

Comparative Evaluation of Pulmonary Function Tests in patients with Stage 3 and Stage 4 Chronic Kidney Disease and Healthy individuals¹Dr Poonam Motwani, Senior Resident, Department of Physiology, GRMC, Gwalior²Dr Yashvardhan Raghuvanshi, Assistant Professor, Department of Physiology, SRVS Government Medical College, Shivpuri³Dr Vikas Jain, Professor, Department of Physiology, GRMC, Gwalior⁴Dr Ajit Singh Rajput, Professor, Department of Physiology, GRMC, Gwalior**Corresponding Author:** Dr Poonam Motwani, Senior Resident, Department of Physiology, GRMC, Gwalior.**How to citation this article:** Dr Poonam Motwani, Dr Yashvardhan Raghuvanshi, Dr Vikas Jain, Dr Ajit Singh Rajput, “Comparative Evaluation of Pulmonary Function Tests in patients with Stage 3 and Stage 4 Chronic Kidney Disease and Healthy individuals”, IJMACR– September – 2026, Volume – 9, Issue – 5, P. No. 948 – 955.**Open Access Article:** © 2026 Dr. Shashank S. Shetty, et al. This is an open access journal and article distributed under the terms of the creative common's attribution license (<http://creativecommons.org/licenses/by/4.0>). Which allows others to remix, tweak, and build upon the work non - commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.**Type of Publication:** Original Research Article**Conflicts of Interest:** Nil**Abstract**

Chronic Kidney Disease is a progressive disorder associated with multisystem complications including pulmonary dysfunction. Respiratory abnormalities become more evident as renal function deteriorates, particularly in Stage 3 and Stage 4 CKD. This study aimed to compare pulmonary function tests (PFTs) in Stage 3 and Stage 4 CKD patients with healthy subjects. Spirometric parameters including Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), FEV1/FVC ratio, and Peak Expiratory Flow Rate (PEFR) were evaluated. CKD patients demonstrated significantly reduced pulmonary function compared to healthy controls, with Stage 4 patients showing greater impairment than Stage 3 patients. Restrictive ventilatory defect was the predominant pattern observed.

Keywords: Chronic Kidney Disease, Pulmonary Function Test, Spirometry, FVC; FEV1, FEV1/FVC, PEFR, Restrictive Ventilatory Defect, Stage 3 CKD, Stage 4 CKD.**Introduction**

Chronic kidney disease (CKD) is a progressive disorder characterized by abnormalities of kidney structure or function that persist for more than 3 months and have implications for an individual's health. CKD is classified according to the cause, glomerular filtration rate (GFR) category, and albuminuria category. ¹ According to the Kidney Disease: Improving Global Outcomes (KDIGO) classification, CKD is divided into different stages based on estimated glomerular filtration rate (eGFR). Stage G3 is further subdivided into G3a (eGFR 45–59 mL/min/1.73

m²) and G3b (30–44 mL/min/1.73 m²), while Stage G4 is characterized by an eGFR of 15–29 mL/min/1.73 m².¹

The kidneys and lungs are closely interconnected organs that contribute to the maintenance of acid–base balance, fluid homeostasis, electrolyte balance, and blood pressure regulation. Disturbances in renal function can therefore have important effects on the respiratory system.^{2,3} Pulmonary complications are frequently observed in patients with CKD and may include pulmonary edema, pleural effusion, pulmonary hypertension, pulmonary calcification, sleep-disordered breathing, and abnormalities in pulmonary function.^{2,4}

The relationship between CKD and pulmonary dysfunction is complex and involves several mechanisms, including fluid overload, uremic toxin accumulation, metabolic acidosis, inflammation, anemia, endothelial dysfunction, and abnormalities of the cardiovascular system.^{2,3,5}

Fluid overload is an important complication of declining renal function. Excessive accumulation of fluid may cause pulmonary vascular congestion and interstitial edema, which can decrease lung compliance and impair normal lung expansion. These changes may contribute to a restrictive pattern of ventilatory impairment.^{4,6}

