Review Article

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Restoring Mobility Post Renal Transplant: A Review

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Abstract:

This literature review aimed to synthesize the current evidence on the effectiveness of physiotherapy and exercise-based rehabilitation programs in restoring mobility, strength, and overall functional capacity among renal transplant recipients. A comprehensive literature search was performed using PubMed, Cochrane Library, and Google Scholar with keywords including "Mobility restoration", "Renal transplantation", and "Rehabilitation". Thirteen studies published after 2015, including randomized controlled trials and systematic reviews, were included based on defined eligibility criteria.

Most studies reported significant improvements in maximal oxygen uptake (VO2 peak), muscle strength, and walking distance among participants who underwent structured exercise interventions. Quality of life also improved, especially when exercise was combined with dietary and behavioral counseling. Metabolic outcomes such as lipid profiles and renal function markers showed mixed results. All studies confirmed that physiotherapy interventions were safe and well-tolerated. Physiotherapy-based rehabilitation appears beneficial in enhancing physical function and quality of life in kidney transplant recipients. More robust, long-term trials are needed to validate its effects on metabolic outcomes and graft survival.

Keywords: mobility restoration, rehabilitation, renal transplantation

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Introduction

A sedentary lifestyle can adversely impact individuals across all stages of chronic kidney disease (CKD), including kidney transplant recipients, thereby potentially reducing overall survival outcomes. Both CKD patients and kidney transplant recipients are at a markedly elevated risk for cardiovascular disease and mortality relative to the general population, highlighting the need for targeted interventions to mitigate these risks[1]. Previous studies have found that individuals with chronic renal failure are less able to actively participate in physical activity[2,3,4]. Additionally, low physical activity is considered a significant modifiable risk factor for mortality in patients with end-stage renal disease[5].

Although kidney transplants are beneficial for end-stage renal disease, postoperative cardiopulmonary and musculoskeletal dysfunctions are frequent[6,7,8]. High cardiovascular risk has been attributed to numerous pathologic alterations associated with CKD, including left ventricular hypertrophy, arterial hypertension, endothelial dysfunction, and coronary artery calcification[9].

Considering the persistent functional limitations and cardiovascular risks, there is a growing need to synthesize current evidence on physiotherapy interventions aimed at restoring mobility and strength in kidney transplant recipients. This literature review seeks to evaluate the role, safety, and effectiveness of exercise-based rehabilitation in improving functional outcomes and quality of life (QOL) in this population.

A literature review was conducted using PubMed, Cochrane Library, and Google Scholar. Keywords included: Mobility restoration, renal transplantation, and rehabilitation. Inclusion criteria for this review were systematic reviews, meta-analyses, and randomized controlled trials (RCTs) published after 2015, studies published in the English language, studies involving adult renal transplant recipients, and articles that reported outcomes related to mobility, functional capacity, quality of life, or metabolic parameters. Studies outside these parameters were excluded. From an initial 100 articles, 13 were ultimately selected for detailed analysis after full-text screening.

Functional recovery and strength

RCTs highlighted improvements in maximal oxygen uptake (VO2 peak), 6-minute walk distance (6MWD), and muscle strength following early structured physiotherapy[10,11]. Some studies have noted that early interventions help preserve respiratory muscle strength but have a limited effect on walking capacity[12]. Early physiotherapy preserved respiratory muscle strength but did not significantly improve peripheral muscle strength or walking capacity[12]. Exercise improved functional performance, 6-minute walk test (6MWT) distance, muscle strength, and fatigue reduction[10]. VO2 peak, 6MWT, and sit-to-stand performance improved with structured exercise[11]. Aerobic and resistance training improved muscle strength and physical function[13]. VO2 peak and aerobic capacity were improved with resistance and aerobic training[14]. Graded exercise training led to improved strength (+9.27kg) and functional capacity (+255m)[15].

Quality of life outcomes

Structured exercise and combined lifestyle interventions led to significant improvements in health-related quality of life (HRQoL) [16,17]. Improvements in both physical and mental well-being were consistently observed, particularly when nutritional counseling was included as part of the intervention[17,18]. Lifestyle modifications, especially those combining structured exercise with dietary changes, were found to significantly enhance overall quality of life[17,18]. Structured exercise led to enhanced HRQoL and faster recovery[16]. There were positive trends in QOL, including energy levels and mental well-being[19]. The Active Care After Renal Transplantation (ACT) trial showed significant

improvement in daily activity and energy expenditure[18]. There were short-term gains in physical functioning from the exercise group, but the long-term effects were inconclusive[17].

Metabolic and Cardiovascular markers

Exercise training led to modest improvements in High-Density Lipoprotein (HDL) levels and arterial stiffness, but showed inconsistent or minimal effects on kidney function, blood pressure, and blood glucose levels across multiple studies[14]. Combined lifestyle interventions were associated with improvements in lipid profiles, blood pressure, and glucose metabolism[18]. A systematic review reported increased HDL levels and modest reductions in creatinine[14]. However, improvements in blood pressure, kidney function, and metabolic syndrome were found to be limited or inconsistent across studies[13]. The ACT trial showed reduced fat mass, improved fat tissue index, and estimated glomerular filtration rate (eGFR)[18]. Improvements in arterial stiffness and VO2 peak were reported in the meta-analysis[13].

