue (FACIT-F) Scale (Version 4), and ADL was measured using the KATZ Index of Independence. Paired and unpaired t-tests and Pearson's correlation coefficient were applied for statistical analysis.* ***Results:*** *Following the intervention, the experimental group demonstrated a significant improvement in fatigue levels, with the mean FACIT-F score increasing from 31.85 (SD = 6.96) pre-intervention to 44.70 (SD = 9.04) post-intervention (mean difference = 12.74; t = 16.02; $p < 0.05$). The mean ADL score also improved from 3.66 to 4.11 in the experimental group, although the difference was not statistically significant. A strong positive correlation was observed between post-test fatigue and ADL scores in both the experimental (r = 0.82, $p < 0.001$) and control (r = 0.92, $p < 0.001$) groups.* ***Conclusion:*** *A two-week intradialytic leg exercise programme significantly reduced fatigue among hemodialysis patients without adverse events, underscoring its value as a structured nursing intervention. The strong correlation between fatigue and ADL highlights the necessity of addressing fatigue to preserve functional independence in this population.*

Keywords: *Intradialytic exercise; hemodialysis; fatigue; activities of daily living; chronic kidney disease; FACIT-F scale; KATZ index; nursing intervention*

INTRODUCTION

Chronic kidney disease (CKD) represents a major and growing global public health burden. The Global Burden of Disease (GBD) study estimated that CKD affects approximately 697.5 million individuals worldwide, with a global prevalence of 9.1%, and accounts for 1.2 million deaths per year and 35.8 million disability-adjusted life-years [1]. The disease disproportionately burdens low- and middle-income countries, where healthcare infrastructure for renal replacement therapy remains inadequate [1,2]. End-stage renal disease (ESRD), defined as kidney function below 15% of normal capacity (glomerular filtration rate [GFR] < 15 mL/min/1.73 m²), represents the terminal stage of CKD and necessitates renal replacement therapy in the form of dialysis or kidney transplantation [3]. Globally, the number of patients receiving hemodialysis has increased substantially as a consequence of population ageing, rising rates of diabetes mellitus, and the increasing prevalence of hypertension, with projections indicating that over two million individuals will require dialysis for ESRD by 2030 [4].

Hemodialysis (HD) remains the most widely used modality of renal replacement therapy, accounting for the majority of dialysis prescriptions worldwide [2]. Although HD prolongs survival and improves solute clearance, patients on maintenance HD experience a significant reduction in physical function, muscle strength, and exercise capacity compared with age-matched healthy individuals [5]. These physiological deteriorations are compounded by uremia, anaemia, inflammation, malnutrition, and the haemodynamic consequences of the dialytic process itself [6].

The burden of CKD is particularly pronounced in South and East Asia. A systematic review and meta-analysis estimated that up to 434.3 million individuals in Eastern, Southern, and South-Eastern Asia have CKD, with China and India collectively accounting for approximately 299.9 million cases; of these, approximately 65.6 million may be in severe or late stages of the disease [7]. In India, the prevalence of CKD is estimated at 800 per million population, with a progressive increase attributable to the epidemic of type 2 diabetes mellitus and hypertension [8]. The incidence of ESRD in India is approximately 232 per million population per year, representing a significant socioeconomic challenge for both households and the healthcare system [8]. The availability of dialysis facilities remains concentrated in urban tertiary-care centres, creating marked disparities in access to care between urban and rural populations [9].

Within Uttar Pradesh, one of the most populous states of India, dialysis services are concentrated in urban centres such as Lucknow, with patients frequently travelling considerable distances to receive regular treatment. The socioeconomic profile of this patient population characterized by low-to-middle incomes, joint family structures, and predominantly secondary-level education shapes the nature of caregiving and the feasibility of exercise interventions [9].

Fatigue is the most frequently reported symptom among patients undergoing chronic HD, affecting 60–97% of this population [10]. Unlike transient fatigue experienced by the general population, HD-related fatigue is chronic, multidimensional, and refractory to standard clinical management. It encompasses physical exhaustion, cognitive difficulties, reduced motivation, and impaired social functioning, ultimately leading to a progressive decline in quality of life [11]. The aetiology of fatigue in HD patients is multifactorial, encompassing uraemic toxin accumulation, anaemia, sleep disturbances, nutritional deficiencies, altered serum electrolytes (including urea, haemoglobin, albumin, sodium, and potassium), haemodynamic effects of ultrafiltration, comorbid depression, and sedentary lifestyle [12].

Activities of daily living (ADL) encompassing fundamental self-care functions such as bathing, dressing, toileting, transferring, continence, and feeding are profoundly affected in HD patients. Impaired ADL constitutes an independent predictor of mortality, hospital admission, and reduced quality of life in this population [13]. The bidirectional relationship between fatigue and ADL creates a cycle of functional decline: fatigue limits participation in daily activities, which in turn leads to further deconditioning and worsening fatigue [14].

Physical activity and structured exercise training have been recognised as cornerstone non-pharmacological interventions for improving physical function, reducing fatigue, and enhancing quality of life in HD patients [15]. Intradialytic exercise conducted during the hemodynamically stable first two hours of a dialysis session offers a pragmatic and time-efficient approach, as it avoids additional appointments and capitalises on the supervised clinical environment [16]. Low- to moderate-intensity exercises, including cycling, resistance training, stretching, and lower-extremity range-of-motion exercises, have been investigated for their feasibility, safety, and efficacy across numerous trials [17].

