DOI: 10.7860/JCDR/2023/62787.18777

Original Article

Physiotherapy Section

Evaluation of Functional Capacity and Rate of Perceived Exertion through Six-minute Walk Test in Pre and Post-haemodialysis Patients with Chronic Kidney Disease: A Prospective Cohort Study

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ABSTRACT

Introduction: Chronic Kidney Disease (CKD) is a condition that affects multiple organs, including the respiratory system. Haemodialysis is a commonly used treatment for End-stage Renal Disease (ESRD), but it can lead to respiratory issues, reduced muscle strength, decreased functional capacity, and lower quality of life. The Six-minute Walk Test (6MWT) is widely accepted for assessing functional capacity in CKD patients.

Aim: To evaluate the impact of haemodialysis on the functional capacity and Rate of Perceived Exertion (RPE) in patients with CKD by employing the 6MWT as a comprehensive measure.

Materials and Methods: A prospective cohort study was conducted in the Department of Nephrology and Dialysis ward at MGM Hospital, Aurangabad, Maharashtra, India, from April 2020 to December 2021. A total of 73 patients were included in the present study. The primary outcome measure was the walked distance assessed using the 6MWT, and secondary outcomes are the RPE were evaluated using the Modified Borg Scale (MBS). Gait speed was also measured. Baseline demographic data, laboratory investigations, and associated co-morbidities were collected. The tests were performed before and immediately after the haemodialysis session. Data were analysed using the Student's t-test and one-way Analysis of Variance (ANOVA), and the statistical significance level was set-up at $p<0.05$.

Results: The mean age of the study participants was 44±8.25 years. The study found a significant reduction in walking distance (mean of 85 meters) after the haemodialysis session compared to the pre-session. The post-haemodialysis session showed a significant increase in RPE and fatigue levels ($p=0.0001$). Additionally, a significant difference in gait speed ($p=0.0001$) was observed between the pre and post-haemodialysis sessions.

Conclusion: The present study findings indicate a significant decrease in walking distance and noteworthy increase in RPE and fatigue levels following haemodialysis sessions in CKD patients. These results emphasise the impact of haemodialysis on functional capacity and perceived exertion among individuals with this condition.

Keywords: End-stage renal disease, Modified borg scale, Respiratory system

INTRODUCTION

The CKD is a significant global health concern due to its high prevalence, morbidity, and mortality rates [1]. India, despite occupying less than 3% of the world's land mass, accommodates approximately 17% of the global population [2]. ESRD, the fifth stage of CKD, necessitates dialysis treatment, such as haemodialysis or peritoneal dialysis, for survival [1]. While haemodialysis has improved patient outcomes, it is associated with various complications, including muscle weakness, iron deficiency anaemia, respiratory issues, and decreased quality of life [3,4]. Respiratory problems in CKD patients stem from factors like interstitial and alveolar oedema, pleural effusion, pulmonary Hypertension (HTN), and respiratory muscle weakness [5,6]. Dyspnoea, a common respiratory symptom in CKD patients, is likely due to neuromechanical dissociation [7,8]. Fatigue is also prevalent but often overlooked among ESRD patients undergoing haemodialysis [9-11].

Among various walk tests, the 6MWT stands out due to its ease of administration, high participant tolerance, and greater relevance in assessing functional capacity aligned with everyday activities [12]. It is considered a valid and reliable measure for dialysis patients, providing insights into their physical capabilities. Dialysis patients often experience co-morbidities that adversely affect their physical performance [13].

Research suggests that exercise-based therapy during haemodialysis sessions can play a significant role in physical rehabilitation for CKD patients [14]. Patients undergoing dialysis experience a significant 40%-50% decrease in aerobic capacity (VO_2 peak) and a corresponding decline of 40%-50% in muscle strength in both upper and lower extremities compared to age-matched asymptomatic individuals. As a result, they face difficulties in meeting the energy requirements of their daily exercises [15]. This reduced functional capacity is attributed to uremic myopathy, anaemia, cardiovascular abnormalities, co-morbidities, and haemodialysis-related factors [16].

