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Physical Activity and Quality of Life in Chronic Kidney Disease: A Systematic Review

Sharvari N. Patil [1], Chetana A. Pawar [2], Sandeep Shinde [2], Manoj Ambali [3], Axita Vani [4], Anand G. Joshi [5]

1. Department of Physiotherapy, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, IND 2. Department of Musculoskeletal Sciences, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, IND 3. Department of Anatomy, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, IND 4. Department of Biochemistry, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, IND 5. Department of Physiology, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, IND

Corresponding author: Sandeep Shinde, drsandeepshinde24@gmail.com

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Abstract

Chronic kidney disease (CKD) is a progressive condition associated with reduced physical function and impaired health-related quality of life (HRQoL). CKD affects HRQoL through the combined burden of reduced physical function, fatigue, symptom load, and psychosocial distress, and this burden increases as patients progress toward kidney replacement therapy. Physical activity and structured exercise interventions have been proposed as low-cost, non-pharmacological strategies to preserve function and HRQoL across the CKD spectrum. This systematic review aimed to synthesise evidence exclusively from randomised controlled trials (RCTs) evaluating the effect of physical activity or exercise interventions on quality of life in patients with CKD, including those on haemodialysis, peritoneal dialysis, and after kidney transplantation.

A systematic search of electronic databases was conducted for RCTs published between January 2015 and December 2025 according to predefined eligibility criteria. Twelve RCTs involving patients with non-dialysis-dependent CKD, haemodialysis, peritoneal dialysis, and kidney transplantation were selected for qualitative synthesis. The included interventions comprised intradialytic aerobic exercise, home-based aerobic and resistance training, combined cognitive-physical training, and nurse-led structured exercise programmes. Methodological quality was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool.

The findings demonstrated that physical activity interventions generally produced favourable improvements in disease-specific and generic HRQoL domains, physical functioning, frailty status, depressive symptoms, and cognitive function, although effect sizes and statistical significance varied by dialysis modality, intervention setting, and outcome instrument. Home-based and low-intensity intradialytic programmes were associated with the most consistent HRQoL gains, whereas one large multicentre intradialytic trial found no clinically significant benefit for the physical component of HRQoL. Evidence in kidney transplant recipients and frail older adults with advanced CKD remains comparatively limited.

The evidence supports incorporating individualised physical activity programmes into routine CKD care as a means of enhancing patient-reported quality of life alongside physical function, though considerable heterogeneity in intervention design and outcome measurement, together with some concerns or high risk of bias in several trials, limits the certainty of pooled conclusions. Further large-scale, high-quality RCTs with standardised HRQoL instruments and longer follow-up are required to establish optimal exercise prescriptions across the CKD spectrum.

Categories: Physical Medicine & Rehabilitation, Nephrology, Healthcare Technology
Keywords: chronic kidney disease, exercise therapy, haemodialysis, kidney transplantation, peritoneal dialysis, physical activity, quality of life

Introduction And Background

Chronic kidney disease (CKD) is a progressive condition affecting a substantial proportion of the global population and is associated with an increasing burden of cardiovascular disease, disability, and premature mortality [1,2]. Beyond its biochemical and structural consequences, CKD has a considerable impact on health-related quality of life (HRQoL). Individuals with CKD frequently experience fatigue, muscle wasting, reduced physical capacity, sleep disturbances, depressive symptoms, and limitations in daily and social activities. These physical and psychological complications can progressively impair functional independence and overall well-being as the disease advances [1,3-5].

The psychosocial burden of CKD further compounds its physical consequences. A systematic review and meta-analysis reported a substantial prevalence of depression among individuals with CKD [3], while another meta-analysis identified physical frailty as a common complication associated with adverse clinical outcomes, including increased mortality [4]. Muscle wasting and sarcopenia, which are associated with

metabolic disturbances, chronic inflammation, and altered protein metabolism in CKD, may further contribute to declining muscle strength, physical function, and quality of life [5]. Together, these complications highlight the importance of interventions that address not only kidney-related clinical outcomes but also patients' functional capacity and HRQoL.

Physical inactivity is both a consequence and a potential contributor to physical deconditioning in individuals with CKD. Observational studies have associated higher levels of physical activity with lower mortality risk and more favourable cardiovascular, renal, and quality-of-life outcomes in this population [6,7]. However, participation in physical activity may be limited by fatigue, comorbidities, physical limitations, concerns about exercise safety, and practical barriers such as time and transportation [8]. Recent clinical guidance and evidence syntheses emphasise the potential role of structured physical activity and exercise in improving physical function, fitness, and other health outcomes in people with CKD [9-11]. Evidence from a multicentre observational study also indicates that physical activity levels are low across different stages of kidney disease and tend to decline with disease progression [12]. The conceptual framework presented in Figure *1* illustrates the proposed relationship between CKD-related physical and psychosocial complications, reduced physical activity, participation in structured exercise interventions, and HRQoL. This framework provides the clinical rationale for examining exercise-based interventions and their potential effects on HRQoL and related health outcomes in individuals with CKD.

