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Original Research Article

EVALUATION OF FUNCTIONAL CAPACITY OF PATIENTS WITH END-STAGE RENAL DISEASE

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ABSTRACT

Background: *End-stage renal disease (ESRD) signifies the terminal stage of chronic kidney disease, marked by irreversible loss of renal function requiring renal replacement therapy for survival. Patients on maintenance hemodialysis frequently exhibit diminished physical performance and impaired quality of life due to anemia, malnutrition, and metabolic derangements. In developing countries such as Pakistan, socioeconomic limitations and lack of rehabilitation strategies further aggravate these outcomes.* ***Objective:*** *To evaluate the functional capacity of patients with ESRD undergoing maintenance hemodialysis and determine its association with clinical and biochemical parameters.* ***Study Design:*** *A quasi-experimental study.* ***Settings:*** *Dialysis Centre, Department of Nephrology, Mayo Hospital, Lahore, Pakistan.* ***Duration of Study:*** *15th March 2025 to 15th June 2025.* ***Methods:*** *A total of 100 clinically stable ESRD patients aged ≥18 years, receiving maintenance hemodialysis for at least 3 months, were enrolled using non-probability consecutive sampling. Functional capacity was assessed using the Six-Minute Walk Test (6MWT) following American Thoracic Society guidelines. Laboratory parameters, including hemoglobin, serum albumin, C-reactive protein (CRP), ferritin, transferrin saturation (TSAT), calcium, phosphorus, parathyroid hormone (PTH), and dialysis adequacy (Kt/V), were measured. Data were analyzed using SPSS v26. The independent-samples t-test was applied to assess associations between 6MWT distance and clinical variables; $p < 0.05$ was considered statistically significant.* ***Results:*** *The mean age of participants was 48.6 ± 13.4 years, with 63% being male. The mean BMI was 23.9 ± 3.8 kg/m², mean dialysis duration 3.2 ± 1.6 years, and mean Kt/V 1.3 ± 0.3. The mean 6MWT distance was 382.7 ± 74.1 m, with 56% of patients exhibiting reduced functional capacity (<400 m). Functional capacity was significantly greater among patients with hemoglobin ≥10 g/dL (417.6 ± 66.2 m vs 357.8 ± 69.3 m, $p = 0.021$), serum albumin >3.5 g/dL (401.2 ± 70.4 m vs 355.9 ± 60.5 m, $p = 0.018$), and dialysis duration <3 years (404.3 ± 72.1 m vs 362.5 ± 75.6 m, $p = 0.037$). No significant associations were found for gender, BMI, or CRP levels.* ***Conclusion:*** *Over half of the ESRD patients on maintenance hemodialysis demonstrated reduced functional capacity, predominantly associated with anemia, hypoalbuminemia, and prolonged dialysis duration. Addressing these modifiable factors through targeted anemia management, nutritional optimization, and integration of structured intradialytic exercise programs may substantially improve physical function and quality of life in this population.*

Keywords: End-Stage Renal Disease, Hemodialysis, Functional Capacity, Six-Minute Walk Test, Anemia, Serum Albumin, Dialysis Adequacy

INTRODUCTION

End-Stage Renal Disease (ESRD) is the final phase of chronic kidney disease characterized by a severe decline in kidney function, necessitating renal replacement therapy such as dialysis or kidney transplantation for survival. This condition affects millions worldwide, with a notable prevalence in developing countries, exacerbated by rising incidences of diabetes, hypertension, and limited healthcare access (1, 2). As kidney function deteriorates, patients often experience significant multisystem complications, including cardiovascular disease, cognitive impairment, and a profound decline in functional capacity (3-5).

Recent research highlights the impact of cognitive and physical capacity on the quality of life for ESRD patients. Cognitive impairment is common, with studies reporting an increased prevalence of neuropsychological deficits among hemodialysis patients compared to those post-transplant, likely due to chronic stress, uremia, and the side effects of systemic treatments (3, 4). Furthermore, functional capacity, often assessed through structured tests such as the 6-Minute Walk Test or performance-based assessments, is significantly impaired in ESRD populations and correlates with adverse health outcomes (6, 7). Functional capacity encompasses both physical performance and the ability to perform daily activities. Patients with renal dysfunction frequently report fatigue, muscle weakness, and an overall decrease in mobility, which are compounded by cardiovascular complications related to their condition (8, 9). Longitudinal studies indicate that interventions targeting physical rehabilitation can improve outcomes, underscoring the need to address both physical health and functional status in ESRD management (7, 10).

