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Six-Minute Walk Test Performance in Non-Dialysis Chronic Kidney Disease: An Observational Study from a Tertiary Hospital Setting

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A B S T R A C T

Background: Functional capacity dramatically declines in non-dialysis chronic kidney disease (CKD-ND), impacting patient prognosis and quality of life. Accurate, practical assessment is crucial for timely intervention. This study evaluated functional capacity using Six-Minute Walk Test (6MWT) and explored associated clinical factors in Indonesian CKD-ND patients. **Methods:** We conducted a cross-sectional study at RSUP Dr. M. Djamil Padang, enrolling 44 patients with CKD stages 3-5 not on dialysis. Using purposive sampling, we collected 6MWT distance (6MWD) following ATS guidelines and extracted demographic/clinical data (age, gender, BMI, eGFR, etiology) from medical records. Functional capacity, expressed as Metabolic Equivalents (METs), was estimated from 6MWD and patient data using the Nury formula. Descriptive statistics summarized the findings. **Results:** The cohort (54.5% male, mean age 56-65 years) predominantly had advanced CKD (43.2% Stage 5) and hypertension etiology (45.4%). Functional capacity was severely impaired: mean 6MWD was low (Men: 291m, Women: 255m), and a striking 70.5% of patients exhibited low functional capacity (<3.0 METs). No participants achieved high capacity (>6.0 METs). Lower mean 6MWD and a higher prevalence of low METs were distinctly observed in patients with lower eGFR and advanced age. **Conclusion:** This study reveals profound functional limitations in Indonesian CKD-ND patients well before dialysis initiation. Lower eGFR and older age were strongly associated with poorer performance. The 6MWT effectively quantifies this impairment, highlighting its utility for routine screening and emphasizing the urgent need for functional assessment and rehabilitation strategies in CKD-ND management.

1. Introduction

Chronic kidney disease (CKD) has emerged as a critical global health issue, affecting a substantial portion of the adult population worldwide. It is estimated that the prevalence of CKD ranges between 10% and 14% among adults globally, posing a significant burden on public health due to its contribution to increased morbidity, mortality, and healthcare costs. CKD is characterized by persistent abnormalities in kidney structure or function, lasting for a period of over three months. The progression of CKD is typically staged based on the estimated glomerular filtration rate (eGFR) and the levels of albuminuria, which serve as key indicators of kidney function and damage. While end-stage renal disease (ESRD), the most severe stage of CKD, often necessitates renal replacement therapy such as dialysis or transplantation, it is crucial to recognize that patients with non-dialysis dependent CKD (CKD-ND), even in the earlier stages, are also at a considerably elevated risk of experiencing adverse health outcomes, with cardiovascular disease (CVD) being particularly prominent. In fact, CVD is the leading cause of mortality in the CKD population, frequently overshadowing the need for renal replacement therapy. The link between CKD and poor health outcomes is complex and involves multiple factors. Beyond the decline in the kidney's excretory functions, CKD triggers a systemic condition marked by chronic inflammation, oxidative stress, endothelial dysfunction, activation of the renin-angiotensin-aldosterone system (RAAS), heightened activity of the sympathetic nervous system, and disruptions in mineral and bone metabolism. These systemic changes contribute to the remodeling of the cardiovascular system, including left ventricular hypertrophy, vascular calcification, and uremic cardiomyopathy, while also accelerating the process of atherosclerosis. Importantly, the systemic effects of CKD extend beyond the cardiovascular system, significantly impacting musculoskeletal health and physical function. Patients with CKD-ND commonly experience reduced muscle mass, a condition known as sarcopenia, muscle weakness (dynapenia), and impaired physical performance. Several mechanisms have been proposed to explain this decline in muscle health, including metabolic acidosis promoting protein catabolism, inflammation interfering with muscle protein synthesis, insulin resistance, vitamin D deficiency, physical inactivity, anemia limiting oxygen delivery, and the potential direct effects of uremic toxins on muscle structure and mitochondrial function. The prevalence of sarcopenia in CKD-ND patients varies widely, with reported rates ranging from 5% to as high as 60%, influenced by the specific definition used and the population studied. This deterioration in muscle health directly leads to diminished functional capacity, which is the ability to perform activities of daily living (ADL) and engage in desired physical tasks.[1-4]