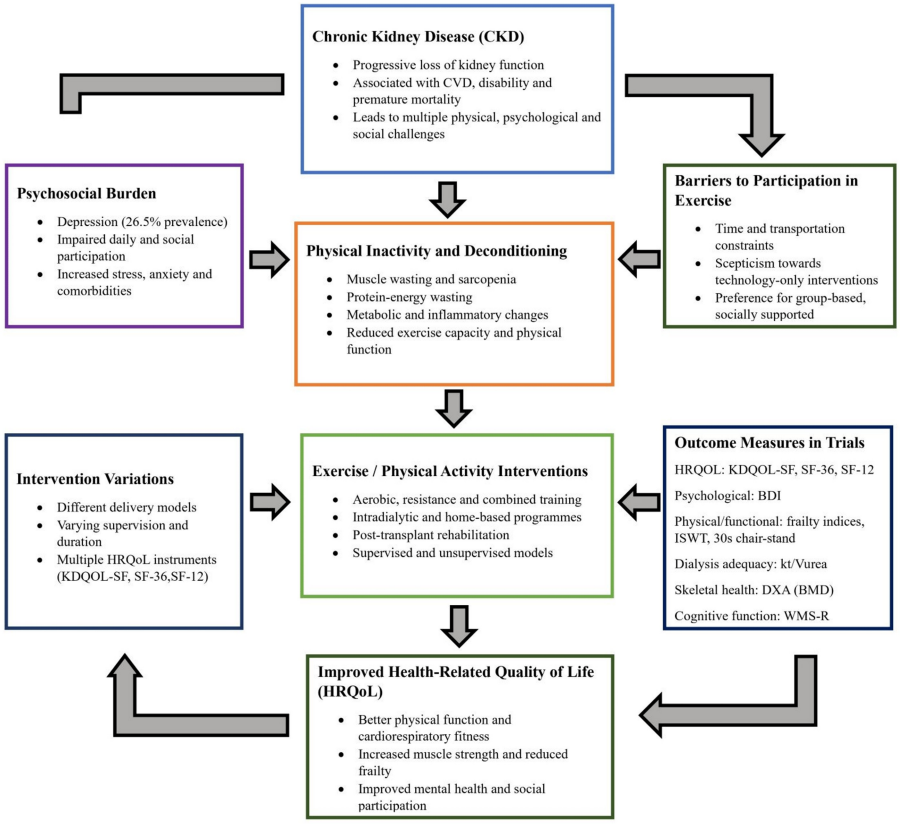


FIGURE 1: Conceptual Logic Model Illustrating the Relationship Between Chronic Kidney Disease, Physical Inactivity, Exercise-Based Interventions, and Health-Related Quality of Life

CKD: Chronic Kidney Disease; HRQoL: Health-Related Quality of Life; KDQOL: Kidney Disease Quality of Life; SF-36: 36-Item Short Form Health Survey; SF-12: 12-Item Short Form Health Survey; BDI: Beck Depression Inventory; ISWT: Incremental Shuttle Walk Test; 30s chair-stand: 30-Second Chair Stand Test; DXA: Dual-Energy X-ray Absorptiometry; BMD: Bone Mineral Density; WMS-R: Wechsler Memory Scale–Revised.

Image credit: This image was created by Chetana A. Pawar using Microsoft PowerPoint (Microsoft Corporation, Redmond, WA).

Despite the growing recognition of exercise as an important component of CKD management, evidence regarding its effects on HRQoL remains variable across patient populations and treatment settings. Exercise interventions have been delivered through different approaches, including intradialytic exercise, home-based aerobic and resistance training, combined physical and cognitive training, and structured exercise

programmes for kidney transplant recipients. These interventions also vary in duration, intensity, supervision, and delivery, which may contribute to differences in reported outcomes. Consequently, a broader evaluation of randomised controlled trials (RCTs) across different CKD populations is important to understand the potential effects of exercise-based interventions on HRQoL and related health outcomes.

Previous evidence syntheses have examined exercise-related outcomes in CKD, although their populations and research scopes have differed. Zhang et al. conducted an umbrella review of systematic reviews and meta-analyses evaluating exercise interventions across several CKD-related outcomes [10]. Young et al. provided a broader overview of physical activity evidence and its implementation in kidney disease [9]. More recently, Traise et al. examined the effects of exercise training on quality of life specifically in individuals with CKD requiring dialysis [13], whereas Redondo-Saenz et al. investigated exercise interventions and HRQoL in individuals with predialysis CKD [14]. Although these reviews provide important evidence, their scopes differ in terms of study populations, intervention settings, and outcome focus. The present review specifically synthesises RCT evidence across non-dialysis CKD, haemodialysis, peritoneal dialysis, and kidney transplantation, with HRQoL as the primary outcome. It also considers related outcomes, including physical function, frailty, depressive symptoms, cognitive function, dialysis adequacy, and bone health, where reported. This broader population-based approach provides an opportunity to examine the consistency of exercise-related HRQoL findings across different CKD treatment settings.

Although the search period extended from January 2015 to December 2025, no eligible RCTs published in 2024 or 2025 were identified. Study inclusion was based on the predefined population, intervention, comparator, study design, and health-outcome criteria. HRQoL was considered the primary outcome, while other relevant patient-centred and clinical outcomes, including physical function, frailty, depressive symptoms, cognitive function, dialysis adequacy, and bone health, were considered secondary outcomes. Therefore, studies reporting eligible secondary outcomes were also considered for inclusion, even when HRQoL was not assessed.

Therefore, this systematic review aimed to evaluate the effects of exercise-based interventions on HRQoL and related health outcomes in adults with CKD across different disease stages and treatment settings. The primary research question was: In adults with CKD, do exercise-based interventions, compared with usual care or non-exercise control interventions, improve HRQoL? Secondary outcomes included physical function, frailty, depressive symptoms, cognitive function, dialysis adequacy, and bone health, where reported.

Review

Methodology

Study Design

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The review protocol was not registered in PROSPERO or any other publicly accessible systematic review registry.

Outcome Measures

Kidney Disease Quality of Life Short Form (KDQOL-SF) [15], frailty was assessed using CKD-specific frailty indices [16], dialysis adequacy using standardised Kt/Vurea [17], Short Form-36 (SF-36) [18], depressive symptoms using the Beck Depression Inventory (BDI) [19], physical function using objective performance tests [20], bone health using dual-energy X-ray absorptiometry (DXA)-derived bone mineral density [21], and cognitive function using the Wechsler Memory Scale-Revised (WMS-R) [22], and the 30-second Chair Stand Test [23], Short Form-12 (SF-12) [24].