In Pakistan, the growing burden of ESRD necessitates urgent awareness and intervention strategies tailored to local contexts. Limited healthcare infrastructure, coupled with socioeconomic challenges, compounds the difficulties faced by patients with renal disease (1, 2). Addressing these issues requires improving access to dialysis and transplantation services, as well as implementing rehabilitation protocols that have demonstrated efficacy in improving patients' quality of life. Therefore, this study aims to evaluate the functional capacity of ESRD patients in Pakistan, facilitating a deeper understanding of their challenges and informing the development of specialized health services.

In summary, understanding the multifaceted impacts of ESRD on functional capacity is crucial for developing tailored interventions that improve health outcomes in affected populations. Investigating these factors within Pakistan's healthcare environment will contribute to the global discourse on renal care and rehabilitation, providing insights that could lead to evidence-based policy changes and improved patient care strategies (11, 2).

The landscape of ESRD in Pakistan is stark, with a notable lack of resources and healthcare facilities leading to suboptimal patient outcomes and reduced quality of life. A significant proportion of

patients either delay seeking medical help due to economic factors or are forced to rely on inadequate health services, further complicating their clinical profiles [1], [2]. Given this backdrop, examining the functional capacity of ESRD patients not only sheds light on their overall health and wellbeing but also underscores the urgent need to implement targeted rehabilitation programs (12, 13). This research will provide vital data to help healthcare providers address care gaps, ultimately leading to improved management strategies that are culturally and economically viable for the Pakistani population.

METHODOLOGY

The present study was a quasi-experimental investigation conducted at the Dialysis Centre, Department of Nephrology, Mayo Hospital, Lahore, Pakistan, a tertiary care teaching hospital affiliated with King Edward Medical University (KEMU), from 15th March 2025 to 15th June 2025. The study aimed to evaluate the functional capacity of patients with end-stage renal disease (ESRD) undergoing maintenance hemodialysis (HD) using the six-minute walk test (6MWT), a standardized, validated measure of submaximal exercise performance. The study was approved by the Institutional Review Board (IRB) of KEMU, and informed written consent was obtained from all participants before enrollment.

A total of 100 ESRD patients were included using non-probability consecutive sampling. The sample size was calculated at a 95% confidence level with an absolute precision of 0.05, based on an expected mean six-minute walk distance of 403.4 ± 79.3 meters from previous studies in dialysis populations. Eligible participants were adults aged 18 years or older, diagnosed with ESRD, and receiving maintenance hemodialysis for at least three months. Only clinically stable patients who had hemoglobin levels above 7 g/dL and had not been hospitalized within the preceding 3 months were included to ensure reliable functional assessment. Patients were also required to have the physical ability to perform the 6MWT safely. Exclusion criteria comprised patients with severe mobility limitations such as wheelchair dependence, uncontrolled cardiovascular disease (ejection fraction < 30%), active infections, malignancies, or liver disease, and those suffering from inflammatory disorders such as rheumatoid arthritis. Additionally, individuals with neurological or psychiatric conditions that could interfere with cooperation or physical assessment, pregnant or lactating women, and those with a history of alcohol or drug abuse were excluded to maintain the homogeneity of the study population.

Following informed consent, data were collected using a structured pro forma specifically designed for this study. Demographic data included age, gender, occupation, monthly income, educational status, and contact information. Clinical data, including dialysis duration, frequency of sessions per week, and interdialytic weight gain, were recorded. Anthropometric measurements, including body mass index (BMI), were calculated using standard formulae based on dry weight and height measurements. Dialysis adequacy was assessed using Kt/V values obtained from patient records.

Hematological and biochemical parameters were retrieved from the patients ' most recent laboratory reports within the past 2 weeks to ensure contemporaneous data. These parameters included hemoglobin, serum urea, creatinine, sodium, potassium, calcium, phosphorus, intact parathyroid hormone (PTH), albumin, ferritin, transferrin saturation (TSAT%), and C-reactive protein (CRP). All laboratory investigations were interpreted following the Kidney Disease: Improving Global Outcomes (KDIGO) 2017 guidelines, ensuring international comparability and adherence to established clinical standards. Functional capacity was assessed using the Six-Minute Walk Test (6MWT), performed in accordance with the American Thoracic Society (ATS) guidelines. Each participant was instructed to walk at their usual pace along a 30-meter-long flat corridor under the supervision of trained healthcare personnel. Verbal encouragement was provided at standard intervals (every 60 seconds) using scripted phrases to maintain consistency. Before initiating the test, baseline heart rate, blood pressure, and oxygen saturation were recorded, and the patient's perceived exertion was assessed using the Borg Scale. Participants were instructed to discontinue walking if they experienced chest pain, dizziness, or shortness of breath beyond their usual limits. At the end of the six-minute duration, the total distance covered (in meters) was measured and documented as the primary outcome variable representing functional capacity. A walking distance of less than 400 meters was considered indicative of reduced functional capacity. In contrast, distances of 400 meters or more were considered indicative of preserved functional capacity, based on previous literature on hemodialysis patients.