Evidence from recent clinical trials supports the beneficial effects of intradialytic exercise on fatigue. Salehi et al. (2020) demonstrated that mini-bike cycling twice weekly for three months significantly reduced multidimensional fatigue scores compared with controls ($p < 0.001$) [18]. A nine-month hybrid aerobic and resistance intradialytic exercise programme reported significant improvements in fatigue ($p = 0.039$), vitality, cognitive function, and depression among HD patients [19]. A large-scale multicentre cluster randomised controlled trial involving 917 participants found that combined endurance and resistance intradialytic training for 12 months significantly improved sit-to-stand capacity (+3.85 repetitions; 95% CI: 2.22 to 5.48; $p < 0.0001$) and six-minute walk distance (+37.5 m; 95% CI: 14.7 to 60.4) [20]. Furthermore, a recent Japanese cohort study reported that intradialytic exercise significantly improved Barthel Index scores (ΔBI = 13.7 points; 95% CI: 0.96–26.38; $p < 0.05$) and gait speed (Δ10-m walk = 0.25 m/s; $p < 0.05$) in hospitalised HD patients [21].

Despite these advances, studies specifically targeting intradialytic *leg* exercises involving stretching, flexion, extension, and rotation on both fatigue and ADL simultaneously in the Indian population remain sparse. Furthermore, the correlation between post-intervention fatigue and ADL, and their associations with clinical and sociodemographic variables, have been insufficiently examined in this context.

The existing body of literature, while growing, is predominantly derived from Western and East Asian populations, with heterogeneous intervention durations, exercise modalities, and outcome measures. Contextual factors specific to Indian HD populations—including socioeconomic constraints, comorbidity profiles, cultural practices, and healthcare access—necessitate locally relevant evidence to guide clinical nursing practice. Intradialytic leg exercise is particularly suitable for resource-limited settings, as it requires no specialised equipment and can be seamlessly integrated into routine nursing care during dialysis.

Study Objectives: The objectives of this study were to assess the level of fatigue before and after intradialytic leg exercise among hemodialysis patients using the FACIT Fatigue Scale, and to assess the level of activities of daily living (ADL) before and after intradialytic leg exercise using the KATZ Index. The study also aimed to evaluate the effectiveness of intradialytic leg exercise in reducing fatigue and improving ADL among hemodialysis patients. Furthermore, it sought to determine the correlation between post-test fatigue and post-test ADL, as well as to identify the association between pre-test fatigue levels and selected sociodemographic variables, and between pre-test ADL levels and selected sociodemographic variables among hemodialysis patients.

MATERIALS AND METHODS

Research Design and Setting: A quasi-experimental, non-randomised pre-test–post-test control group design was employed. The study was conducted at the hemodialysis unit of selected hospital, a single-speciality institution (100 beds; 7 HD beds; 24-hour service) specialising in urology and nephrology, located within 5 kilometres of the investigator's institution in Lucknow, Uttar Pradesh, India.

Study Population and Eligibility Criteria: The target population comprised all adults with chronic renal failure undergoing maintenance hemodialysis at the selected hospital. The accessible population was restricted to patients receiving dialysis for at least six months prior to enrolment.

Inclusion criteria: Adult patients (≤60 years) undergoing maintenance hemodialysis - Ability to communicate in English or Hindi - Willingness to participate in leg exercise - Receiving hemodialysis for at least six months - Undergoing regular hemodialysis at least twice weekly

Exclusion criteria: Age above 60 years - Presence of femoral catheter - Comorbid conditions including asthma, chronic obstructive pulmonary disease, and arthritis - Congenital lower-extremity anomalies (e.g., poliomyelitis sequelae) - Paraplegia or lower-extremity fractures

Sample Size: A total of 54 participants were included in the study to ensure adequate statistical power and equal group allocation, with 27 participants assigned to the experimental group and 27 participants assigned to the control group. Purposive sampling was employed, allocating participants to experimental (n = 27) and control (n = 27) groups based on the dialysis schedule and unit allocation.

Data Collection Instruments

Three standardised instruments were used:

Tool I – Sociodemographic and Clinical Variables Questionnaire: This section captured age, gender, religion, marital status, educational level, occupation, monthly income, family type, area of residence, duration of HD, use of relaxation techniques, and frequency of home exercise. Clinical variables included serum creatinine, serum urea, systolic and diastolic blood pressure, haemoglobin, sodium, potassium, and calcium levels.

Tool II – KATZ Index of Independence in Activities of Daily Living: Developed by Katz et al. (1963), this widely validated instrument assesses six core ADL domains: bathing, dressing, toileting, transferring, continence, and feeding [22]. Each domain is rated as independent (1) or dependent (0); total scores range from 0 to 6. Scoring categories: full function (6), moderate impairment (3–5), and severe impairment (0–2). The scale demonstrates robust internal consistency (Cronbach's $\alpha = 0.82$) and excellent test–retest reliability (intraclass correlation coefficient [ICC] = 0.82; 95% CI: 0.77–0.85; $p < 0.001$) [22].

Tool III – FACIT Fatigue Scale (Version 4): Developed by Tennant and colleagues, this 13-item patient-reported outcome measure evaluates fatigue severity over the preceding seven days. Items are scored on a 5-point Likert scale (4 = "Not at all" to 0 = "Very much"), with reverse scoring applied to items 7 and 8. The total score (range: 0–52) is calculated as the sum of individual item scores, multiplied by 13, and divided by the number of items answered. A score ≤ 30 indicates severe fatigue; 31–39 indicates moderate fatigue; and 40–52 indicates mild fatigue (i.e., better quality of life). The FACIT-F demonstrates high internal consistency (Cronbach's $\alpha = 0.96$) and excellent test–retest reliability (ICC = 0.95) [23].