Uremia may also adversely affect respiratory function. Accumulation of uremic toxins and metabolic abnormalities can impair respiratory muscle performance and contribute to reduced ventilatory capacity.^{2,5}

Respiratory muscle weakness is another important feature observed in patients with advanced CKD. Studies have demonstrated reduced respiratory muscle strength in CKD patients, which may contribute to decreased pulmonary function and exercise capacity.^{7,8}

Pulmonary hypertension is also recognized as an important complication of CKD. Its prevalence increases

with worsening renal function and is associated with cardiovascular morbidity and mortality.^{9,10}

Previous studies have demonstrated that patients with CKD may have lower FEV₁, FVC, and peak expiratory flow compared with healthy individuals.^{7,11} A cross-sectional analysis of the National Health and Nutrition Examination Survey (NHANES) demonstrated an association between CKD and abnormal lung function, including restrictive and obstructive patterns.¹¹ Similarly, studies of patients with chronic renal failure have reported reductions in FVC and FEV₁, with some studies demonstrating a predominantly restrictive ventilatory abnormality.^{12,13}

The severity of pulmonary impairment may increase as renal function deteriorates. Patients with more advanced CKD may experience greater fluid retention, metabolic disturbances, muscle weakness, anemia, and cardiovascular complications, all of which may adversely affect respiratory function.^{2,4,5}

Pulmonary function tests (PFTs) are non-invasive investigations used to evaluate respiratory function. Spirometry is the most commonly used pulmonary function test and provides objective measurements of airflow and ventilatory function.¹⁴ The major spirometric parameters include forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), FEV₁/FVC ratio, and peak expiratory flow rate (PEFR).¹⁴

A restrictive ventilatory pattern is generally suggested by a reduced FVC with a preserved or increased FEV₁/FVC ratio; however, spirometry alone cannot definitively confirm restriction, and measurement of total lung capacity is required for confirmation.^{11,15}

Previous studies have shown that pulmonary dysfunction may be present in CKD even before the development of end-stage kidney disease.^{11,13} A recent systematic review

and meta-analysis also demonstrated that respiratory muscle training can improve FEV1 and FVC in patients with CKD, further emphasizing the importance of respiratory impairment in this population.¹⁷

Although pulmonary abnormalities have been extensively studied in patients with advanced CKD and those receiving dialysis, comparatively less attention has been given to pulmonary function in non-dialysis Stage 3 and Stage 4 CKD patients. Therefore, assessment of pulmonary function in Stage 3 and Stage 4 CKD patients may help identify respiratory impairment at an earlier stage and provide information regarding the relationship between worsening renal function and pulmonary dysfunction.

Aim and Objectives

1. To assess pulmonary function in Stage 3 and Stage 4 chronic kidney disease patients.
2. To compare spirometric parameters between CKD patients and healthy subjects.
3. To determine the pattern of pulmonary dysfunction associated with CKD.

Material and Methods

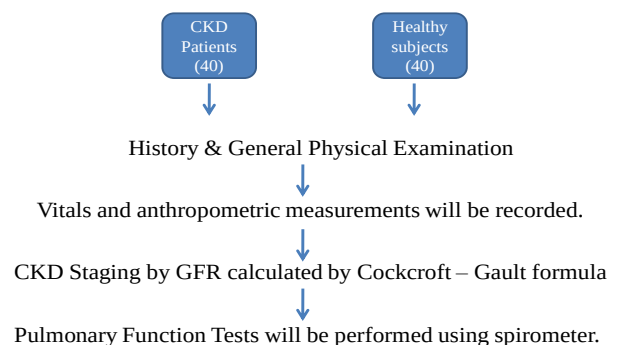
This Comparative cross-sectional study conducted in the Department of Physiology, G.R. Medical College, Gwalior. A total of 80 subject were enrolled, including 40 patients with CKD Stage 3,4 & 40 age and sex-matched healthy control. CKD subject was recruited from the Medicine Outpatient Department.

The study included patients aged 18–65 years with Stage 3 and Stage 4 chronic kidney disease who were willing to participate, while smokers and patients with bronchial asthma, chronic obstructive pulmonary disease, pulmonary tuberculosis, congestive cardiac failure, active respiratory infections, a history of hospitalization for cardiovascular events, anemia, musculoskeletal

deformities, and those undergoing haemodialysis were excluded.