Search Strategy

A systematic literature search was conducted across five electronic databases: PubMed/MEDLINE, the Physiotherapy Evidence Database (PEDro), the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Scopus, and the Cochrane Central Register of Controlled Trials (CENTRAL). The search targeted studies published between January 1, 2015, and December 31, 2025. The final searches were conducted between October 12 and October 15, 2026, with the individual database search dates presented in Table *1*. Search strategies incorporated relevant Medical Subject Headings (MeSH), where supported, database-specific free-text terms, and Boolean operators (AND, OR). Two main concepts were combined: chronic kidney disease and its treatment modalities, and physical activity or exercise-based interventions. Search syntax was adapted to the indexing systems and functionalities of individual databases. English-language and RCT restrictions were applied where supported by the respective database search interfaces. The complete database-specific search strategies, including search terms, Boolean operators, filters, and publication-date restrictions, are presented in Table *1* to facilitate transparency and reproducibility of the literature search.

Database	Search strategy	Filters/limits applied	Final search date
PubMed/MEDLINE	("Chronic Kidney Disease" OR CKD OR "End-Stage Renal Disease" OR haemodialysis OR "Peritoneal Dialysis" OR "Kidney Transplantation") AND ("Physical Activity" OR Exercise OR "Exercise Therapy" OR Rehabilitation)	English; randomised controlled trials; January 2015–December 2025	12 October 2026
PEDro	("chronic kidney disease" OR CKD OR "end-stage renal disease" OR haemodialysis OR "peritoneal dialysis" OR "kidney transplantation") AND ("physical activity" OR exercise OR "exercise therapy" OR rehabilitation)	English; clinical trials; January 2015–December 2025	13 October 2026
CINAHL	("Chronic Kidney Disease" OR CKD OR "End-Stage Renal Disease" OR haemodialysis OR "Peritoneal Dialysis" OR "Kidney Transplantation") AND ("Physical Activity" OR Exercise OR "Exercise Therapy" OR Rehabilitation)	English; randomised controlled trials; January 2015–December 2025	13 October 2026
Scopus	TITLE-ABS-KEY (("chronic kidney disease" OR CKD OR "end-stage renal disease" OR haemodialysis OR "peritoneal dialysis" OR "kidney transplantation") AND ("physical activity" OR exercise OR "exercise therapy" OR rehabilitation))	English; randomised controlled trials; January 2015–December 2025	14 October 2026
Cochrane CENTRAL	("Chronic Kidney Disease" OR CKD OR "End-Stage Renal Disease" OR haemodialysis OR "Peritoneal Dialysis" OR "Kidney Transplantation") AND ("Physical Activity" OR Exercise OR "Exercise Therapy" OR Rehabilitation)	English; randomised controlled trials; January 2015–December 2025	15 October 2026

TABLE 1: Search Strategies Used in the Electronic Databases

CKD: chronic kidney disease; CENTRAL: Cochrane Central Register of Controlled Trials; KDQOL-SF: Kidney Disease Quality of Life Short Form.

Eligibility Criteria

Studies were eligible for inclusion if they enrolled adults aged 18 years or older with CKD at any stage, including individuals receiving haemodialysis or peritoneal dialysis and kidney transplant recipients; evaluated a structured physical activity or exercise intervention against a comparator; and employed an RCT design. Studies reporting at least one patient-relevant health outcome following the intervention were considered eligible. The primary outcome was HRQoL, assessed using validated generic or kidney-specific instruments. Secondary outcomes included physical function, physical performance, frailty, cognitive function, psychological well-being, bone health, dialysis adequacy, and other relevant clinical or functional outcomes. Only English-language studies published between January 2015 and December 2025 were considered eligible. The inclusion and exclusion criteria are presented in Table *2*. The eligibility criteria were applied consistently during title and abstract screening and full-text assessment to ensure transparent and reproducible study selection.

Criteria	Inclusion criteria	Exclusion criteria
Participants	Adults aged 18 years or older with chronic kidney disease (CKD) (any stage, including dialysis and post-transplant)	Paediatric populations; studies not restricted to chronic kidney disease (CKD)
Intervention	Structured physical activity/exercise intervention (aerobic, resistance, combined, home-based, or intradialytic)	Pharmacological, dietary-only, or purely educational interventions without an exercise component
Comparator	Usual care, standard nephrology care, wait-list, or attention control	Studies without a concurrent control/comparison group
Outcomes	At least one patient-relevant health outcome, including HRQoL, physical function, physical performance, frailty, cognitive function, psychological well-being, bone health, or dialysis adequacy	Studies reporting no relevant patient-reported, functional, cognitive, or clinical health outcome
Study design	Randomised controlled trials (parallel-group, cluster, or pilot RCTs)	Protocols without outcome data, editorials, and other non-original publications
Publication period	Published between January 2015 and December 2025	Published before 2015 or after 2025

TABLE 2: Eligibility Criteria of the Included Studies

CKD: Chronic Kidney Disease; RCT: Randomised Controlled Trial; KDQOL-SF: Kidney Disease Quality of Life-Short Form; SF-36/SF-12: Short Form Health Survey; EQ-5D: EuroQol 5-Dimension Questionnaire

Study Selection and Data Extraction

Titles and abstracts were independently screened by two reviewers against the predefined eligibility criteria, followed by independent full-text assessment of potentially relevant articles. Disagreements regarding study eligibility were resolved through discussion until consensus was reached.