Intervention Protocol: The intradialytic leg exercise programme was administered to the experimental group during the first hour of each hemodialysis session for 30 minutes, twice weekly over two weeks (four sessions total). The exercise protocol comprised passive and active lower-extremity movements: Ankle dorsiflexion and plantar flexion (ankle pumps), Knee flexion and extension (seated leg raises), Hip flexion (seated marching), Lower-extremity rotation (ankle circles), Hamstring and calf stretching Exercises were performed in the supine or semi-recumbent position on the dialysis chair. A trained nurse supervised all sessions and monitored for adverse events, including haemodynamic instability, muscle cramps, and pain. No adverse events were reported throughout the intervention period. The control group received standard hemodialysis care without any structured exercise programme.

Data Collection Procedure: Prior written approval was obtained from the hospital administration and the investigator's institution. Informed written consent was obtained from all participants in both groups before data collection commenced. Pre-test assessments of fatigue (FACIT-F) and ADL (KATZ) were administered to both groups via structured interview at the beginning of the study. The intervention was subsequently delivered to the experimental group over two weeks. Post-test assessments were conducted in both groups on the last day of the second week, using the same instruments and interview method. Demographic and clinical data were collected from patient records and direct interview after dialysis initiation, within a 15-minute window.

Statistical Analysis: Data were analysed using descriptive statistics (frequency, percentage, mean, and standard deviation) and inferential statistics. The paired t-test was employed to compare pre-test and post-test scores within each group. The unpaired t-test was used to compare post-test scores between the experimental and control groups. Pearson's correlation coefficient (r) was calculated to examine the relationship between post-test fatigue and ADL scores. The chi-square (χ^2) test was applied to determine associations between pre-test fatigue or ADL levels and sociodemographic variables. A level of significance of $p < 0.05$ was adopted throughout. Statistical analyses were performed using standard statistical software.

Ethical Considerations: The study was conducted following approval from the Institutional Ethics Committee before the commencement of data collection. Written informed consent was obtained from all participants after explaining the purpose and procedures of the study. Participants were assured that their participation was entirely voluntary and that they had the right to withdraw from the study at any stage without any consequences. Anonymity, confidentiality, and privacy of the participants' information were strictly maintained throughout the study. Furthermore, participants were informed that their decision to participate or decline participation would not affect the standard of clinical care they received.

RESULTS

Section A: Sociodemographic and Clinical Profile of Participants

Table 1. *Classification of Chronic Kidney Disease Stages by Glomerular Filtration Rate*

Stage	*Description*	*GFR (mL/min/1.73 m²)*
Stage 1	*Kidney damage with normal or increased GFR*	*≥ 90*
Stage 2	*Kidney damage with mildly decreased GFR*	*60–89*
Stage 3a	*Moderately decreased GFR*	*45–59*
Stage 3b	*Moderately decreased GFR*	*30–44*
Stage 4	*Severely decreased GFR*	*15–29*
Stage 5	*Kidney failure*	*< 15 (or dialysis)*

Source: Adapted from KDIGO Clinical Practice Guidelines for CKD Evaluation and Management [3].

Pre-test and Post-test Distribution of Demographic and Clinical Variables in Experimental Group

The majority of the participants (37.03%) were aged 51–55 years, followed by 25.92% in the 46–50 years age group, while 18.51% each belonged to the 35–40 years and 41–45 years age groups. Most participants were male (92.59%), Hindu (92.59%), and all were married (100%). Regarding educational status, 70.37% had completed secondary education, 25.92% were postgraduates, and 3.70% were graduates. The majority (70.37%) were employed in the private sector, whereas 29.63% were self-employed. More than half of the participants (51.85%) had a monthly income of ₹25,000–35,000, followed by 44.44% earning ≤₹25,000 and 3.70% earning ₹36,000–50,000. All participants (100%) belonged to joint families, and the majority (77.78%) resided in urban areas. Most participants (70.37%) had been undergoing hemodialysis for 6 months to 1 year, while 25.92% had been on dialysis for 1–2 years and 3.70% for more than 4 years. Exercise (59.25%) was the most commonly practiced relaxation technique, followed by meditation (22.22%) and yoga (18.51%). Regarding exercise at home, 59.25% exercised occasionally, 29.62% exercised rarely, 7.40% exercised frequently, and 3.70% never exercised.

At the pre-test, 51.85% of participants had serum creatinine levels between 4–6 mg/dL, while 48.15% had levels >6 mg/dL. Serum urea levels were between 200–300 mg/dL in 96.29% of participants and between 300–400 mg/dL in 3.70%. Regarding blood pressure, 55.55% had systolic blood pressure between 140–160 mmHg and 44.44% between 161–180 mmHg. Diastolic blood pressure was 102–120 mmHg in 74.07% of participants, 122–140 mmHg in 14.81%, and ≤100 mmHg in 11.11%. Most participants (55.55%) had moderate anaemia, while 37.03% had severe anaemia and 7.40% had mild anaemia. All participants (100%) had normal serum sodium levels (135–145 mmol/L). Serum potassium levels were within the normal range (3.5–5.3 mmol/L) in 59.25% of participants, ≤3.5 mmol/L in 37.03%, and >5.3 mmol/L in 3.70%. Serum calcium levels were between 4.5–5.5 mg/dL in 59.25% of participants, ≤4.50 mg/dL in 25.92%, and >5.5 mg/dL in 14.81%.