A computerized spirometer was used for pulmonary function assessment, and the procedure was performed according to standardized spirometry recommendations.¹⁴ Informed consent was obtained from all participants, and there was no financial burden on either cases or controls. Subjects were comfortably seated and were given adequate instructions regarding the spirometry procedure. Each subject was then asked to perform a maximal inspiration followed by a rapid and forceful expiration into the spirometer. Pulmonary function testing was carried out using a MEDICAID SPIRO EXCEL digital spirometer, and the parameters FEV₁, FVC, FEV₁/FVC ratio, and PEFR were recorded. At least three acceptable readings were obtained for each subject, and the best acceptable value was considered for analysis in accordance with standardized spirometry procedures.¹⁴

Data collection will be as following



Statistical Analysis

Data were expressed as mean $\pm$ standard deviation. Student's t-test and ANOVA were applied. A p-value <0.05 was considered statistically significant. Statistical analysis was performed using Graph Pad Prism version 5.0.

Results

Table 1: Anthropometric Parameters of CKD group and Healthy Group

S. No.	Parameters	Healthy Group	CKD Stage 3	CKD Stage 4	p-value
1	Age (years)	43.70±7.206	44.61±7.243	43.70±7.206	0.4793
2	Height (cm)	164±4.34	165± 6.08	164±4.34	0.3551
3	Weight (Kg)	66.17±5.851	67.92±6.84	66.17±5.851	0.1227
4	BMI (kg/m ²)	24.54±1.670	24.91±1.707	24.54±1.670	0.2162

Table 2: Comparison of Pulmonary Function Parameters of CKD group and Healthy Group

Parameter	Healthy Subjects	Stage 3 CKD	Stage 4 CKD	P value
FVC (% predicted)	84.80±2.142	82.55±3.5759	80.65±3.5135	p<0.001
FEV1 (% predicted)	84.25±2.8447	82.45±2.7429	80.45±3.5600	p=0.001
FEV1/FVC ratio	82.10±2.1981	82.60±2.0622	81.35±1.8144	p=0.156
PEFR	87.75±2.2213	84.05±3.2196	80.45±4.1228	p<0.001

The present study demonstrated lower FVC and FEV1 values among CKD patients compared with healthy subjects.

Stage 4 CKD patients demonstrated greater reductions in FVC and FEV1 compared with Stage 3 CKD patients.

The FEV1/FVC ratio remained relatively preserved or increased in CKD patients despite reductions in FVC and FEV1.

This pattern was suggestive of a restrictive ventilatory abnormality, which is consistent with findings reported in previous studies of CKD populations.¹¹⁻¹³

The PEFR was mildly reduced in Stage 3 CKD patients and markedly reduced in Stage 4 CKD patients.

Discussion

The present study demonstrated impaired pulmonary function in patients with Stage 3 and Stage 4 CKD compared with healthy subjects. The observed reductions in FVC and FEV1 are consistent with previous studies showing impaired pulmonary function among patients with CKD.^{7,11,12}

Rezende et al. reported significantly lower FEV1, FVC, and peak expiratory flow values in CKD patients compared with healthy individuals, supporting the findings of the present study.⁷

Navaneethan et al., using NHANES data, reported an association between CKD and abnormal lung function and demonstrated that restrictive lung function was relatively common among individuals with CKD.¹¹

Studies in chronic renal failure patients have similarly demonstrated reduced FVC and FEV1, with restrictive ventilatory abnormalities being reported as an important pattern of pulmonary dysfunction.^{12,13}

In the present study, both FVC and FEV1 were reduced, whereas the FEV1/FVC ratio remained preserved or increased. This finding is suggestive of a restrictive ventilatory pattern.^{11,15}

However, it is important to note that spirometry alone cannot definitively establish a restrictive ventilatory defect. Confirmation of restriction requires measurement of total lung capacity by complete pulmonary function testing.¹⁵

The restrictive pattern observed in CKD may be explained by several mechanisms.