Data were extracted independently by two reviewers using a predefined structured data extraction form. The information collected included the first author's name, year of publication, country, study design, sample size, participant characteristics, CKD stage, treatment modality, intervention characteristics, comparator intervention, intervention duration, exercise frequency, session duration, supervision, adherence, follow-up duration, outcome measures, and principal findings. Particular attention was given to HRQoL outcomes and other relevant health outcomes, including physical function, frailty, depressive symptoms, cognitive function, dialysis adequacy, and bone health. The extracted information was compared, and discrepancies were resolved through discussion and consensus. The data were organised into study characteristics and outcome findings tables. This systematic review was conducted and reported in accordance with the PRISMA 2020 guidelines [25].

Risk-of-bias assessments were also independently conducted by two reviewers, with disagreements resolved through discussion.

Quality Assessment

The methodological quality and risk of bias of the included RCTs were assessed using the Cochrane Risk of Bias 2 (RoB 2) tool [26]. The tool evaluates five domains: bias arising from the randomisation process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported result. Each domain was assessed and categorised as low risk of bias, some concerns, or high risk of bias according to the RoB 2 criteria. An overall risk-of-bias judgement was determined for each study based on the assessments across all five domains. Particular attention was given to the measurement of HRQoL, the primary outcome of this review. The findings were considered when interpreting the results and assessing the reliability of the evidence.

Data Synthesis

A structured narrative synthesis was conducted because considerable clinical and methodological heterogeneity was identified among the included studies, particularly in CKD populations, treatment modalities, exercise interventions, intervention duration, HRQoL assessment instruments, and outcome

reporting. These differences limited the comparability of the findings and did not support quantitative pooling through meta-analysis.

The studies were first grouped according to CKD population and treatment modality, including haemodialysis, peritoneal dialysis, non-dialysis-dependent CKD, and kidney transplantation. Within these groups, findings were organised according to HRQoL and other reported health outcomes. The exercise interventions were also described according to their type, delivery setting, frequency, session duration, intervention duration, and intensity, where these details were available in the original publications.

For interpretation, a favourable finding was defined as an improvement in the outcome in the exercise group relative to the comparator group, based primarily on the between-group results reported by the original study authors. Statistical significance was considered according to the significance threshold used in each original study. Where a study reported only within-group improvement without a corresponding between-group difference, this was described as a within-group change and was not interpreted as evidence of superiority over the comparator. Effect estimates, confidence intervals, and P-values were extracted and reported where available in the original publications. Where these statistics were not reported, the findings were summarised descriptively without estimating or imputing missing values.

The synthesis focused on the direction and nature of the reported findings, differences between intervention and comparator groups, and the consistency of findings across comparable outcomes. No formal vote-counting analysis, pooled effect estimates, or meta-regression analyses were performed. Conclusions regarding the relative effectiveness of specific exercise settings, intensities, or modalities were avoided where the available data did not permit reliable comparisons.

Study Selection

A total of 241 records were identified through searches of five electronic databases. Following the removal of duplicates and other records before screening, 155 records were screened based on their titles and abstracts. Of these, 88 records were excluded, and 67 full-text reports were sought for retrieval. Three reports could not be retrieved, leaving 64 full-text reports for eligibility assessment. Following full-text evaluation, 52 reports were excluded for reasons including ineligible study design, publication outside the specified period, absence of an HRQoL outcome, ineligible population, absence of an exercise component, or duplicate or insufficient data. Ultimately, 12 RCTs met the eligibility criteria and were included in the systematic review.

Study selection was independently performed by two reviewers. Initially, titles and abstracts were screened against the predefined eligibility criteria. Full texts of potentially eligible studies were subsequently assessed independently by both reviewers. Disagreements regarding study eligibility were resolved through discussion until consensus was reached. Reasons for excluding reports following full-text assessment were documented, and the selection process is presented in the PRISMA 2020 flow diagram (Figure *2*).

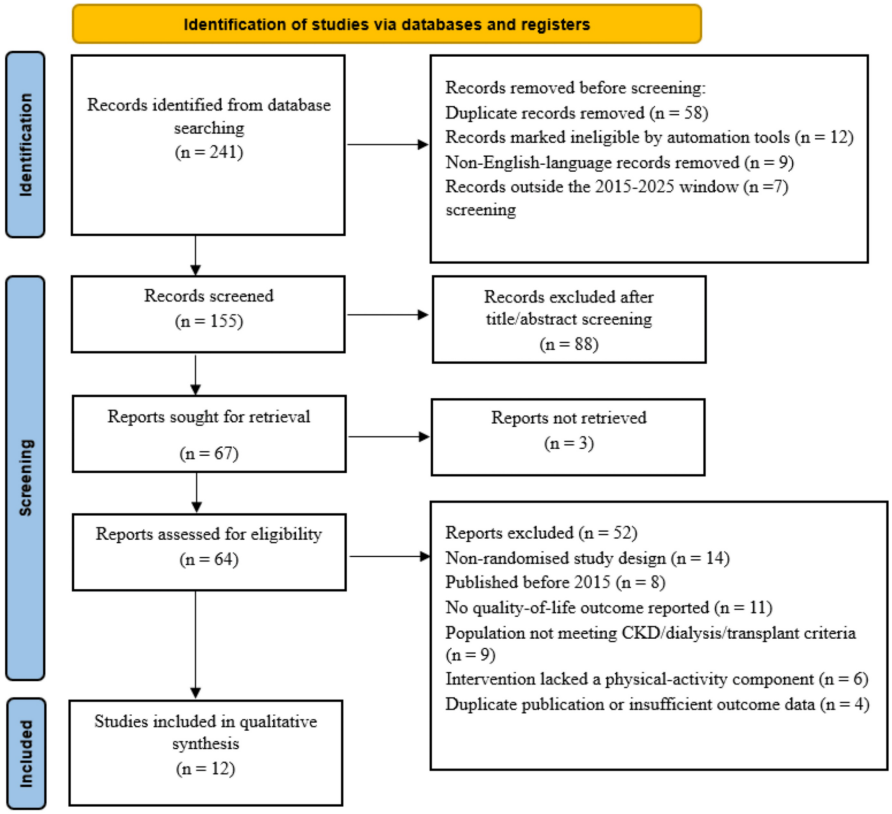


FIGURE 2: PRISMA Flow Diagram of Study Identification and Selection

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; CKD: Chronic Kidney Disease.