At the post-test, 96.29% of participants had serum creatinine levels ≤1.3 mg/dL, while 3.70% had levels between 1.3–3 mg/dL. Serum urea levels were ≤200 mg/dL in 81.48% of participants and 200–300 mg/dL in 18.52%. All participants (100%) had systolic blood pressure between 140–160 mmHg. Diastolic blood pressure was 102–120 mmHg in 51.85% of participants and ≤100 mmHg in 48.15%. Most participants (92.59%) had moderate anaemia, while 7.40% had mild anaemia. All participants (100%) had normal serum sodium levels (135–145 mmol/L). Serum potassium levels were ≤3.5 mmol/L in 77.78% of participants and within the normal range (3.5–5.3 mmol/L) in 22.22%. Regarding serum calcium, 48.15% of participants had levels ≤4.50 mg/dL, 48.15% had levels between 4.5–5.5 mg/dL, and 3.70% had levels >5.5 mg/dL.

Pre-test and Post-test Distribution of Demographic and Clinical Variables in Control Group

The highest proportion of participants (37.03%) belonged to the 41–45 years age group, followed by 29.62% in the 51–55 years age group, 18.51% in the 46–50 years age group, and 14.81% in the 35–40 years age group. The majority of participants were male (70.37%), Hindu (92.59%), and married (81.48%). Regarding educational status, 40.74% had completed primary education, 33.33% had secondary education, and 25.92% were postgraduates. Most participants (55.55%) were employed in the private sector, followed by 33.33% who were self-employed and 11.11% who were government employees. More than half of the participants (55.55%) had a monthly income of ≤₹25,000, while 40.74% earned ₹25,000–35,000 and 3.70% earned ₹36,000–50,000. Slightly more than half (51.85%) belonged to joint families, 44.44% to nuclear families, and 3.70% to extended families. The majority of participants (77.78%) resided in urban areas. Most participants (74.07%) had been undergoing hemodialysis for 6 months to 1 year, while 25.92% had received hemodialysis for 1–2 years. Exercise (48.14%) was the most commonly practiced relaxation technique, followed by meditation (33.33%), yoga (11.11%), and other techniques (7.40%). Regarding exercise at home, 74.07% exercised occasionally, 18.51% exercised rarely, and 7.40% exercised frequently.

At the pre-test, 55.55% of participants had serum creatinine levels between 4–6 mg/dL, 25.92% had levels >6 mg/dL, 11.11% had levels between 1.3–3 mg/dL, and 7.40% had levels ≤1.3 mg/dL. Serum urea levels were between 300–400 mg/dL in 77.78% of participants and >500 mg/dL in 22.22%. Regarding systolic blood pressure, 48.14% had values between 161–180 mmHg, 29.62% had values between 140–160 mmHg, 14.81% had values ≤140 mmHg, and 7.40% had values >180 mmHg. Diastolic blood pressure was ≤100 mmHg in 44.44% of participants, 102–120 mmHg in 37.03%, and 122–140 mmHg in 18.51%. Most participants (74.07%) had severe anaemia, while 22.22% had moderate anaemia and 3.70% had mild anaemia. All participants (100%) had normal serum sodium levels (135–145 mmol/L). Serum potassium levels were within the normal range (3.5–5.3 mmol/L) in 88.89% of participants, while 7.40% had levels >5.3 mmol/L and 3.70% had levels ≤3.5 mmol/L. Serum calcium levels were between 4.5–5.5 mg/dL in 88.89% of participants and >5.5 mg/dL in 11.11%.

At the post-test, 77.78% of participants had serum creatinine levels between 1.3–3 mg/dL, while 22.22% had levels ≤1.3 mg/dL. Serum urea levels were between 200–300 mg/dL in 62.96% of participants and between 300–400 mg/dL in 37.03%. Most participants (81.48%) had systolic blood pressure between 140–160 mmHg, while 18.51% had values ≤140 mmHg. Diastolic blood pressure was ≤100 mmHg in 62.96% of participants and between 102–120 mmHg in 37.03%. The majority of participants (92.59%) had moderate anaemia, while 7.40% had severe anaemia. All participants (100%) had normal serum sodium levels (135–145 mmol/L). Serum potassium levels were ≤3.5 mmol/L in 55.55% of participants and within the normal range (3.5–5.3 mmol/L) in 44.44%. Regarding serum calcium, 88.89% of participants had levels ≤4.50 mg/dL, while 11.11% had levels between 4.5–5.5 mg/dL.

Section B: Level of Fatigue Before and After Intradialytic Leg Exercise

Table 2. Pre-test and Post-test Level of Fatigue Among Hemodialysis Patients in the Experimental Group (*n*=27)

S.No	*Name of Test*	*Level of Fatigue*	*Frequency*	*Percentage*	*Mean*	*SD*
1	*Pre-test*	*Mild (40–52)*	*0*	*0%*	*31.85*	*159.8*
		Moderate (31–39)	*22*	*81.48%*		
		Severe (≤ 30)	*5*	*18.51%*		
2	*Post-test*	*Mild (40–52)*	*26*	*96.29%*	*44.7*	*223.68*
		Moderate (31–39)	*0*	*0%*		
		Severe (≤ 30)	*1*	*3.7%*		

In the experimental group, the majority of participants (81.48%) experienced moderate fatigue and 18.51% experienced severe fatigue at pre-test. Following the intradialytic leg exercise intervention, 96.29% of participants reported mild fatigue and only 3.7% reported severe fatigue at post-test. The mean FACIT-F score increased from 31.85 to 44.7, indicating a clinically meaningful improvement in fatigue levels.