Functional capacity is a critical predictor of health outcomes across various chronic conditions, including CKD. Reduced functional capacity in CKD patients is independently associated with an increased risk of hospitalization, cardiovascular events, faster progression to ESRD, frailty, decreased quality of life, and higher all-cause mortality. Therefore, the accurate assessment and monitoring of functional capacity are essential components of comprehensive CKD management. The gold standard for evaluating cardiorespiratory fitness and functional capacity is Cardiopulmonary Exercise Testing (CPET), which involves measuring peak oxygen consumption (VO_2peak) during maximal exertion. However, CPET has limitations in routine clinical practice due to the requirement for specialized equipment, trained personnel, and maximal patient effort, making it less practical, particularly in resource-limited settings or for patients with significant comorbidities or physical limitations. In contrast, field walking tests, such as the Six-Minute Walk Test (6MWT), offer a practical, safe, and well-validated alternative for assessing submaximal functional capacity. The 6MWT measures the maximum distance a patient can walk on a flat, hard surface over a six-minute period. It reflects the integrated response of the pulmonary, cardiovascular, and musculoskeletal systems during moderate, self-paced exercise, potentially providing a closer representation of the demands of daily activities compared to maximal exercise tests. The distance covered in the 6MWT (6MWD) has been shown to correlate with VO_2 peak and is predictive of mortality and hospitalization in various cardiorespiratory conditions, including heart failure and pulmonary disease. Its use is also increasing in the CKD population. Studies involving dialysis patients have established a link between lower 6MWD and an increased risk of mortality and hospitalization.[5-7]

Furthermore, functional capacity can be estimated from 6MWD using prediction equations to calculate Metabolic Equivalents (METs). METs provide a standardized measure of exercise capacity relative to resting energy expenditure. One MET is defined as the energy cost of resting quietly, which is approximately 3.5 mL O2/kg/min. Low functional capacity is commonly defined as a MET level of less than 3 or 4.

Despite the growing recognition of functional impairment in CKD-ND, there is a scarcity of research in developing countries like Indonesia. Understanding the extent of functional limitation and identifying the factors associated with poor performance in these populations is essential for the development of culturally and contextually appropriate interventions. Several factors are known to influence 6MWD in the general population and in individuals with other chronic diseases, including age, gender, height, weight/BMI, cognitive function, and the presence of cardiorespiratory or musculoskeletal comorbidities. In the context of CKD, declining eGFR, anemia, inflammation markers, and nutritional status are also implicated as contributing factors to reduced functional capacity.[8-10] This study was conducted at a tertiary referral hospital in Padang, West Sumatra, Indonesia, to address the gap in knowledge regarding functional capacity in CKD-ND patients in this region. The primary objective of the study was to describe the functional capacity, assessed by the 6MWT and estimated METs, in a group of patients with CKD stages 3-5 who were not yet undergoing dialysis. The secondary objective was to explore the associations between functional capacity (6MWD and METs) and key demographic and clinical characteristics, including age, gender, BMI, CKD etiology, and eGFR category, within this specific patient group.

2. Methods

This study employed an observational descriptive design to investigate functional capacity in patients with non-dialysis CKD. Data collection spanned from November 2024 to March 2025. The research activities were carried out at the outpatient Internal Medicine clinic, specifically within the nephrology and hypertension service, and at the Integrated Heart Center, where the Six-Minute Walk Test (6MWT) procedures were conducted. These facilities are part of Dr. M. Djamil General Hospital, a tertiary referral and teaching hospital situated in Padang, West Sumatra, Indonesia.

The study received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Universitas Andalas. The approval was granted under the reference number DP.04.03/D.XVI.XI/507/2024. The study protocol was meticulously designed to adhere to the ethical principles outlined in the Declaration of Helsinki, ensuring the protection of participants' rights and well-being throughout the research process.

The study focused on adult patients diagnosed with CKD who were attending the Internal Medicine outpatient clinic at Dr. M. Djamil General Hospital Padang, for routine follow-up care. A key inclusion criterion was that these patients were not currently undergoing renal replacement therapy, such as dialysis or transplantation. The selection of participants was conducted using a purposive sampling technique. This involved screening patients during their clinic visits to determine their eligibility based on a set of predefined inclusion and exclusion criteria.

The inclusion criteria for participation in the study were carefully defined to ensure the selection of appropriate individuals. These criteria were as follows; A confirmed diagnosis of CKD stage 3, 4, or 5, determined by the estimated Glomerular Filtration Rate (eGFR). The eGFR was calculated using the CKD-EPI formula, derived from the most recent serum creatinine value documented in the patient's medical record, aligning with the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines; Participants were required to be 17 years of age or older, based on the definition of adulthood used in Indonesia; Participants were required to be in a clinically stable condition, as assessed and determined by their attending physician; Participants needed to demonstrate the ability to comprehend study instructions and provide informed consent, ensuring their voluntary and informed participation; Participants were required to have no absolute contraindications for the 6MWT. Absolute contraindications specifically included unstable angina or myocardial infarction within the 30 days immediately preceding the study. To maintain the study's integrity and focus, several exclusion criteria were applied to identify individuals who were not suitable for participation. These criteria included; Patients with a history of receiving hemodialysis, peritoneal dialysis, or kidney transplantation were excluded from the study; Individuals with significant physical disabilities that would impede their ability to complete the six-minute walk test were excluded. This encompassed conditions such as severe arthritis, amputation, or neurological impairment; Women who were currently pregnant were excluded from participation; Individuals with severe cognitive impairment or diagnosed psychological conditions that could interfere with their understanding of the study procedures or their adherence to the test protocol were excluded; Patients presenting with relative contraindications for the 6MWT at the time of assessment were excluded. These relative contraindications included a resting heart rate exceeding 120 beats per minute, systolic blood pressure greater than 180 mmHg, or diastolic blood pressure greater than 100 mmHg.