Results

Because of the heterogeneity in study populations, exercise interventions, and outcome assessment methods, the findings were synthesised narratively rather than statistically pooled. Accordingly, the results are presented descriptively, based on the individual findings reported in the included studies.

The 12 included RCTs evaluated exercise-based interventions across different CKD populations and treatment settings. These included individuals receiving maintenance haemodialysis, patients undergoing peritoneal dialysis, individuals with non-dialysis-dependent CKD, kidney transplant recipients, and older adults with advanced CKD and frailty. The interventions included intradialytic aerobic cycling, home-based aerobic and resistance training, combined physical and cognitive training, and nurse-led rehabilitation programmes. Intervention durations ranged from 12 weeks to six months. Study characteristics, including participant populations, sample sizes, intervention approaches, and study designs, are summarised in Table *3*.

Study	Study design	Sample size	Population	Intervention and duration
Greenwood SA et al. (2021) [27]	Multicentre, single-blind RCT	NA	Adults receiving maintenance haemodialysis	Progressive intradialytic aerobic exercise using cycle ergometry versus usual care; 6 months
Kim S et al. (2022) [28]	Single-centre RCT	39 (18 exercise; 21 control)	Patients receiving haemodialysis	Supervised intradialytic aerobic cycling versus usual care; duration to be verified
Lin CH et al. (2021) [29]	RCT	64 (32 exercise; 32 control)	Patients receiving haemodialysis in Taiwan	Intradialytic exercise versus usual lifestyle; 12 weeks
Vogiatzaki E et al. (2022) [30]	RCT	NA	Patients receiving haemodialysis	Intradialytic exercise versus usual care; 6 months
Ortega-Perez de Villar L et al. (2020) [31]	Pilot RCT	NA	Patients receiving haemodialysis	Intradialytic exercise versus home-based exercise; duration to be verified
Uchiyama K et al. (2021) [32]	RCT	46 (23 exercise; 23 control)	Patients with severe/stage 4 CKD	Home-based aerobic exercise combined with resistance training versus usual care; 6 months
Uchiyama K et al. (2019) [33]	RCT	47 (24 exercise; 23 control)	Patients receiving peritoneal dialysis	Home-based aerobic exercise combined with resistance training versus usual care; 12 weeks
Watanabe K et al. (2021) [34]	Randomised pilot study	53 (26 exercise; 27 control)	Peritoneal dialysis outpatients	Home-based resistance, stretching, and aerobic exercise versus usual care; 6 months
Otobe Y et al. (2021) [35]	RCT	53 (27 exercise; 26 control)	Adults aged 65 years or older with stage G3–G4 CKD	Combined group-based and home exercise versus usual care; 24 weeks
Zhang P et al. (2023) [36]	Prospective RCT	106	Kidney transplant recipients	Nurse-led physical exercise programme incorporating Baduanjin versus standard care; duration to be verified
Kren A, Bogataj Š (2023) [37]	Randomised clinical controlled trial	NA	Patients with end-stage kidney disease receiving haemodialysis	Combined intradialytic cognitive and physical training versus usual dialysis care; duration to be verified
Nixon AC et al. (2021) [38]	Mixed-methods pilot RCT	29 (15 exercise; 14 control)	Pre-frail or frail adults aged 65 years or older with CKD G3b–G5	Progressive home-based multicomponent exercise versus usual care; 12 weeks

TABLE 3: Characteristics of the Included Studies

CKD: Chronic Kidney Disease; RCT: Randomised Controlled Trial.

The main findings of the included studies, including the effects of exercise and physical activity interventions on HRQoL and other health-related outcomes, are summarised in Table 4.

Study	Primary/secondary outcome measures reported	Main findings
Greenwood SA et al. (2021) [27]	HRQoL: KDQOL-SF 1.3 Physical Component Summary (PCS). Other outcomes: cost-effectiveness and adverse events.	Intradialytic aerobic exercise did not significantly improve HRQoL compared with usual care, although the intervention was considered safe.
Kim S et al. (2022) [28]	Other outcomes: frailty index, dialysis adequacy (Kt/V), and quality of life.	Intradialytic aerobic exercise reduced frailty and improved dialysis adequacy and reported quality of life.
Lin CH et al. (2021) [29]	HRQoL: Health-related quality of life. Other outcomes: depression status and dialytic parameters.	Intradialytic exercise improved HRQoL and reduced depressive symptoms, while dialytic parameters remained unchanged.
Vogiatzaki E et al. (2022) [30]	Other outcomes: Dialysis adequacy and body composition parameters.	The 6-month intradialytic exercise programme improved dialysis adequacy and body composition parameters.
Ortega-Perez de Villar L et al. (2020) [31]	HRQoL: Health-related quality of life. Other outcomes: physical functioning, physical activity level, and adherence.	Both intradialytic and home-based exercise approaches were feasible and associated with improvements in physical activity and physical functioning; HRQoL remained unchanged.
Uchiyama K et al. (2021) [32]	HRQoL: KDQOL-SF domains. Other outcomes: incremental shuttle walk test and aerobic capacity.	Home-based combined aerobic and resistance exercise improved aerobic capacity and selected HRQoL domains in patients with severe CKD.
Uchiyama K et al. (2019) [33]	HRQoL: KDQOL-SF domains. Other outcomes: incremental shuttle walk test and physical function.	Home-based exercise improved physical function and HRQoL in patients receiving peritoneal dialysis.
Watanabe K et al. (2021) [34]	Other outcomes: lumbar spine and femoral neck bone mineral density and physical function.	Home-based exercise was feasible and associated with preservation of bone health and physical function in peritoneal dialysis patients.
Otobe Y et al. (2021) [35]	Other outcomes: Wechsler Memory Scale–Revised, including immediate and delayed recall.	Exercise improved memory function in older adults with stage G3–G4 CKD.
Zhang P et al. (2023) [36]	HRQoL: patient-reported quality-of-life indices. Other outcomes: 30-second chair-stand test, fatigue, and motivation for physical activity.	The nurse-led exercise programme improved selected physical performance outcomes, fatigue, and motivation; no significant between-group differences were observed in quality-of-life questionnaire dimensions.
Kren A, Bogataj Š (2023) [37]	Other outcomes: physical ability and cognitive ability measures.	Combined intradialytic cognitive and physical training improved physical and cognitive abilities in patients with end-stage kidney disease.
Nixon AC et al. (2021) [38]	HRQoL: SF-12. Other outcomes: feasibility, frailty status, and physical function.	Home-based exercise was feasible and acceptable and showed preliminary potential to improve frailty and HRQoL.