Table 3. Pre-test and Post-test Level of Fatigue Among Hemodialysis Patients in the Control Group (*n* = 27)

S.No	*Name of Test*	*Level of Fatigue*	*Frequency*	*Percentage*	*Mean*	*SD*
1	*Pre-test*	*Mild (40–52)*	*24*	*88.88%*		
		Moderate (31–39)	*0*	*0%*	*43.25*	*216.5*
		Severe (≤ 30)	*3*	*11.11%*		
2	*Post-test*	*Mild (40–52)*	*1*	*3.7%*		
		Moderate (31–39)	*23*	*85.18%*	*33.4*	*167.16*
		Severe (≤ 30)	*3*	*11.11%*		

In the control group, the majority of participants (88.88%) had mild fatigue at pre-test. However, by post-test, 85.18% had deteriorated to moderate fatigue and 11.11% reported severe fatigue. The mean FACIT-F score declined from 43.25 to 33.4, reflecting progressive fatigue worsening in the absence of the exercise intervention.

Section C: Level of ADL Before and After Intradialytic Leg Exercise

Table 4. Pre-test and Post-test Level of ADL Among Hemodialysis Patients in the Experimental Group (*n* = 27)

S.No	*Name of Test*	*Level of ADL*	*Frequency*	*Percentage*	*Mean*	*SD*
1	*Pre-test*	*Full functioning (6)*	*0*	*0%*		
		Moderate impairment (3–5)	*26*	*96.29%*	*3.66*	*18.34*
		Severe impairment (0–2)	*1*	*3.7%*		
2	*Post-test*	*Full functioning (6)*	*0*	*0%*		
		Moderate impairment (3–5)	*26*	*96.29%*	*4.11*	*20.6*
		Severe impairment (0–2)	*1*	*3.7%*		

The pre-test and post-test distributions of ADL categories were unchanged in the experimental group; however, the mean KATZ score increased from 3.66 to 4.11, suggesting a modest improvement in the degree of functional independence. The relatively large standard deviation reflects variability in baseline ADL capacity among participants.

Table 5. Pre-test and Post-test Level of ADL Among Hemodialysis Patients in the Control Group (*n* = 27)

S.No	*Name of Test*	*Level of ADL*	*Frequency*	*Percentage*	*Mean*	*SD*
1	*Pre-test*	*Full functioning (6)*	*0*	*0%*		
		Moderate impairment (3–5)	*26*	*96.29%*	*3.92*	*0.38*
		Severe impairment (0–2)	*1*	*3.70%*		
2	*Post-test*	*Full functioning (6)*	*0*	*0%*		
		Moderate impairment (3–5)	*26*	*96.29%*	*3.92*	*0.38*
		Severe impairment (0–2)	*1*	*3.70%*		

The control group demonstrated no change in ADL distribution or mean score (3.92 at both pre-test and post-test), confirming the absence of spontaneous improvement in functional status during the two-week observation period without exercise intervention.

Section D: Effectiveness of Intradialytic Leg Exercise on Level of Fatigue

Table 6. Effectiveness of Intradialytic Leg Exercise on Fatigue Level in the Experimental and Control Groups – Paired *t*-Test (*n*= 54)

S.No	*Group*	*Test*	*Mean*	*SD*	*Mean Difference*	*Paired t-value*	*df*	*Tabulated t*	*Remarks*
1	*Experimental*	*Pre-test*	*31.85*	*6.96*	*12.74*	*t = 16.02*	*26*	*2.06*	***S***
		Post-test	*44.70*	*9.04*					
2	*Control*	*Pre-test*	*43.26*	*10.35*	*9.85*	*t = 9.30*	*26*	*2.06*	***S***
		Post-test	*33.41*	*7.29*					

S = Significant at p < 0.05.

The experimental group demonstrated a significant improvement in fatigue levels, with a mean difference of 12.74 and a calculated *t*-value of 16.02, which exceeds the tabulated critical value of 2.06 at 26 degrees of freedom ($p < 0.05$). In the control group, a significant mean difference of 9.85 was also observed; however, this represents a deterioration in fatigue (mean score declined from 43.26 to 33.41), with the calculated *t*-value of 9.30 also exceeding the tabulated value, reflecting statistically significant worsening. There is a significant difference in the post-test level of fatigue among hemodialysis patients in the experimental group at the 0.05 level of significance.

Table 7. Effectiveness of Intradialytic Leg Exercise on Post-test Fatigue Level – Unpaired *t*-Test (*n* = 54)

S.No	*Group*	*Test*	*Mean*	*SD*	*Unpaired t-value*	*df*	*Tabulated t*	*Remarks*
1	*Experimental*	*Post-test*	*44.70*	*9.03*	*t = 5.05*	*52*	*2*	*S*
2	*Control*	*Post-test*	*33.40*	*7.28*				

S = Significant at p < 0.05.

Comparison of post-test fatigue scores between the two groups using the unpaired *t*-test revealed a statistically significant difference ($t = 5.05$; df = 52; tabulated value = 2; $p < 0.05$). The experimental group achieved a significantly higher FACIT-F score (mean = 44.70, SD = 9.03) than the control group (mean = 33.40, SD = 7.28), confirming the superiority of the intradialytic leg exercise intervention.

Section E: Effectiveness of Intradialytic Leg Exercise on Level of ADL

Table 8. Effectiveness of Intradialytic Leg Exercise on ADL Level in the Experimental and Control Groups – Paired *t*-Test (*n* = 54)

S.No	*Group*	*Test*	*Mean*	*SD*	*Mean Difference*	*Paired t-value*	*df*	*Tabulated t*	*Remarks*
1	*Experimental*	*Pre-test*	*3.66*	*0.96*	*0.45*	*t = 1.12*	*26*	*2.06*	***NS***
		Post-test	*4.11*	*0.97*					
2	*Control*	*Pre-test*	*3.92*	*0.38*	*0.00*	*t = 0.0*	*26*	*2.06*	***NS***
		Post-test	*3.92*	*0.38*					

NS = Not Significant at p < 0.05.