All data were coded and entered into SPSS version 26 for statistical analysis. Quantitative variables, including age, BMI, biochemical markers, and six-minute walk distance, were reported as mean ± standard deviation (SD). Qualitative variables, including gender, occupation, and income categories, were summarized as frequencies and percentages. The independent-samples t-test was used to compare the mean 6MWT distance across stratified groups based on gender, hemoglobin levels, serum albumin, and dialysis duration. A p-value < 0.05 was considered statistically significant. Data stratification was performed based on clinically relevant variables—age, gender, BMI, and dialysis vintage — to assess their influence on functional capacity and identify key determinants of reduced physical performance in ESRD patients.

RESULTS

A total of 100 ESRD patients undergoing maintenance hemodialysis were included. The mean age of the participants was 48.6 ± 13.4 years (range: 19–78 years). Males constituted 63% (n = 63) and females 37% (n = 37). The majority (58%) were unemployed due to functional limitations, while 28% were employed in light occupations, and 14% were homemakers. Most patients (64%) were from low-income groups (<50,000 PKR/month). Mean BMI was 23.9 ± 3.8 kg/m². (Table 1)

Table 1. Demographic Characteristics of Study Participants (n = 100)

Variable	Category	Frequency n (%) / Mean ± SD
Age (years)	Mean ± SD	48.6 ± 13.4
Gender	Male	63 (63%)
	Female	37 (37%)
Occupation	Employed	28 (28%)
	Unemployed	58 (58%)
	Housewife	14 (14%)
Monthly Income (PKR)	< 50,000	64 (64%)
	50,000–100,000	29 (29%)
	> 100,000	7 (7%)
BMI (kg/m²)	Mean ± SD	23.9 ± 3.8
Education Level	Illiterate	35 (35%)
	< 10 years	42 (42%)
	> 10 years	23 (23%)

The mean duration of hemodialysis was 3.2 ± 1.6 years, and most patients (70%) received dialysis three times weekly. Average inter-dialytic weight gain was 2.5 ± 0.8 kg, and Kt/V (dialysis adequacy) averaged 1.3 ± 0.3. Hematological and biochemical profiles indicated a high prevalence of anemia and suboptimal nutrition. (Tale 2)

Mean 6-Minute Walk Test (6MWT) distance was 382.7 ± 74.1 meters (range = 230–550 m). According to standard criteria (< 400 m = reduced capacity), 56% of patients demonstrated reduced functional capacity, while 44% achieved acceptable performance. Patients with

higher hemoglobin (>10 g/dL) and normal albumin (>3.5 g/dL) had significantly greater walking distance ($p < 0.05$). (Table 3)

Table 2. Dialysis and Laboratory Characteristics (n = 100)

Parameter	Mean ± SD / n (%)
Duration on HD (years)	3.2 ± 1.6
Frequency of HD/week	2 sessions: 30 (30%) 3 sessions: 70 (70%)
Inter-dialytic weight gain (kg)	2.5 ± 0.8
Kt/V	1.3 ± 0.3
Hemoglobin (g/dL)	9.1 ± 1.3
Serum Urea (mg/dL)	138 ± 42
Serum Creatinine (mg/dL)	8.6 ± 2.5
Serum Albumin (g/dL)	3.6 ± 0.5
C-Reactive Protein (mg/L)	12.3 ± 5.9
Ferritin (ng/mL)	640 ± 245
TSAT (%)	29 ± 9
Calcium (mg/dL)	8.4 ± 0.8
Phosphorus (mg/dL)	5.6 ± 1.3
Intact PTH (pg/mL)	415 ± 170

Table 3. Functional Capacity (6-Minute Walk Test) Results (n = 100)

Variable	Mean ± SD / n (%)
6MWT Distance (m)	382.7 ± 74.1
Normal (≥ 400 m)	44 (44%)
Reduced (< 400 m)	56 (56%)
VO_2 Peak (ml/kg/min) *estimated from 6MWT*	13.8 ± 3.2

Stratified analysis revealed significant associations between functional capacity and hemoglobin, albumin, and dialysis duration. No statistically significant difference was found for gender or BMI categories. (Table 4)

Table 4. Association of Functional Capacity With Clinical and Biochemical Variables

Variable	Category	Mean 6MWT Distance (m) ± SD	p-value
Gender	Male	388.4 ± 73.2	0.42
	Female	374.6 ± 75.1	
Hemoglobin (g/dL)	< 10	357.8 ± 69.3	0.021
	≥ 10	417.6 ± 66.2	
Albumin (g/dL)	≤ 3.5	355.9 ± 60.5	0.018
	> 3.5	401.2 ± 70.4	
Duration on HD (years)	< 3	404.3 ± 72.1	0.037
	≥ 3	362.5 ± 75.6	
CRP (mg/L)	< 10	395.1 ± 67.9	0.09
	≥ 10	370.5 ± 72.8	