TABLE 4: Outcome Measures and Main Findings of the Included Studies

HRQoL: Health-Related Quality of Life; KDQOL-SF: Kidney Disease Quality of Life Short Form; Kt/V: Dialysis Adequacy Measure; SF-12: 12-Item Short Form Health Survey.

Findings According to CKD Population

Haemodialysis

Six studies evaluated exercise interventions among patients receiving haemodialysis [27-31,37]. Interventions included intradialytic aerobic cycling, supervised exercise programmes, comparisons between intradialytic and home-based exercise, and combined cognitive and physical training. Greenwood et al. [27] reported no significant improvement in HRQoL following a six-month intradialytic aerobic exercise programme. In contrast, Kim et al. [28] and Lin et al. [29] reported improvements in selected quality-of-life outcomes following intradialytic exercise. Vogiatzaki et al. [30] reported improvements in dialysis adequacy

and body composition, while Ortega-Perez de Villar et al. [31] found that both intradialytic and home-based exercise approaches were feasible, with improvements in physical activity and physical functioning but no significant change in HRQoL. Kren and Bogataj [37] reported improvements in physical and cognitive abilities following combined cognitive and physical training.

Peritoneal Dialysis

Two studies investigated exercise interventions among patients receiving peritoneal dialysis [33,34]. Uchiyama et al. [33] evaluated a home-based aerobic and resistance exercise programme and reported improvements in physical function and selected HRQoL domains. Watanabe et al. [34] examined a home-based programme incorporating resistance, stretching, and aerobic exercise, reporting findings related to bone health and physical function.

Non-Dialysis-Dependent CKD

Three studies examined exercise interventions in individuals with non-dialysis-dependent or advanced CKD [32,35,38]. Uchiyama et al. [32] reported improvements in aerobic capacity and selected HRQoL domains following a six-month home-based aerobic and resistance exercise programme in patients with stage 4 CKD. Otobe et al. [35] reported improvements in memory function among older adults with stage G3-G4 CKD following a combined exercise intervention. Nixon et al. [38] investigated a multicomponent home-based exercise programme in frail and pre-frail older adults with advanced CKD and reported favourable feasibility and acceptability findings, with preliminary improvements in selected functional and HRQoL outcomes.

Kidney Transplant Recipients

One study evaluated a nurse-led physical exercise programme among kidney transplant recipients [36]. Zhang et al. [36] reported improvements in selected physical performance outcomes, fatigue, and motivation to participate in physical activity. However, no significant between-group differences were observed in the HRQoL questionnaire dimensions.

Effects on HRQoL and Related Outcomes

The reported effects of exercise interventions varied across the included studies and outcome domains. Some trials demonstrated improvements in selected HRQoL domains, physical function, frailty, depressive symptoms, or cognitive performance, whereas others reported no significant differences in HRQoL. Improvements in physical function and other related health outcomes were reported in several studies; however, these findings did not consistently correspond to improvements in patient-reported HRQoL. Differences in assessment instruments and intervention characteristics limited direct comparisons across trials.

The statistical findings varied across the included studies, reflecting differences in study populations, exercise intervention protocols, outcome assessment instruments, and statistical reporting methods. Where available, individual study-level statistical results, including effect estimates, confidence intervals, and P-values, were considered when summarising the findings. However, differences in outcome measures and reporting approaches limited direct quantitative comparisons between studies. Consequently, the findings were synthesised narratively rather than statistically pooled.

Risk of Bias Assessment

A risk-of-bias evaluation was performed for each of the 12 included RCTs to support the credibility of the synthesised data, using the RoB 2 tool. The risk-of-bias assessment of the included RCTs using the Cochrane Risk of Bias 2 (RoB 2) tool is presented in Table *5*.