Prior to the commencement of any study-related procedures, all eligible patients were required to provide written informed consent. This process ensured that participation was voluntary and that patients were fully aware of the study's purpose, procedures, potential risks, and their rights as participants.

The sample size for this study was initially estimated using the Lemeshow formula, a statistical method commonly employed for prevalence studies. The calculation aimed to achieve a target sample size of approximately 41 participants, based on an assumed prevalence of the condition of interest within the population and the desired level of precision for the study's findings. Ultimately, a total of 44 patients met all the inclusion and exclusion criteria and successfully completed the 6MWT. These 44 participants were included in the final analysis of the study.

The data collection process for this study involved two primary components: the acquisition of primary data through the administration of the 6MWT and the extraction of secondary data from the participants' existing medical records. The 6MWT served as the primary measure for assessing the functional capacity of the study participants. The tests were conducted by trained personnel in a designated, quiet, indoor corridor within the hospital's Integrated Heart Center. The chosen corridor provided a flat, hard surface, measuring 30 meters in length, to ensure standardized testing conditions. The corridor was carefully marked at 3-meter intervals, with cones strategically placed to indicate the turning points for the participants. The 6MWT procedures were meticulously carried out in accordance with the standardized guidelines established by the American Thoracic Society (ATS). These guidelines ensured uniformity and accuracy in the administration and execution of the test; Preparation: Participants were instructed to wear comfortable clothing and shoes to facilitate ease of movement during the test. They were also advised to take their usual medications as prescribed. To minimize any potential influence on the test results, participants were asked to refrain from strenuous exercise for at least two hours prior to the test. Before commencing the test, participants were allowed to rest in a chair positioned near the starting line for a minimum of 10 minutes. During this rest period, baseline measurements of several physiological parameters were recorded, including heart rate (measured by palpation or pulse oximeter), blood pressure (measured using a digital sphygmomanometer), and peripheral oxygen saturation (SpO_2, measured using a pulse oximeter). The contraindications for the 6MWT were carefully rechecked to ensure the safety of each participant. Standardized instructions were then provided to the patient, clearly explaining the objective of the test, which was to walk as far as possible within the six-minute timeframe. Participants were also informed about safety precautions, emphasizing that they were permitted to slow down, stop, or rest if necessary, while the timer would continue to run. The examiner performed a brief demonstration walk to further clarify the procedure for the patient; Execution: The test began with the examiner's command "Begin," and the stopwatch was started simultaneously to accurately measure the six-minute duration. The examiner walked slightly behind the patient, providing supervision and ensuring safety, but refrained from walking alongside or pacing the patient to avoid influencing their performance. Standardized phrases of encouragement were used at each minute mark to motivate the participants. These phrases were delivered in a neutral tone and included statements such as "You are doing well," and "Keep up the good work," followed by an indication of the time remaining. To maintain consistency and minimize distractions, no other conversation took place during the test. The number of laps completed by each participant was carefully tracked to accurately determine the total distance covered. The test was immediately stopped if a participant exhibited any signs of severe distress, such as dyspnea, chest pain, dizziness, leg cramps, diaphoresis, or an excessively pale appearance. Participants were also allowed to voluntarily stop the test if they felt the need to rest. In such cases, they were instructed to remain stationary until they felt ready to resume walking, and the timer continued to run during these rest periods; Post-Test: Upon completion of the six-minute duration, participants were instructed to stop walking. The total distance walked (6MWD) was then measured to the nearest meter. This measurement was based on the number of completed laps plus the distance covered in the final partial lap. Immediately following the test, several physiological parameters and subjective symptoms were recorded. These included heart rate, blood pressure, SpO_2, and perceived exertion or symptoms such as dyspnea and fatigue, often assessed using a Borg scale or simple questioning. Participants were required to rest in a chair until their physiological parameters returned to baseline levels. It was noted that six patients were unable to complete the full six minutes of the test due to experiencing dyspnea.