The 6MWT has been used in studies involving children with stage 5 CKD, highlighting decreased exercise tolerance due to various factors such as anaemia, metabolic acidosis, electrolyte imbalance, osteopenia, growth deficiency, malnutrition, inactivity, uremic muscle dysfunction, and other conditions [17]. In the present unique study, authors assessed how haemodialysis affects CKD patients' functional capacity and perceived exertion. Focusing on regular haemodialysis recipients, authors provided real-time insights into this underexplored aspect of CKD care. Understanding the impact of haemodialysis sessions on functional capacity is crucial, as it directly affects patient efficiency. Although several studies have investigated reduced functional capacity in non dialysis days among CKD patients, limited reliable evidence exists regarding the immediate impact of haemodialysis on walking distance, RPE, and fatigue levels [14,15].

The aim of the present study was to evaluate the impact of haemodialysis on the functional capacity and RPE in patients with CKD by employing the 6MWT as a comprehensive measure. The primary objective of the present study was to assess the changes in functional capacity, as measured by the distance walked during the 6MWT, in patients with CKD before and after haemodialysis sessions. The secondary objective was to investigate alterations in the RPE, as determined by the MBS, in CKD patients undergoing haemodialysis, both pre and post-treatment.

MATERIALS AND METHODS

This prospective cohort study was conducted in the Department of Nephrology and Dialysis ward at MGM Hospital, Aurangabad, Maharashtra, India, from April 2020 to December 2021. The study analysed data from 84 patients diagnosed with CKD who recently started undergoing haemodialysis. Ethical approval was obtained from the Institutional Ethics Committee (IEC) on March 13, 2020 (MGM-ECRHS /2020/16) and trial was prospectively registered with the Clinical trials registry-India (CTRI/2021/06/033965). Written consent was obtained from all participating patients.

Inclusion criteria: Patients with CKD of stage 5 between the age group of 30 to 60 years and who recently started undergoing haemodialysis were included in the study. CKD staging was determined by a nephrologist based on clinical criteria (duration>three months), Glomerular Filtration Rate (GFR) <50 m/min/1.73 m^2, Kidney damage as defined by structural or functional abnormality other than decreased GFR, radiological findings, and laboratory investigations [18].

Exclusion criteria: Patients with recent myocardial ischaemia, stable and unstable angina pectoris, heart failure of New York Heart Association (NYHA) stage 3 or 4 and uncontrolled HTN, with chronic respiratory involvement, patients with muscle weakness and with active malignant disease or chronic infection, neurological involvement were excluded from the study.

Sample size: The sample size for the present study was determined based on a 5% prevalence of CKD worldwide, with a 95% confidence interval and 5% precision, resulting in an estimated sample size of 73 participants [2,19].

Study Procedure

Outcome measures: The primary outcome measure was the walked distance, which was assessed using the 6MWT. The secondary outcomes are RPE were evaluated using the MBS [20,21]. A total of 73 patients diagnosed with CKD were enrolled in the study. Baseline demographic data, including age, sex, Body Mass Index (BMI), haemodialysis history (number of months since HD started), route of haemodialysis, and the latest laboratory investigations such as haemoglobin level, blood urea, and serum creatinine level, were collected from the participants [21]. Additionally, information regarding any associated co-morbidities, if present, was also obtained. Additionally, gait speed was calculated to assess the effect of haemodialysis on the walking speed of patients undergoing the treatment [22]. These outcome measures were employed to comprehensively evaluate the functional capacity and perceived exertion of the participants. The gait speed test was performed following the guidelines outlined by BC [22]. Patients were instructed to walk on a flat 6 meter surface, which included a 1 meter acceleration zone, a 4 meter testing zone, and a 1 meter deceleration zone. This standardised protocol ensured consistency and accuracy in measuring the gait speed of the participants. Both the 6MWT and the gait speed test were performed on the same day, both before and immediately after the haemodialysis session. These tests were conducted by the same investigator to ensure consistency and minimise interobserver variability.

Six-minute Walk Test (6MWT) [13]: The 6MWT was conducted following the standardised protocol outlined by the American Thoracic Society (ATS). The test took place on a 30 m flat and hard surface, with 3 m intervals marked for distance measurement. Participants were instructed to walk at their usual pace, and they were allowed to take rests or pauses during the test without stopping the timer. Before initiating the test, a 10-minute rest period was provided to the participants. Baseline measurements of Heart Rate (HR), Respiratory Rate (RR), Oxygen Saturation (SPO_2), RPE were assessed. Once the 6MWT was completed, the distance covered by the participants was calculated. Post-test measurements of the aforementioned parameters were also recorded.