Study	Bias arising from the randomisation process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcome	Bias in selection of the reported result	Overall risk of bias
Greenwood SA et al. [27]	Low risk	Low risk	Low risk	Some concerns	Some concerns	Some concerns
Kim S et al. [28]	Low risk	Some concerns	Low risk	Some concerns	Some concerns	Some concerns
Lin CH et al. [29]	Low risk	Low risk	Low risk	Some concerns	Some concerns	Some concerns
Vogiatzaki E et al. [30]	Low risk	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
Ortega-Perez de Villar L et al. [31]	Some concerns	Some concerns	Some concerns	High risk	Some concerns	High risk
Uchiyama K et al. [32]	Low risk	Low risk	Low risk	Some concerns	Some concerns	Some concerns
Uchiyama K et al. [33]	Low risk	Low risk	Low risk	Some concerns	Some concerns	Some concerns
Watanabe K et al. [34]	Low risk	Low risk	Low risk	Some concerns	Some concerns	Some concerns
Otobe Y et al. [35]	Low risk	Low risk	Some concerns	Some concerns	Some concerns	Some concerns
Zhang P et al. [36]	Some concerns	Some concerns	Some concerns	High risk	Some concerns	High risk
Kren A, Bogataj Š [37]	Low risk	Low risk	Low risk	Some concerns	Some concerns	Some concerns
Nixon AC et al. [38]	Some concerns	Low risk	Some concerns	Some concerns	Some concerns	Some concerns

TABLE 5: Risk of Bias Assessment of the Included Randomised Controlled Trials Using the Cochrane RoB 2 Tool

The risk-of-bias assessment indicated variability across the included studies. Some concerns were identified in the randomisation process and missing outcome data in several trials, while concerns regarding deviations from intended interventions and outcome measurement were also observed. These limitations should be considered when interpreting the findings, particularly because blinding participants and personnel is challenging in exercise-based interventions and HRQoL is frequently assessed using patient-reported measures.

The majority of included studies were classified as having some concerns regarding the overall risk of bias. Two studies, Ortega-Perez de Villar et al. [31] and Zhang et al. [36], were assessed as having a high overall risk of bias, primarily due to concerns related to outcome measurement and other methodological limitations.

Discussion

This systematic review examined the effects of exercise and physical activity interventions on HRQoL and related health outcomes among individuals with CKD. The 12 included RCTs evaluated different exercise approaches across haemodialysis, peritoneal dialysis, non-dialysis CKD, and kidney transplantation populations. Findings were variable, with improvements reported in selected HRQoL domains and related physical, functional, and psychological outcomes, while some trials demonstrated no significant HRQoL improvement. Differences in populations, intervention characteristics, and outcome measures limit the consistency and comparability of the available evidence [27-38].

The effects of exercise on HRQoL were not consistent across all included trials. Greenwood et al. [27]

reported no significant improvement in HRQoL following intradialytic aerobic cycling compared with usual care. In contrast, Kim et al. [28] reported improvements in quality of life alongside reductions in frailty, while Lin et al. [29] demonstrated improvements in HRQoL and depressive symptoms following a 12-week intradialytic exercise intervention. Vogiatzaki et al. [30] reported improvements in dialysis adequacy and body composition following a six-month intradialytic exercise programme, although these outcomes should be distinguished from direct HRQoL improvements. Differences in exercise intensity, frequency, duration, supervision, adherence, baseline functional status, and the instruments used to assess HRQoL may partly explain the variation in findings across these studies.

Evidence from non-dialysis and home-based CKD populations was also encouraging. Home-based aerobic and resistance exercise programmes demonstrated improvements in aerobic capacity and selected HRQoL domains among individuals with stage 4 CKD [32] and improvements in physical function and HRQoL among individuals receiving peritoneal dialysis [33]. Watanabe et al. [34] reported findings related to the preservation of bone health and physical function following a home-based exercise programme in peritoneal dialysis patients. In addition, a home-based multicomponent exercise programme was found to be feasible and acceptable among frail and pre-frail older adults with advanced CKD, with preliminary indications of potential benefits in frailty and HRQoL [38]. Collectively, these findings suggest that appropriately designed exercise programmes may support physical function and functional independence across different CKD populations.

The mode of exercise delivery may also influence participation and clinical outcomes. Home-based programmes may offer greater flexibility and accessibility, whereas intradialytic exercise can be incorporated into routine dialysis sessions. Ortega-Perez de Villar et al. [31] compared intradialytic and home-based exercise approaches and reported that both were feasible, with improvements in physical activity and physical function; however, HRQoL did not significantly improve. Similarly, combined cognitive and physical training delivered during dialysis demonstrated potential benefits for physical and cognitive abilities in individuals with end-stage kidney disease [37]. These findings suggest that exercise prescription should be individualised according to CKD stage, treatment modality, functional capacity, accessibility, safety considerations, and patient preferences.

Several included studies also investigated outcomes related to, but distinct from, HRQoL. Otobe et al. [35] reported improvements in memory function following an exercise intervention among older adults with stage G3-G4 CKD. In kidney transplant recipients, Zhang et al. [36] reported improvements in selected physical performance outcomes, fatigue, and motivation to participate in physical activity; however, no significant between-group differences were observed in HRQoL questionnaire dimensions. These findings highlight the importance of distinguishing improvements in specific physical or cognitive outcomes from direct improvements in HRQoL. Nevertheless, improvements in physical function, cognitive performance, and functional independence may contribute to aspects of patients' overall well-being and daily participation.

Despite these encouraging findings, the evidence should be interpreted cautiously. Considerable heterogeneity was observed across the included studies in participant characteristics, CKD stage, treatment modality, exercise type, intensity, frequency, duration, supervision, and sample size [27-38]. Furthermore, although several trials assessed HRQoL directly, other studies primarily investigated outcomes such as dialysis adequacy, body composition, bone health, frailty, physical performance, or cognitive function [30,34,35,37]. Consequently, improvements in these related outcomes should not automatically be interpreted as direct improvements in HRQoL. Differences in the use of generic and kidney disease-specific HRQoL instruments and variations in statistical reporting also limited direct comparisons across studies. Moreover, exercise intensity and delivery characteristics were not consistently reported, preventing reliable comparisons between home-based and supervised programmes or between different exercise intensities. Therefore, the available evidence does not establish the superiority of a particular exercise setting, intensity, or intervention modality. The findings should instead be interpreted in the context of individual study results and their methodological limitations.