In addition to the primary data collected through the 6MWT, relevant clinical and demographic data for each participant were extracted from their existing medical records maintained by the hospital. This extraction process allowed for the collection of important variables that could provide context for the 6MWT results and aid in the analysis of factors associated with functional capacity. The variables collected from the medical records included; Demographics: Age, categorized into the following groups: 17-25 years, 26-35 years, 36-45 years, 46-55 years, 56-65 years, and greater than 65 years; and gender, recorded as male or female; Anthropometrics: The most recent recorded height and weight measurements were used to calculate Body Mass Index (BMI). BMI was calculated using the formula: weight (kg) / height (m^2). BMI was then categorized according to the Asia-Pacific criteria, which include the following categories: <18.5 kg/m^2 (Underweight), 18.5-22.9 kg/m^2 (Normal), 23.0-24.9 kg/m^2 (Overweight), 25.0-29.9 kg/m^2 (Obesity I), and ≥30.0 kg/m^2 (Obesity II); CKD Characteristics: The primary etiology of CKD, as documented in the medical record, was categorized as: Hypertension, Diabetes Mellitus, Obstructive Nephropathy, or Other. Estimated Glomerular Filtration Rate (eGFR) was calculated from the most recent serum creatinine measurement to confirm the CKD stage. CKD stage was categorized as Stage 3 (eGFR 30-59 mL/min/1.73m^2), Stage 4 (eGFR 15-29 mL/min/1.73m^2), or Stage 5 (eGFR <15 mL/min/1.73m^2); Blood Pressure: Systolic and diastolic blood pressure measurements, taken immediately before the 6MWT, were recorded; Functional Capacity Estimation: Functional capacity was estimated using Metabolic Equivalents (METs). METs were indirectly calculated from the 6MWD using the Nury prediction formula for estimated peak oxygen consumption (VO_2peak). The Nury formula incorporates 6MWD, age, gender, height, and weight to estimate VO_2peak. VO_2peak was then converted to METs using the equation: METs = VO_2peak / 3.5. Functional capacity was subsequently categorized based on the METs values: Low (<3.0 METs), Moderate

(3.0-6.0 METs), or High (>6.0 METs). These categories were established based on recognized thresholds for interpreting METs values.

Data collected from the 6MWT forms and the medical record abstraction sheets were entered into a database to facilitate organization and analysis. Data cleaning procedures were performed to ensure the accuracy and completeness of the dataset. This involved checking for any inconsistencies or missing values that could potentially affect the integrity of the analysis. Statistical analysis was conducted using SPSS version 15.0. The statistical analysis was primarily descriptive and univariate in nature. Categorical variables, including gender, age group, BMI category, CKD etiology, eGFR stage, and MET category, were summarized using frequencies and percentages to describe their distribution within the sample. Continuous variables, such as baseline blood pressure and 6MWD, were summarized using means and standard deviations (SD), along with minimum and maximum values, to provide a comprehensive description of their central tendency and variability. Mean 6MWD values were calculated and descriptively compared across different categories of gender, age group, eGFR stage, and BMI category to explore potential associations between these characteristics and functional capacity. The distribution of functional capacity, as represented by the MET categories, was described for the overall cohort and further stratified by eGFR stage to examine how functional capacity varied across different stages of CKD. The results of the analysis are presented descriptively, focusing on the observed patterns and distributions within the study sample.

3. Results

Table 1 provides a comprehensive overview of the baseline demographic and clinical characteristics of the 44 non-dialysis chronic kidney disease (CKD) patients included in the study. This table is crucial for understanding the composition of the study population and for contextualizing the subsequent findings related to functional capacity; Age Distribution: The table categorizes the patients' ages into six groups: 17-25, 26-35, 36-45, 46-55, 56-65, and >65 years. This grouping allows for a clear visualization of the age distribution within the cohort. The largest proportion of patients (17 out of 44, or 38.6%) falls within the 56-65 years age group. This indicates that the study population is largely composed of middle-aged to older adults. A significant number of patients (11 out of 44, or 25.0%) are older than 65 years. This highlights the substantial representation of elderly individuals within the CKD cohort. Relatively few patients are in the younger age groups, with only 1 patient (2.3%) in each of the 17-25 and 26-35 age groups. This suggests that the study population primarily consists of older individuals. The age distribution is important because age is a known factor influencing CKD progression and functional capacity. The predominance of older patients may be relevant to the study's findings on functional limitations; Gender Distribution: The study includes a slightly higher number of male patients (24 out of 44, or 54.5%) compared to female patients (20 out of 44, or 45.5%). While there is a slight male predominance, the gender distribution is reasonably balanced, allowing for potential comparisons between males and females within the cohort. Gender can influence CKD and related outcomes, so this distribution is important to consider when interpreting the results; Body Mass Index (BMI): BMI is categorized according to the Asia-Pacific criteria, with categories including Underweight (<18.5 kg/m²), Normal (18.5-22.9 kg/m²), Overweight (23.0-24.9 kg/m²), Obese I (25.0-29.9 kg/m²), and Obese II (≥30.0 kg/m²). The largest group of patients (17 out of 44, or 38.6%) falls within the normal weight category. A substantial proportion of patients are either overweight (10 out of 44, or 22.7%) or obese (11 Obese I, 2 Obese II, totaling 31.8%). This indicates a considerable presence of excess weight within the cohort. A small number of patients (4 out of 44, or 9.1%) are underweight. BMI is a significant factor in CKD and is related to other comorbidities. The distribution of BMI in this cohort is relevant to understanding potential risk factors and outcomes;