Fluid overload is one of the important complications of CKD. Accumulation of excess fluid can produce pulmonary vascular congestion and interstitial edema, which may reduce lung compliance and restrict lung expansion.^{4,6}

Pierson described pulmonary edema, pleural effusion, pulmonary calcification, sleep-related breathing abnormalities, and other respiratory complications in patients with renal failure.⁶

The kidney–lung interaction is also mediated through acid–base regulation, fluid balance, inflammation, endothelial function, and immune mechanisms.^{2,3}

Bollenbecker et al. emphasized the importance of kidney–lung cross-talk and described several pathways through which CKD can contribute to pulmonary disease, including abnormalities in acid–base balance, phosphate metabolism, inflammation, and vascular function.³

Uremic toxin accumulation may additionally contribute to pulmonary and respiratory muscle dysfunction.^{2,5}

Respiratory muscle weakness may be another mechanism responsible for the reduction in pulmonary function observed in CKD patients. Studies have demonstrated reduced respiratory muscle strength in patients with CKD and have shown that respiratory muscle dysfunction may be related to uremic and metabolic abnormalities.⁸

In the present study, Stage 4 CKD patients demonstrated greater impairment of FVC and FEV1 than Stage 3 patients.

This finding may be explained by the greater severity of renal dysfunction in Stage 4 disease, which may be associated with greater fluid retention, metabolic abnormalities, inflammation, cardiovascular complications, and muscle dysfunction.^{1,2,5}

Previous research has also demonstrated that pulmonary dysfunction may become more pronounced with progression of renal disease.¹³

Mani et al. reported that respiratory complications become more common with increasing severity of CKD and described pulmonary edema, pleural effusion, sleep apnea, and other respiratory abnormalities among CKD patients.⁴

The reduction in PEF observed in the present study may reflect impaired expiratory flow and respiratory muscle performance. Similar reductions in peak expiratory flow have been reported among patients with CKD.^{7,12}

The association between CKD and pulmonary hypertension may also contribute to impaired respiratory and exercise capacity. Pulmonary hypertension is relatively common among CKD patients, and its prevalence tends to increase with worsening renal function.^{9,10}

A recent systematic review and meta-analysis involving more than 17,000 CKD patients estimated a substantial prevalence of pulmonary hypertension and demonstrated that advanced kidney disease was associated with increased risk.⁹

Respiratory muscle dysfunction may be clinically important because respiratory muscle training has been shown to improve respiratory muscle strength and selected pulmonary function parameters in CKD patients.¹⁷

A systematic review and meta-analysis of randomized controlled trials found that respiratory muscle training improved FEV1 and FVC in patients with CKD, suggesting that respiratory impairment in CKD may have potentially modifiable components.¹⁷

Recent evidence from a meta-analysis of hemodialysis studies also suggests that removal of excess fluid and

uremic solutes during dialysis may improve selected pulmonary function parameters, supporting the contribution of fluid overload and the uremic milieu to pulmonary dysfunction.¹⁸

The findings of the present study therefore support the concept that CKD is associated with clinically relevant impairment of pulmonary function and that the degree of impairment may increase with progression of renal disease.

Conclusion

Patients with Stage 3 and Stage 4 chronic kidney disease demonstrated impaired pulmonary function compared with healthy subjects.

The reductions in FVC and FEV1 with a relatively preserved or increased FEV1/FVC ratio were suggestive of a restrictive ventilatory pattern.^{11,15}

Pulmonary impairment was greater in Stage 4 CKD patients than in Stage 3 CKD patients.

The pulmonary abnormalities observed in CKD may be related to fluid overload, pulmonary congestion, uremic toxin accumulation, metabolic disturbances, inflammation, respiratory muscle weakness, and cardiovascular complications.^{2,3,5,6}

Previous studies have similarly demonstrated impaired pulmonary function and respiratory muscle performance in CKD patients.^{7,8,11,13}

Therefore, pulmonary function assessment may be useful for identifying respiratory impairment in CKD patients, particularly as renal function deteriorates.

Early recognition of pulmonary dysfunction may help clinicians identify patients who require further respiratory evaluation and appropriate management.

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