The paired *t*-test revealed that the calculated *t*-value for the experimental group (1.12) and the control group (0.0) were both below the tabulated critical value of 2.06 ($p = 0.05$; df = 26). Whilst the mean ADL score increased from 3.66 to 4.11 in the experimental group, this improvement did not achieve statistical significance. The control group exhibited no change. There is no statistically significant difference in ADL levels after the intervention in either group.

The unpaired *t*-test (Table -9) comparing post-test ADL scores confirmed no statistically significant difference between the groups ($t = 1.03$; df = 52; $p = 0.2$).

Table 9. Effectiveness of Intradialytic Leg Exercise on Post-test ADL Level – Unpaired *t*-Test (*n* = 54)

S.No	*Group*	*Test*	*Mean*	*SD*	*Unpaired t-value*	*df*	*Tabulated t*	*Remarks*
1	*Experimental*	*Post-test*	*4.11*	*0.97*	*t = 1.03*	*52*	*2*	***NS***
2	*Control*	*Post-test*	*3.92*	*0.38*				

NS = Not Significant at p = 0.05.

Section F: Correlation Between Fatigue and ADL Among Hemodialysis Patients

Table 10. Correlation Between Post-test Fatigue Level and ADL Level Among Hemodialysis Patients ($n = 54$)

S.No	*Group*	*Post-test Observations*	*Pearson r*	*p-value*
1	*Experimental*	*Fatigue vs. ADL*	*0.82*	***0.00001****
2	*Control*	*Fatigue vs. ADL*	*0.92*	*0.00001**

* *Significant at p < 0.05.*

A strong positive correlation was observed between post-test fatigue and ADL scores in both the experimental group ($r = 0.82$, $p < 0.001$) and the control group ($r = 0.92$, $p < 0.001$). These findings indicate that higher fatigue levels are consistently associated with higher ADL capacity scores on the FACIT-F scale, reflecting the inverse relationship: as fatigue is ameliorated, functional performance improves. There is a significant correlation between fatigue and ADL among hemodialysis patients at the 0.05 level of significance.

Section G: Association Between Pre-test Fatigue and Sociodemographic Variables

In the experimental group, no significant association was found between pre-test fatigue and most sociodemographic variables. However, statistically significant associations were identified for type of family ($\chi^2 = 10.70$; df = 4; $p < 0.05$) and area of residence ($\chi^2 = 8.93$; df = 2; $p < 0.05$).

In the control group, significant associations were identified between pre-test fatigue and occupation ($\chi^2 = 10.8$; df = 4; $p < 0.05$) and sodium level ($\chi^2 = 16.33$; df = 4; $p < 0.05$). Most other sociodemographic variables showed no significant association.

Section H: Association Between Pre-test ADL and Sociodemographic Variables

In the experimental group, statistically significant associations were found between pre-test ADL levels and type of family ($\chi^2 = 23.15$), duration of HD ($\chi^2 = 27$), serum urea level ($\chi^2 = 27$), sodium level ($\chi^2 = 23.15$), and potassium level ($\chi^2 = 27$).

In the control group, a significant association was found between pre-test ADL levels and serum creatinine levels ($\chi^2 = 12.98$; df = 6; $p < 0.05$). No other significant associations were identified.

DISCUSSION

This quasi-experimental study examined the effectiveness of a structured two-week intradialytic leg exercise programme on fatigue and ADL in 54 adult hemodialysis patients in Lucknow, India. The principal finding was a statistically significant reduction in fatigue levels following the intervention, whereas improvements in ADL, although numerically evident, did not reach statistical significance. A strong positive correlation between post-test fatigue and ADL was observed in both groups.

Fatigue Outcomes

The experimental group demonstrated a marked improvement in FACIT-F scores following the intradialytic leg exercise programme, with the mean score rising from 31.85 (moderate fatigue range) to 44.70 (mild fatigue range), yielding a mean difference of 12.74 (paired $t = 16.02$; $p < 0.05$). Simultaneously, the control group, which received no exercise intervention, exhibited a deterioration in fatigue from a mean score of 43.26 to 33.41, confirming the natural progression of fatigue in the absence of structured activity.

These findings align with and extend the existing literature. Salehi et al. (2020) conducted a randomised controlled trial in Iran in which mini-bike cycling twice weekly for three months significantly reduced multidimensional fatigue scores in HD patients compared with controls ($p < 0.001$), and the benefit persisted at one-month follow-up [18]. The directional consistency between that study and the present findings suggests that even short-duration, low-complexity leg exercises can achieve meaningful fatigue reduction within two weeks. Grigoriou et al. (2021) similarly reported significant improvements in fatigue ($p = 0.039$) following a nine-month hybrid aerobic and resistance intradialytic exercise programme, demonstrating the durability of exercise-induced benefits over extended periods [19]. In an Indian context, Pangambam and Bhutia (2023) employed a four-week quasi-experimental design in Sikkim and found that intradialytic leg ergometry combined with stretching yielded post-test fatigue scores significantly lower in the intervention group than in controls (mean 26.86 ± 8.228 versus 32.40 ± 8.726; $p < 0.05$) [24]. The larger mean difference observed in the present study (12.74) compared with many prior Indian studies may reflect both the severity of baseline fatigue in the study cohort and the particular responsiveness of patients who had not previously received structured exercise.

The physiological mechanisms underlying exercise-induced fatigue reduction in HD patients are multifactorial. Regular aerobic and resistance exercise enhances skeletal muscle oxidative capacity, improves haemodynamic efficiency, reduces inflammatory cytokine burden (including interleukin-6 and tumour necrosis factor-α), and attenuates anaemia-related fatigue by stimulating erythropoietin sensitivity [25]. Exercise during HD additionally promotes better solute clearance by redistributing blood flow to exercising muscles, potentially improving dialysis adequacy [15]. The clinical improvements observed in biochemical parameters in the experimental group including reductions in serum creatinine, urea, and blood pressure are consistent with improved dialysis efficiency secondary to intradialytic exercise.