Primary Etiology of CKD: The most common primary etiology of CKD in this study is hypertension (20 out of 44, or 45.4%). This suggests that high blood pressure is a major contributor to CKD in this population. Diabetes mellitus is the second most common etiology (12 out of 44, or 27.3%), indicating that diabetes is also a significant cause of CKD. Obstructive nephropathy accounts for 9 patients (20.5%), and other causes, including nephrotic syndrome, are present in 3 patients (6.8%). Identifying the primary etiology of CKD is crucial for understanding the underlying causes of kidney disease in this cohort and for informing treatment and management strategies; Baseline Blood Pressure: The mean systolic blood pressure for the entire cohort (n=44) is 140.75 mmHg, with a standard deviation of 25 mmHg. The systolic blood pressure ranges from 89 mmHg to 210 mmHg. This shows a wide variability in systolic pressure, with some patients having relatively normal blood pressure and others having significant hypertension. The mean diastolic blood pressure is 84.73 mmHg, with a standard deviation of 14 mmHg. The diastolic blood pressure ranges from 56 mmHg to 116 mmHg. Similar to systolic pressure, there's a range in diastolic pressure, with some patients exhibiting elevated levels. Blood pressure is a critical factor in CKD progression and cardiovascular complications. The baseline blood pressure measurements provide insight into the cardiovascular health of the patients at the start of the study; eGFR Category (CKD Stage): The patients are categorized into CKD stages based on their estimated Glomerular Filtration Rate (eGFR): Stage 3 (30-59 ml/min/1.73m²), Stage 4 (15-29 ml/min/1.73m²), and Stage 5 (<15 ml/min/1.73m²). The largest group of patients (19 out of 44, or 43.2%) is in Stage 5, indicating advanced CKD. A considerable number of patients are also in Stage 3 (13 out of 44, or 29.5%) and Stage 4 (12 out of 44, or 27.3%). eGFR is a key indicator of kidney function. The distribution of patients across CKD stages is essential for understanding the severity of kidney disease in the cohort and for analyzing how kidney function relates to functional capacity.

Table 1. Baseline demographic and clinical characteristics of non-dialysis CKD patients (N=44).

Characteristic	**Category / Statistic**	**Frequency (n)**	**Percentage (%)**	**Mean ± SD**	**Min-Max Range**
Age (years)	17-25	1	2.3%		
	26-35	1	2.3%		
	36-45	9	20.5%		
	46-55	5	11.4%		
	56-65	17	38.6%		
	>65	11	25.0%		
Gender	Male	24	54.5%		
	Female	20	45.5%		
Body mass index (BMI, kg/m²)	(Asia-Pacific Criteria)				
	Underweight (<18.5)	4	9.1%		
	Normal (18.5-22.9)	17	38.6%		
	Overweight (23.0-24.9)	10	22.7%		
	Obese I (25.0-29.9)	11	25.0%		
	Obese II (≥30.0)	2	4.5%		
Primary etiology of CKD	Hypertension	20	45.4%		
	Diabetes Mellitus	12	27.3%		
	Obstructive Nephropathy	9	20.5%		
	Other (Nephrotic Syndrome)	3	6.8%		
Baseline blood pressure (mmHg)	(Pre-6MWT)				
	Systolic	44		140.75 ± 25	89 - 210
	Diastolic	44		84.73 ± 14	56 - 116
eGFR category (ml/min/1.73m²)	(CKD Stage)				
	30-59 (Stage 3)	13	29.5%		
	15-29 (Stage 4)	12	27.3%		
	<15 (Stage 5)	19	43.2%		

Notes: CKD = Chronic Kidney Disease; BMI = Body Mass Index; SD = Standard Deviation; eGFR = estimated Glomerular Filtration Rate; 6MWT = Six-Minute Walk Test.