Modified Borg Scale [20,21]: To assess the RPE, the Modified Borg Scale was employed in the present study. The MBS is a reliable and validated scale that ranges from 0 (indicating no exertion or fatigue) and progress to 10 (representing maximal exertion or fatigue). Participants were asked to rate their perceived exertion and fatigue levels before and after completing the test using this scale.

STATISTICAL ANALYSIS

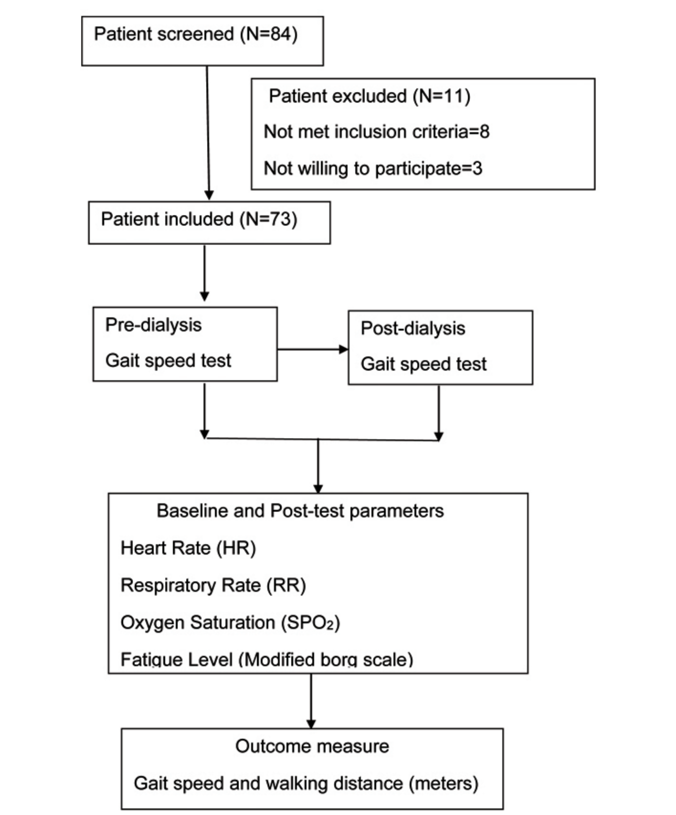
The data were analysed using the Statistical Package for Social Sciences (SPSS) version 27.0 software. The normality of the data was assessed using descriptive variables. Descriptive statistics, such as mean and Standard Deviation (SD), were calculated to summarise the demographic and clinical characteristics of the study participants. For the comparison of variables between the pre and post-haemodialysis sessions, paired t-tests were conducted. The differences in the distance walked, gait speed, RPE and changes in vital parameters were analysed using these tests. Additionally, ANOVA was employed to examine any significant differences among the different groups or subgroups within the study population. The statistical significance level was set at $p<0.05$, indicating that p-values less than this threshold were considered statistically significant.

RESULTS

Initially, 84 patients were screened for eligibility, and after excluding eight patients, who did not meet the inclusion criteria and three patients who declined to participate, a total of 73 patients were recruited and included in the study [Table/Fig-1].

[Table/Fig-2] displays the descriptive characteristics of the study participants. Of the 73 patients included, 45 were males and 28 were females. The mean age of the participants was 44 years, with a SD of 8.25. Haemodialysis history ranged from less than one week to 20 months, with a mean duration of 32 months. The majority of participants underwent haemodialysis via an Arteriovenous (AV) fistula n=41 (56%), followed by the central route n=32 (44%).Co-morbidities varied among the participants with five having no co-morbidities, 16 having Diabetes Mellitus (DM), 26 having HTN, and 26 having both DM and HTN. Haemoglobin (Hb), serum creatinine, and blood urea levels were also recorded, with average values of 9.54±1.84 g/dL, 15.04±11.06 mg/dL, and 54±34.36 mg/dL, respectively.