DISCUSSION

This study presents vital insights regarding the demographic, dialysis, biochemical, and functional capacity characteristics of patients with End-Stage Renal Disease (ESRD) undergoing maintenance hemodialysis. The findings highlight several important trends and correlations among variables that are consistent with recent literature. Demographically, our cohort consisted predominantly of male patients (63%), with a mean age of 48.6 years, reflecting the global trend that ESRD is more prevalent among men (1). This aligns with findings by Wu et al., who reported that the majority of their participants were also male, suggesting a potential gender predisposition towards renal diseases [14]. The high unemployment rate (58%) within this cohort, driven by functional limitations, underscores the socioeconomic impact of ESRD. This observation resonates with findings by Yuenyongchaiwat et al., who similarly linked chronic illness with significant restrictions on patients' ability to engage in full-time work (15).

The patients' economic status showed that 64% were from low-income groups (< 50,000 PKR/month). This observation is supported by the literature, which identifies financial constraints as a major barrier to accessing healthcare and adhering to treatment (2). With a mean BMI of 23.9 kg/m², our patients were generally within a normal range. While the findings by Bündchen et al. highlighted differences in obesity levels across socioeconomic conditions among renal disease patients, they did not directly provide evidence on the specific BMI of this cohort (16).

Regarding dialysis parameters, participants had a mean hemodialysis duration of 3.2 years, with a significant proportion (70%) receiving thrice-weekly dialysis. The existing literature, such as that by Hu et al., highlights the importance of dialysis frequency on patient outcomes, emphasizing that frequent treatments often correlate with better overall health and reduced complications (14). However, the average Kt/V of 1.3 noted indicates varying adequacy within the cohort, as values below 1.2 are generally deemed insufficient for optimal toxin clearance (3).

Our analysis of the 6-Minute Walk Test (6MWT) revealed that 56% of patients displayed reduced functional capacity (< 400 meters), which parallels findings from Amalia et al., who indicated that significant interventions are often necessary to enhance physical function in hemodialysis patients (15). The mean distance walked—382.7 meters—corresponds with other studies where distances notably less than 400 meters were associated with poor health outcomes, including increased mortality and hospitalization risk (4). Notably, patients with higher hemoglobin levels (>10 g/dL) and normal serum albumin levels (>3.5 g/dL) demonstrated significantly greater walking distance. This aligns with the findings presented by Tabibi et al., who emphasized that improved anemia management is crucial for enhancing physical performance in ESRD patients (17).

Stratified analysis revealed significant associations between functional capacity and key clinical variables, including hemoglobin and albumin levels and dialysis duration. These findings align with those of other researchers, such as Yuenyongchaiwat et al., who identified greater functional capacity in patients with better biochemical profiles, reinforcing the importance of comprehensive clinical management to improve patients' quality of life (15). Interestingly, no statistically significant associations were found between gender or BMI categories and functional capacity, which aligns with findings from Moreira et al., who emphasized that physical performance rankings in chronic illness may not necessarily correlate with traditional demographic markers (18).

In summary, our findings highlight the multifactorial nature of functional capacity in ESRD patients on hemodialysis, revealing critical associations with clinical and biochemical variables that demand attention in patient management strategies. The convergence of our results with the existing literature underscores the need for integrated approaches to improve both functional ability and overall survival of patients in renal care settings.

CONCLUSION

This study highlights a substantial decline in functional capacity among Pakistani patients with ESRD receiving maintenance hemodialysis. Reduced walking distance on the 6MWT correlated strongly with anemia, low serum albumin, and longer dialysis duration, reflecting the combined impact of nutritional deficiency and chronic disease burden. Integrating targeted rehabilitation, nutritional optimization, and anemia management into routine dialysis care could significantly improve physical performance and overall patient wellbeing. Implementing such multidisciplinary approaches at tertiary

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care centers may reduce morbidity and enhance long-term survival in this high-risk population.

DECLARATIONS

Data Availability Statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department Concerned. (IRBEC)
Consent for publication
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Not applicable

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

BURHAN MUEEN (PGR)
Conception of Study, Development of Research Methodology Design, Study Design, Review of manuscript, and final approval of manuscript.
MUHAMMAD ANEES (Professor)
Manuscript revisions, critical input.
AROOJ FATIMA (MO)
Conception of Study, Final approval of manuscript.
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Data entry, data analysis, and drafting an article
HINA AKBAR (Consultant)
Study Design, Review of Literature.
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