The methodological quality of the included trials also warrants consideration. Although most studies presented some concerns regarding risk of bias, two studies were rated as having an overall high risk of bias [31,36]. Potential methodological limitations, including incomplete outcome data and difficulties with blinding in exercise interventions, may have influenced the reliability of some reported findings. In addition, several trials had relatively small sample sizes or were designed primarily as pilot or feasibility studies. These limitations may reduce the certainty and generalisability of the findings. Future research should therefore include adequately powered RCTs with clearly defined and reproducible exercise programmes, standardised reporting of exercise intensity and adherence, and consistent use of validated HRQoL outcome measures.

Comparison With Existing Literature

The findings of this review should be considered in the context of previous evidence syntheses examining exercise interventions in patients with CKD. The umbrella review by Zhang et al. [10] evaluated the

therapeutic effects of exercise across several health outcomes in CKD, including physical fitness, dialysis-related outcomes, and HRQoL. Although that review provided a broad overview of the potential benefits of exercise, the present review specifically focused on RCTs reporting HRQoL and considered evidence across different CKD populations and treatment settings, including non-dialysis CKD, haemodialysis, peritoneal dialysis, and kidney transplantation.

A systematic review and meta-analysis by Traise et al. [23] specifically examined exercise training and quality of life in individuals with CKD requiring dialysis. Their pooled findings indicated improvements in physical and mental component summary scores; however, the effects varied according to the HRQoL instrument used, with no statistically significant improvement reported for the kidney disease-specific quality-of-life measure. These findings highlight the importance of considering the specific HRQoL instrument and outcome domain when interpreting the effects of exercise in dialysis populations. In comparison, the present review included both dialysis and non-dialysis populations and found variable effects across studies, with some trials reporting improvements in HRQoL and others showing no significant changes.

The 2025 review by Young et al. [9] discussed the evidence for physical activity in kidney disease and highlighted the importance of translating exercise evidence into clinical practice. The present review complements this broader perspective by examining intervention-based RCT evidence with HRQoL as the primary outcome. Additionally, the review by Redondo-Saenz et al. [24], focusing on exercise interventions and HRQoL in predialysis CKD, provides more recent context for the potential effects of exercise in non-dialysis populations. However, its population-specific focus differs from the broader range of CKD treatment settings considered in the present review.

Differences between the findings of the present review and previous evidence syntheses may be explained by variations in CKD stage, dialysis status, exercise modality, intervention duration, supervision, sample size, and HRQoL assessment instruments. Furthermore, the present review used a predefined RCT-based eligibility framework and a qualitative synthesis rather than pooling results across clinically and methodologically heterogeneous studies. Collectively, these comparisons suggest that exercise may improve selected HRQoL domains in some CKD populations, but the magnitude and consistency of these effects remain uncertain. Further adequately powered RCTs using standardised HRQoL measures and longer follow-up periods are needed.

Clinical Implications

The findings suggest that structured physical activity and exercise-based rehabilitation may contribute to improvements in selected HRQoL domains among individuals with CKD. Exercise programmes may be considered as part of individualised rehabilitation, taking into account disease stage, treatment modality, functional capacity, and patient tolerance. Appropriate supervision and clinical monitoring are important when implementing exercise interventions in this population.

Limitations

This review has several limitations. First, the literature search was restricted to English-language RCTs, which may have introduced language bias and resulted in the exclusion of potentially relevant studies published in other languages. The requirement for an explicit HRQoL outcome may also have excluded relevant evidence reported in qualitative studies exploring barriers to exercise participation and implementation. Second, the included studies primarily reported short- to medium-term follow-up (12 weeks to six months), limiting conclusions regarding the long-term sustainability of improvements in HRQoL and their potential effects on clinical outcomes such as hospitalisation and mortality. Third, considerable heterogeneity in study populations, exercise modalities, supervision intensity, intervention duration, and HRQoL assessment instruments precluded meta-analysis and limited direct comparisons across studies. Additionally, several included trials had relatively small sample sizes, and two studies were rated as having an overall high risk of bias, which may reduce the certainty of the findings. The literature search did not include Embase, an important database for biomedical research. Therefore, some potentially relevant studies may not have been identified, and the possibility of database-related selection bias cannot be excluded. Finally, the limited number of studies in certain CKD populations restricts the generalisability of the findings across different disease stages and treatment settings.

Future Directions

Future research should prioritise adequately powered RCTs with standardised exercise protocols and validated HRQoL assessment instruments. Longer follow-up periods are needed to evaluate the sustainability of intervention effects and their potential association with clinical outcomes. Further studies should address under-represented CKD populations, particularly patients receiving peritoneal dialysis and kidney transplant recipients, to strengthen the generalisability of the evidence.

Conclusions

This systematic review suggests that structured exercise and physical activity interventions may improve selected HRQoL domains among individuals with CKD across different treatment settings. However, heterogeneity in study populations, interventions, and outcome measures limits the comparability and certainty of the findings. Further high-quality RCTs with standardised outcome measures and longer follow-up are needed to establish the long-term benefits of exercise-based interventions in this population.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Sandeep Shinde, Sharvari N. Patil, Chetana A. Pawar, Manoj Ambali, Axita Vani, Anand G. Joshi

Acquisition, analysis, or interpretation of data: Sandeep Shinde, Sharvari N. Patil, Chetana A. Pawar, Manoj Ambali, Axita Vani, Anand G. Joshi

Drafting of the manuscript: Sandeep Shinde, Sharvari N. Patil, Chetana A. Pawar, Manoj Ambali, Axita Vani, Anand G. Joshi

Critical review of the manuscript for important intellectual content: Sandeep Shinde, Sharvari N. Patil, Chetana A. Pawar, Manoj Ambali, Axita Vani, Anand G. Joshi

Supervision: Sandeep Shinde, Sharvari N. Patil, Chetana A. Pawar, Manoj Ambali, Axita Vani, Anand G. Joshi

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