[Table/Fig-3] presents the results of the pre and post-dialysis 6MWT along with the mean differences in various parameters. The parameters assessed include RR, RPE, SPO_2, walking distance, and gait speed. The results showed that there is an increase in RR, RPE, and SPO_2 after the test, indicating higher respiratory



[Table/Fig-1]: Flowchart of study participants.

Variables	Values
Gender (M/F)	45/28
Age (in years) (Mean±SD)	44±8.25
Haemodialysis history	
a) Number of months of haemodialysis history	(<1 week-20 months)
b) Route of haemodialysis history	
(i) Central	32
(ii) AV fistula	41
Associated co-morbidities (n)	
a) No co-morbidities	5
b) DM	16
c) HTN	26
d) DM and HTN	26
Laboratory investigations (Mean±SD)	
a) Haemoglobin level (g/dL)	9.54±1.84
b) Serum creatinine level (mg/dL)	15.04±11.06
c) Blood urea level (mg/dL)	54±34.36

[Table/Fig-2]: Demographic and clinical characteristics of study participants.
AV: Arteriovenous; DM: Diabetes mellitus; HTN: Hypertension; Descriptive statistics were computed using the mean and Standard Deviation (SD)

Parameters		Predialysis 6MWT	Post-dialysis 6MWT	Mean difference	p-value
RR (bpm)	Baseline	17.17±3.35	20.45±3.56	3.28	0.001
	After test	23.76±2.91	26.82±2.78	3.06	
RPE	Baseline	0.36±0.52	1.44±0.82	1.08	0.0001
	After test	3.15±0.86	4.06±1.18	0.91	
SPO_2 (%)	Baseline	96.82±1.33	95.52±1.65	1.3	0.0001
	After test	94.56±1.28	92.46±1.38	2.1	
Walking distance (m)		343.04±62.69	257.39±65.53	85.65	0.0001
Gait speed (m/s)		0.97±0.20	0.75±0.17	0.22	0.0001

[Table/Fig-3]: Comparison of parameter values in pre and post-dialysis 6MWT.
6MWT: Six-minute walk test; RR: Respiratory rate; RPE: Rate of perceived exertion; bpm: Breaths per minute; The statistical tests used include Student's t-test, with p-value in bold font indicates statistically significant values

effort and perceived exertion, but a decrease in SPO_2. Moreover, the walking distance (85.65 m) and gait speed (0.22 m/sec) are significantly reduced in the post-dialysis measurements compared to the predialysis measurements.

[Table/Fig-4] provides a comprehensive comparison of the walking distance before and after dialysis in relation to age, route of haemodialysis, and months of haemodialysis history. The table includes the number of patients in each category and the mean walking distance for both pre and post-dialysis measurements. The data revealed a consistent pattern of decreased walking distance with advancing age. Statistical analysis confirms a significant difference in walking distance among different age groups. Additionally, participants undergoing haemodialysis through AV fistula demonstrate higher walking distances compared to those with a central route, as supported by significant p-values (p=0.0001). Moreover, an increase in the duration of haemodialysis history corresponds to an augmented walking distance, with statistically significant differences (p=0.0001) observed across different time intervals.

S. No.	Variables	Number of patients	Mean walking distance (m)	
			Predialysis	Post-dialysis
1	**Age range (in years)**			
	31-40	29	314±60.096	230±54.69
	41-50	26	353±54.49	260±63.61
	51-60	18	375±60.25	296.44±66.74
	p-value		0.0017	0.002
2	**Route of haemodialysis**			
	Central	32 (44%)	301.28±48.19	215.28±37.63
	AV fistula	41 (56%)	375.63±52.82	290.26±64.08
	p-value		0.0001	0.0001
3	**Number of months of haemodialysis history (n)**			
	<1-5 months	33	302.75±51.20	217.60±43.03
	6-10 months	25	373.04±51.17	286±67.18
	11-15 months	11	369.54±53.38	290.90±53.55
	16-20 months	4	415±32.76	314.75±70.12
	p-value		0.0001	0.0001
Total		73	343.04±32.69	257.39±65.53

[Table/Fig-4]: Comparison of pre and post-dialysis walking distance based on age, route of haemodialysis, and number of months of haemodialysis history.
The statistical tests used include Student's t-test and one-way Analysis of Variance (ANOVA), with p-value in bold font indicates statistically significant values