Table 2 displays the results of the Six-Minute Walk Test (6MWT), a measure of functional capacity, among the 44 participants, categorized by various demographic and clinical characteristics. The table provides valuable insights into how these characteristics relate to walking performance in this CKD population; Overall by Gender: The mean 6MWD for male participants (n=24) is 290.83 meters, with a standard deviation of 67 meters. The distances walked by males range from 180 to 417 meters. The mean 6MWD for female participants (n=20) is 255.15 meters, with a standard deviation of 56 meters. The distances walked by females range from 180 to 367 meters. On average, males walked a greater distance than females. This difference suggests a potential gender-based variation in functional capacity, as measured by the 6MWT, within this CKD cohort. While the mean distance differs, there is an overlap in the ranges, indicating that some females walked farther than some males, and vice versa. This stratification highlights the potential influence of gender on exercise tolerance in CKD patients; By eGFR Category (ml/min/1.73m²): Patients in Stage 3 CKD (n=13) have a mean 6MWD of 303.85 meters, with a standard deviation of 66 meters. The range is 180 to 417 meters. Patients in Stage 4 CKD (n=12) have a mean 6MWD of 280.50 meters, with a standard deviation of 52 meters. The range is 220 to 358 meters. Patients in Stage 5 CKD (n=19) have a mean 6MWD of 255.63 meters, with a standard deviation of 66 meters. The range is 180 to 380 meters. There is a clear trend of decreasing mean 6MWD as the eGFR category declines (i.e., as CKD stage progresses). Patients with better kidney function (Stage 3) tend to walk farther than those with poorer kidney function (Stages 4 and 5). Despite the lowest mean, Stage 5 patients show a wide range of walking distances. This stratification strongly suggests that kidney function, as indicated by eGFR, is a significant determinant of functional capacity in CKD. Worsening kidney function is associated with reduced walking ability; By Age Group (years): The two youngest participants (one in each group) walked 320 and 358 meters, respectively. However, these groups have very small sample sizes (n=1 each), limiting generalizability. Patients in the 36-45 age group (n=9) have a mean 6MWD of 314.56 meters (SD=61 m), with a range of 237-417 meters. Patients in the 46-55 age group (n=5) have a mean 6MWD of 284.20 meters (SD=79 m), with a range of 185-362 meters. Patients in the 56-65 age group (n=17) have a mean 6MWD of 261.41 meters (SD=58 m), with a range of 180-374 meters. older than 65 years (n=11) have a mean 6MWD of 245.82 meters (SD=56 m), with a range of 180-357 meters. There is a general trend of decreasing mean 6MWD with increasing age. Older age groups tend to walk shorter distances. Variability within age groups, as indicated by the standard deviations and ranges, suggests that age is not the *sole* determinant of walking distance. Age is an important factor influencing functional capacity in CKD, with older patients generally exhibiting poorer performance; By BMI Category (kg/m²) (Asia-Pacific Criteria): Underweight patients (n=4) have a mean 6MWD of 309.50 meters (SD=90 m), with a range of 180-380 meters. Normal weight patients (n=17) have a mean 6MWD of 267.41 meters (SD=66 m), with a range of 180-367 meters. Overweight patients (n=10) have a mean 6MWD of 265.40 meters (SD=55 m), with a range of 198-374 meters. Obese I patients (n=11) have a mean 6MWD of 276.64 meters (SD=62 m), with a range of 205-417 meters. Obese II patients (n=2) have a mean 6MWD of 301.00 meters (SD=93 m), with a range of 235-367 meters. The relationship between BMI and 6MWD is not linear. Normal and overweight categories show the lowest mean distances. Underweight and Obese II groups have relatively higher mean distances. The Obese II category has a very small sample size (n=2), making it difficult to draw firm conclusions. The underweight group has a high standard deviation, indicating substantial variability in walking distances within this group. The impact of BMI on functional capacity in CKD is complex and may not follow a simple linear pattern. Both low and very high BMI may be associated with better walking performance in this specific cohort compared to the normal and overweight categories.

However, these findings should be interpreted cautiously, especially for the underweight and Obese II categories, due to small sample sizes and high variability.

Table 2. Six-minute walk distance (6MWD) stratified by participant characteristics (N=44).