The observed deterioration in fatigue among the control group warrants specific attention. This worsening likely reflects the natural history of uremic fatigue in a sedentary dialysis population over two weeks of observation, compounded by the progressive deconditioning cycle inherent to untreated HD fatigue [11]. This finding underscores the importance of proactive exercise prescription, as passive standard care was insufficient to prevent functional decline even over a short observation period.

ADL Outcomes

The mean KATZ ADL score improved numerically from 3.66 to 4.11 in the experimental group following the intervention, while the control group showed no change (3.92 at both timepoints). However, the improvement in the experimental group did not achieve statistical significance (paired $t = 1.12$; $p > 0.05$), and the between-group comparison was similarly nonsignificant (unpaired $t = 1.03$; $p = 0.2$).

These results may be interpreted in the context of the KATZ Index's categorical structure and the two-week intervention duration. As a clinician-rated ordinal tool designed to capture fundamental self-care functions, the KATZ Index has limited sensitivity to detect incremental improvements in ADL when the majority of participants are clustered within the moderate impairment category (score 3–5). The relatively homogeneous pre-test distribution (96.29% moderate impairment in both groups) may have introduced a floor effect that constrained the magnitude of detectable change within two weeks [22]. Consistent with this observation, Takahashi et al. (2025) employed the Barthel Index—a more sensitive ADL instrument—and reported significant improvements ($\Delta BI = 13.7$ points; $p < 0.05$) and gait speed gains (Δ10-m walk = 0.25 m/s; $p < 0.05$) in hospitalised HD patients receiving intradialytic exercise [21]. The greater responsiveness of the Barthel Index compared with the KATZ tool in detecting graded functional changes may partly explain the non-significant ADL findings in the present study. Consistent with this, the large-scale multicentre RCT by Anding-Rost et al. (2023) demonstrated that 12 months of combined intradialytic exercise produced significant improvements in sit-to-stand capacity (+3.85 repetitions; $p < 0.0001$) and six-minute walk distance (+37.5 m; $p < 0.05$), suggesting that longer intervention durations and objective performance-based measures may better capture ADL-related functional gains [20].

The positive numerical trend observed in the experimental group's ADL scores, coupled with the significant fatigue reduction, supports the clinical value of the intervention for enhancing the functional trajectory of HD patients, even if two weeks is an insufficient timeframe for statistically significant KATZ ADL improvements.

Correlation Between Fatigue and ADL

The strong positive correlations observed between post-test fatigue and ADL scores in both the experimental ($r = 0.82$, $p < 0.001$) and control ($r = 0.92$, $p < 0.001$) groups provide robust evidence for the bidirectional relationship between fatigue severity and functional independence in this population. Higher FACIT-F scores (indicating less fatigue) were associated with higher KATZ ADL scores (indicating better functional independence). This mechanistic link is well recognised in the nephrology literature; patients experiencing profound fatigue engage less in routine self-care activities, resulting in progressive muscular deconditioning, diminished exercise tolerance, and further functional decline [14]. The strong correlation coefficient observed here is consistent with findings reported by previous investigators, who have identified fatigue as an independent predictor of functional impairment and reduced quality of life in HD patients [13]. These findings have critical clinical implications: targeted fatigue reduction through intradialytic exercise is expected to have cascading benefits for ADL performance and quality of life, suggesting that fatigue management should be a primary nursing outcome goal in hemodialysis care.

Associations with Sociodemographic Variables

The chi-square analyses revealed several clinically meaningful associations. In the experimental group, pre-test fatigue was significantly associated with type of family ($\chi^2 = 10.70$; $p < 0.05$) and area of residence ($\chi^2 = 8.93$; $p < 0.05$). Patients residing in rural areas exhibited a higher proportion of severe fatigue, potentially reflecting limited access to healthcare services, nutritional support, and social support networks characteristic of rural settings in India [9]. Joint family members may experience collective coping and support mechanisms that modify fatigue experience. In the control group, occupation ($\chi^2 = 10.8$; $p < 0.05$) and sodium level ($\chi^2 = 16.33$; $p < 0.05$) were significantly associated with pre-test fatigue. Sodium dysregulation is a recognised contributor to fatigue in HD patients through its effects on cellular hydration, nerve conduction, and haemodynamic stability [12].

Pre-test ADL in the experimental group was significantly associated with type of family ($\chi^2 = 23.15$), duration of HD ($\chi^2 = 27$), serum urea ($\chi^2 = 27$), sodium ($\chi^2 = 23.15$), and potassium ($\chi^2 = 27$), indicating that both social determinants and metabolic factors shape baseline functional capacity. The association between duration of HD and ADL is particularly noteworthy, as longer dialysis vintage is associated with cumulative muscle wasting, cardiovascular complications, and chronic fatigue, all of which impair ADL performance [26]. In the control group, serum creatinine was significantly associated with pre-test ADL ($\chi^2 = 12.98$; $p < 0.05$), consistent with the role of uraemic retention solutes in mediating fatigue and functional limitation [6].

STRENGTHS

1. This study addresses a clinically relevant and poorly studied intervention intradialytic leg exercise in an Indian HD population, contributing contextually specific evidence to the nursing and nephrology literature.
2. The use of two well-validated and widely adopted standardised tools (FACIT-F Version 4 and KATZ Index) ensures reproducibility and comparability with international studies.
3. The pre-test–post-test control group design, with matched sample sizes (27 per group), provides a robust framework for causal inference within the quasi-experimental paradigm.
4. The incorporation of both biochemical and sociodemographic variables in the association analyses provides a holistic characterisation of the HD patient profile.
5. No adverse events were recorded during the exercise sessions, confirming the safety of the intradialytic leg exercise protocol in this population.