DISCUSSION

The purpose of the present study was to examine the difference in functional capacity, RPE, and fatigue level between pre and post-haemodialysis sessions in patients with CKD. It is well-known that patients with CKD on haemodialysis experience a reduction in functional capacity [12]. The present study aimed to fill the gap in knowledge regarding the immediate effects of haemodialysis on functional capacity. The main finding of the study was a significant reduction (p=0.001) of 85 meters in functional capacity, as measured by the 6MWT, immediately after the haemodialysis session compared to the pre-haemodialysis session. This finding aligns with previous studies that have reported lower exercise capacity among dialysis patients compared to the general population [1,21,22]. Several factors may contribute to this reduction, including anaemia and decreased spontaneous gait speed.

The study also identified a relationship between age groups and walking distance, with the 51-60 years age group demonstrating the highest walked distance, followed by the 41-50 years age group, and then the 31-40 years age group. This finding can be attributed to the duration of haemodialysis, as patients in the 51-60 years age group had been on haemodialysis for a longer period, potentially leading to reduced fatigue levels due to adaptation, lower work of breathing, positive attitudes, and psychological factors [9,23,24]. Additionally, the administration port of haemodialysis may play a role, as older patients on AV fistula reported less breathlessness compared to younger patients on a central port. Attitudes, beliefs, and mood towards physical activity may also contribute to these age-related differences.

Vital parameters, particularly RR, showed a significant change (p=0.001) between pre and post-haemodialysis sessions. RR was higher at the baseline level in the post-dialysis session, likely due to the therapeutic effects of haemodialysis and increased work of breathing [1,5]. SPO_2 also exhibited a slight but statistically significant change between the pre and post-haemodialysis sessions, supporting previous studies that reported a decrease in arterial SPO_2 during and immediately after haemodialysis [23]. The study found a significant increase (p=0.001 for baseline and <0.001 for post-test value) in the RPE in the post-haemodialysis session. Patients in the predialysis group did not report exertion at baseline, but in the post-dialysis session, they experienced slight to very slight dyspnoea. This dyspnoea can be attributed to respiratory muscle dysfunction and weakening of inspiratory muscles over time due to continuous haemodialysis maintenance therapy [3]. Dyspnoea is a significant limiting factor in the physical performance of dialysis patients [12].

Furthermore, the study observed a significant increase in rate of exertion (p=0.001) in the post-haemodialysis session. This could be attributed to the side effects of haemodialysis, such as muscle cramping, which may be caused by fluid loss during the procedure [24,25]. These findings are consistent with previous studies that have reported persistent fatigue in patients undergoing haemodialysis, with post-dialysis fatigue being more commonly observed [26-28]. The clinical significance of the present study lies in emphasising the critical role of evaluating functional capacity and delivering comprehensive care to haemodialysis patients. Acknowledging the impact post-dialysis and considering individual variances, healthcare professionals can optimise treatments, enhance patient well-being, and foster improved outcomes for individuals with CKD undergoing haemodialysis.

Limitation(s)

It is important to acknowledge the limitations of the present study, including the lack of consideration of psychological factors in assessing the results of the 6MWT and the potential influence of haemodialysis duration and dialyser solution on dyspnoea and fatigue levels. Additionally, incorporating additional tests to assess functional capacity in pre and post-haemodialysis sessions and studying patients undergoing haemodialysis for shorter durations could provide valuable insights.

CONCLUSION(S)

The present study investigated the impact of haemodialysis on functional capacity, RPE, and fatigue level in patients with CKD. The findings demonstrated a significant reduction in functional capacity, as evidenced by an 85 meter decrease in the distance covered during the 6MWT immediately after the haemodialysis session compared to before. Future research should explore the effects of pharmaceutical or exercise-based therapies on fatigue and dyspnoea, as well as overall functional capacity.

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AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 06, 2023
- Manual Googling: Sep 02, 2023
- iThenticate Software: Oct 23, 2023 (9%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

Date of Submission: **Jul 01, 2023**
Date of Peer Review: **Sep 05, 2023**
Date of Acceptance: **Oct 26, 2023**
Date of Publishing: **Dec 01, 2023**