Stratification variable	**Category / Group**	**Frequency (n)**	**Mean 6MWD (m) ± SD**	**Min-Max 6MWD (m)**
Overall by gender	Male	24	290.83 ± 67	180 - 417
	Female	20	255.15 ± 56	180 - 367
	Total	**44**		
By eGFR category (ml/min/1.73m²)	30-59 (Stage 3)	13	303.85 ± 66	180 - 417
	15-29 (Stage 4)	12	280.50 ± 52	220 - 358
	<15 (Stage 5)	19	255.63 ± 66	180 - 380
By age group (years)	17-25	1	320.00	320 - 320
	26-35	1	358.00	358 - 358
	36-45	9	314.56 ± 61	237 - 417
	46-55	5	284.20 ± 79	185 - 362
	56-65	17	261.41 ± 58	180 - 374
	>65	11	245.82 ± 56	180 - 357
By BMI Category (kg/m²)	(Asia-Pacific Criteria)			
	Underweight (<18.5)	4	309.50 ± 90	180 - 380
	Normal (18.5-22.9)	17	267.41 ± 66	180 - 367
	Overweight (23.0-24.9)	10	265.40 ± 55	198 - 374
	Obese I (25.0-29.9)	11	276.64 ± 62	205 - 417
	Obese II (≥30.0)	2	301.00 ± 93	235 - 367

Notes: 6MWD = Six-Minute Walk Distance; SD = Standard Deviation; m = meters; eGFR = estimated Glomerular Filtration Rate; BMI = Body Mass Index.

Table 3 presents the functional capacity of the study participants, measured in Metabolic Equivalents (METs), and how it varies with the severity of kidney disease as indicated by eGFR categories. Functional capacity is categorized into three levels: Low (<3.0 METs), Moderate (3.0-6.0 METs), and High (>6.0 METs). The majority of participants (31 out of 44, or 70.5%) exhibit Low functional capacity. This indicates that a substantial portion of the cohort has limitations in their ability to perform physical activities. A smaller proportion of participants (13 out of 44, or 29.5%) fall into the Moderate functional capacity category. None of the participants (0 out of 44, or 0.0%) achieved High functional capacity. This highlights a significant impairment in exercise tolerance within the study population; eGFR 30-59 (Stage 3): In this group (n=13), 8 participants (61.5%) have Low METs, and 5 participants (38.5%) have Moderate METs. No participants in this group exhibit High METs (0.0%); eGFR 15-29 (Stage 4): In this group (n=12), 7 participants (58.3%) have Low METs, and 5 participants (41.7%) have Moderate METs. Again, no participants in this group have High METs (0.0%); eGFR <15 (Stage 5): In this group (n=19), a larger majority, 16 participants (84.2%), have Low METs, while only 3 participants (15.8%) have Moderate METs. Similar to the other stages, no participants in this group reached High METs (0.0%).

Table 3. Functional capacity estimated in metabolic equivalents (METs) overall and stratified by eGFR category (N=44).

Functional capacity category	**Definition**	**Overall frequency (n)**	**Overall percentage (%)**
Low	<3.0 METs	31	70.5%
Moderate	3.0-6.0 METs	13	29.5%
High	>6.0 METs	0	0.0%
Total		**44**	**100.0%**
Stratification by eGFR Category (ml/min/1.73m²)	**MET Category**	**Frequency (n)**	**Percentage within eGFR Category (%)**
eGFR 30-59 (Stage 3)	(n=13)		
	Low	8	61.5%
	Moderate	5	38.5%
	High	0	0.0%
	Total	**13**	**100.0%**
eGFR 15-29 (Stage 4)	(n=12)		
	Low	7	58.3%
	Moderate	5	41.7%
	High	0	0.0%
	Total	**12**	**100.0%**
eGFR <15 (Stage 5)	(n=19)		
	Low	16	84.2%
	Moderate	3	15.8%
	High	0	0.0%
	Total	**19**	**100.0%**

Notes: METs = Metabolic Equivalents; eGFR = estimated Glomerular Filtration Rate. Functional Capacity (METs) estimated using the Nury formula based on 6MWD, age, gender, height, and weight.