LIMITATIONS

1. The relatively small sample size ($N = 54$) from a single centre limits the statistical power of some analyses and restricts the generalisability of findings to broader HD populations.
2. The two-week intervention period, while sufficient to demonstrate fatigue reduction, may be too short to detect significant improvements in ADL using the KATZ Index. Longer-duration studies are required to examine sustained functional benefits.
3. The non-randomised design introduces the possibility of selection bias and confounding, as allocation to groups was guided by unit scheduling rather than randomisation.
4. The study population was predominantly Hindu (92.59% in both groups), married, and urban-dwelling, limiting the representativeness of findings across socioeconomically and culturally diverse populations.
5. The use of self-reported instruments for fatigue and ADL may introduce response bias; future studies should incorporate objective performance-based measures, such as the six-minute walk test, sit-to-stand test, or grip strength assessment.
6. The absence of long-term follow-up precludes assessment of the durability of exercise-induced fatigue improvements beyond the two-week observation period.

NURSING IMPLICATIONS

Nursing Practice: Intradialytic leg exercise can be integrated into the routine standard of care for HD patients as a structured nursing intervention. The protocol employed in this study requiring no specialized equipment and performable by trained nurses during the haemodiastable first hour of dialysis is feasible in resource-limited Indian dialysis units. Nurses are ideally positioned to assess patient fatigue at each dialysis session using validated tools such as the FACIT-F Scale, identify patients at risk of functional decline, and administer or supervise intradialytic exercise safely. Incorporating individual patient-level data on sociodemographic factors (particularly residence, family structure, occupation, and biochemical parameters) into holistic nursing assessments will enable more personalised, evidence-based fatigue and ADL management plans**.**

Nursing Education: Undergraduate and postgraduate nursing curricula should incorporate evidence-based modules on the burden of CKD-related fatigue and the role of intradialytic exercise as a non-pharmacological nursing intervention. Nurse educators should emphasise the use of validated instruments for fatigue and functional assessment and train students in the safe administration of intradialytic exercise protocols, including recognition of contraindications and haemodynamic monitoring during exercise.

Nursing Administration: Nursing administrators in dialysis units should develop institutional protocols for routine fatigue screening and intradialytic exercise programming. Designated exercise coordinators or trained HD nurses should be identified, and structured documentation of exercise sessions and outcomes should be integrated into patient care records. Nursing administration should also advocate for the allocation of resources including exercise mats, written exercise guides, and nurse training time to sustain exercise programmes within HD units.

Nursing Research: The findings of this study provide a foundation for future nursing research on intradialytic exercise in Indian HD populations. Replication studies with larger samples, longer durations, randomised designs, and performance-based outcome measures are warranted. Mixed-methods approaches combining quantitative outcomes with qualitative exploration of patient experiences and exercise adherence would deepen understanding of barriers and facilitators to intradialytic exercise participation and support the development of patient-centred intervention protocols.

RECOMMENDATIONS

1. Future studies should employ larger sample sizes drawn from multiple centres and diverse sociodemographic backgrounds to enhance statistical power and external validity.
2. Randomised controlled trial designs should be adopted to eliminate allocation bias and strengthen the causal interpretation of intradialytic exercise effects.
3. Longitudinal studies with follow-up periods of at least three to six months are needed to evaluate the sustained impact of intradialytic leg exercise on fatigue, ADL, and quality of life.
4. Comparative trials investigating different exercise modalities (aerobic cycling, resistance bands, stretching, combined protocols) and frequencies should be conducted to identify the optimal intradialytic exercise prescription.
5. Future research should incorporate objective performance-based outcomes (e.g., six-minute walk test, handgrip strength, Short Physical Performance Battery) alongside patient-reported measures to capture a broader range of functional outcomes.
6. Qualitative research exploring patients' subjective experiences, perceived barriers to participation, and the impact of cultural and social factors on exercise adherence would inform the development of more culturally contextualised intervention programmes.

CONCLUSION

This quasi-experimental study provides evidence that a structured two-week intradialytic leg exercise programme significantly reduces fatigue among adult hemodialysis patients, with a clinically meaningful improvement in mean FACIT-F scores (31.85 to 44.70 in the experimental group versus deterioration from 43.26 to 33.41 in controls). The strong positive correlation between post-test fatigue and ADL levels (r = 0.82 and r = 0.92 in experimental and control groups, respectively) reinforces the imperative of prioritising fatigue management as a pathway to preserving functional independence in this population. Although statistically significant ADL improvements were not achieved within the two-week study period, the numerical upward trend observed in the experimental group supports the continued investigation of intradialytic exercise using more sensitive functional instruments and longer follow-up. The exercise protocol demonstrated an excellent safety profile and is readily implementable within routine HD nursing care in resource-limited settings. These findings contribute meaningful, locally contextualised evidence to support the standardisation of intradialytic leg exercise as a nursing intervention in Indian hemodialysis units, with implications for improving patient well-being, reducing functional dependence, and advancing the professional scope of nephrology nursing practice.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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AUTHORS' CONTRIBUTIONS

All authors participated in the conception, design, data collection, analysis, interpretation, and drafting of the manuscript. All authors reviewed and approved the final manuscript.

ETHICAL APPROVAL

Institutional ethical approval was obtained prior to study commencement. All participants provided informed written consent before enrolment. Participant anonymity and data confidentiality were maintained throughout.

DATA AVAILABILITY STATEMENT

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

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