4. Discussion

The most salient finding of this study is the strikingly high prevalence of low functional capacity among the participants. A substantial majority, exceeding 70%, of the participants exhibited METs values below 3.0. This level of functional capacity is clinically significant as it is frequently associated with marked limitations in the ability to perform even light-intensity activities of daily living. Such limitations are indicative of poor physical fitness and carry significant implications for the overall health and well-being of these patients. The implications of this degree of functional limitation are profound, affecting not only their ability to carry out routine daily tasks but also their overall quality of life and their risk for adverse health outcomes. The mean 6MWD values observed in this study, approximately 291 meters for men and 255 meters for women, are markedly lower than the reference values reported for healthy Indonesian adults. They are also lower than those reported for elderly populations in some Western countries. This comparison underscores the severity of functional impairment in this CKD-ND cohort. It is important to note that while precise age- and gender-matched reference values for 6MWD in the Indonesian population require further validation, the existing data strongly suggest a significant reduction in exercise tolerance among these CKD-ND patients. For context, it is plausible to expect that healthy Indonesian adults would typically achieve considerably greater distances in the 6MWT, potentially exceeding 500-600 meters. However, the absence of definitive reference values tailored specifically for this population highlights an area for future research. Establishing such population-specific norms would provide a more accurate benchmark for assessing functional capacity and identifying individuals at risk for functional decline. Even when compared to reference values for older adult populations, the distances achieved by the CKD-ND cohort in this study, whose mean age was concentrated around 56-65 years, appear substantially reduced. This observation aligns with the broader understanding that CKD imposes a significant burden on physical function, leading to a decline in exercise tolerance and overall physical performance. Previous research has consistently demonstrated that CKD-ND patients exhibit significantly lower 6MWD, muscle strength, and balance compared to healthy controls, further supporting the notion that CKD is associated with substantial functional impairment. The finding in this study that no participant achieved high functional capacity, defined as METs greater than 6.0, further emphasizes the pervasive nature of this impairment. This absence of high functional capacity underscores the degree to which CKD can compromise the ability to engage in vigorous physical activity and highlights the importance of addressing functional limitations in the management of CKD. The observed mean distances in this study fall into categories that are frequently described as "poor" or "very poor" in functional classifications based on 6MWT performance. These classifications provide a framework for interpreting 6MWD results and for assessing the severity of functional impairment. The fact that the majority of participants fall into these lower performance categories underscores the clinical significance of the findings and highlights the need for interventions aimed at improving functional capacity in this population.[11-15]

The reasons underlying such profound functional limitation in CKD-ND are multifactorial, reflecting the complex pathophysiology of the disease. Uremia, chronic inflammation, oxidative stress, anemia, hormonal imbalances, metabolic acidosis, and malnutrition collectively contribute to muscle wasting (sarcopenia) and dysfunction (uremic myopathy). These factors create a systemic environment that is detrimental to muscle health and overall physical function. Anemia, which is highly prevalent in CKD, with estimates ranging from approximately 50% to 90% depending on the stage of the disease, plays a significant role in limiting functional capacity. Anemia directly reduces the oxygen-carrying capacity of the blood, leading to reduced oxygen delivery to working muscles. This results in premature fatigue during exercise and a shift towards less efficient anaerobic metabolic pathways earlier in the exercise bout. The failing kidneys' deficient erythropoietin production is a primary driver of this anemia, further exacerbating the limitations on physical activity. Cardiovascular complications, which are ubiquitous in CKD, also exert a critical influence on functional capacity. Left ventricular dysfunction, both systolic and diastolic, which is characteristic of uremic cardiomyopathy, impaired endothelial function that reduces vasodilation, and increased arterial stiffness collectively limit the heart's ability to augment cardiac output and blood flow to exercising muscles. These cardiovascular limitations directly constrain VO_2 peak and exercise tolerance, contributing to the reduced 6MWD observed in this study. The finding that a notable proportion of participants, approximately 14%, had to discontinue the 6MWT prematurely due to dyspnea likely reflects these underlying cardiorespiratory limitations. Dyspnea, or shortness of breath, is a common symptom in CKD patients and can be a significant barrier to physical activity. The presence of dyspnea during the 6MWT suggests that these patients experience significant limitations in their ability to tolerate even moderate exercise. Physical inactivity, frequently adopted by patients due to fatigue, symptoms, or psychosocial factors, further compounds the problem, creating a vicious cycle that exacerbates functional decline. Reduced physical activity leads to muscle deconditioning, decreased cardiovascular fitness, and increased fatigue, which in turn further discourages physical activity. Breaking this cycle is crucial for improving functional capacity and overall health outcomes in CKD patients.[16-20]

5. Conclusion

This study provides compelling evidence of the profound functional limitations present in patients with non-dialysis CKD. The findings highlight that a significant majority of these patients exhibit low functional capacity, characterized by reduced exercise tolerance and limitations in performing daily activities. The 6MWT results demonstrate a clear impairment in walking capacity compared to expected values, underscoring the clinical relevance of functional assessments in this population. The study also elucidates the multifactorial nature of functional decline in CKD, implicating uremia, inflammation, oxidative stress, anemia, and cardiovascular complications. These factors collectively contribute to muscle wasting, dysfunction, and reduced oxygen delivery, ultimately constraining exercise tolerance. Furthermore, the study reveals a strong association between declining eGFR and poorer functional capacity, reinforcing the importance of monitoring kidney function in the context of physical performance. Older age was also identified as a significant factor contributing to reduced 6MWD, highlighting the cumulative impact of age and CKD on functional limitations. In conclusion, this research underscores the critical need for routine functional capacity assessments in CKD-ND patients. The 6MWT serves as a valuable tool for identifying individuals at risk for functional decline and for guiding the development of targeted interventions, including exercise rehabilitation strategies. Addressing functional limitations is essential for improving patient outcomes, enhancing quality of life, and potentially reducing the burden of CKD-related complications.

6. References

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