Safety and feasibility

All the included studies reported that the exercise interventions were safe and feasible with no significant adverse events[10,11,13]. Adherence to the exercise programs was generally high among participants[11,13]. All the interventions were reported to be safe with no adverse effects[10]. High adherence and good tolerability were reported in the RCT conducted by Knobbe et al.[13]. Exercise and dietary interventions were feasible and well accepted[17,18].

A summary of the articles included in the review of Physiotherapy and Exercise Interventions Post Renal Transplant can be found in Table 1.

Rehabilitation following kidney transplantation is gaining attention as a vital component of the long-term recovery and improved quality of life. However, this area remains underexplored, with relatively few high-quality studies offering robust evidence of the efficacy, safety, and optimal design of rehabilitation programs for kidney transplant recipients[20].

Evidence from multiple studies highlights the importance of structured exercise and lifestyle interventions in improving cardiorespiratory fitness, physical function, and QOL among kidney transplant recipients[10,18,20]. Most studies consistently report improvements in VO2 peak, 6MWD, muscle strength, and self-reported physical functioning following aerobic and resistance training interventions[18,20].

Despite these promising findings, the results remain heterogeneous, with significant variations in intervention type, duration, intensity, and outcome measures[10,18]. For instance, some studies observed improvements in fatigue levels, mental well-being, and body composition, whereas others reported no significant effects on kidney function, blood pressure, or long-term HRQoL[10,11,18]. In particular, short-term improvements in HRQoL were noted, but the long-term benefits remain uncertain, as highlighted in trials with follow-ups extending up to 15 months[20,21].

One notable randomized controlled trial (RCT) conducted during hospitalization found that early physiotherapy preserved respiratory muscle strength, but it had no significant effect on functional walking capacity or peripheral muscular strength[22]. This suggests that the timing of intervention (inpatient vs outpatient) and the targeted outcomes may influence the degree of benefit observed[22].

Systematic reviews and meta-analyses further support the role of exercise training in enhancing overall health and reducing factors contributing to heart disease[10–12,18,20]. Improvements in arterial stiffness and aerobic capacity have been documented, with minimal adverse effects reported[11,12]. Exercise is believed to improve cardiovascular health through several physiological

Table 1 Summary of the articles included in the review of physiotherapy and exercise interventions post renal transplant

No.	Study title	Design & sample	Intervention	Outcomes	Key findings
1	Impact of an early physiotherapy after kidney transplant[22]	RCT, n=63 (Exp: 30, Ctrl: 33)	• Early physiotherapy vs. standard care. • Intervention– supervised daily physiotherapy: breathing, walking, step–ups; stair climbing and resistance from day 2. • Frequency and duration– 30 min/day from day 1 to discharge (daily) • Intensity– moderate intensity per patient tolerance; progressive overload in walking & stair reps; 2 min rest between sets.	Respiratory muscle strength, peripheral strength, functional capacity	↑ Respiratory muscle strength (p–value <0.001); No sig. diff. in functional or peripheral muscle strength
2	Lifestyle intervention to improve QOL& weight gain after renal transplant[14]	Multicenter RCT, n=219	• Usual care vs. exercise vs. exercise+nutrition. • Intervention– daily lifestyle intervention with exercise (walking, resistance bands, counseling)±diet • Frequency and duration– daily during inpatient rehabilitation phase (approx 8 weeks posttransplant) • Intensity– Moderate intensity aerobic and resistance; progressive goal–setting and counseling plans	QOL, weight gain, cardiometabolic health	↑ QOL, ↓ weight (exercise and diet); ↑ performance (exercise only); structured interventions are beneficial
3	Effect of exercise training intervention in kidney transplant recipients (systematic review)[20]	Meta–analysis of 16 RCTs, n=827	• Exercise–based interventions. • Intervention– aerobic, resistance, or combined programs (in individual RCTs) • Frequency and duration– • Intensity– 20–60 min per session; 2–7×/week; median duration 14 weeks moderate intensity aerobic (>60% HR max/VO_2 peak); resistance ~35–70% 1RM; individualized progression	VO2 peak, 6MWT, HDL, creatinine	↑ VO2 peak, HDL, strength; ↓ creatinine; No effect on BP/kidney function
4	Systematic review of exercise training in kidney transplant recipients[18]	Review, 24 studies, n=654	• Aerobic, resistance, and combined training. • Intervention– varied RCT interventions including aerobic (treadmill/cycling), resistance training • Frequency and duration– most RCTs used 12–week programs, 3 sessions/week, 30–45 min/session • Intensity– moderate intensity (e.g. 60–70% HRmax), progressing resistance	VO2 peak, HRmax, lipid profile, QOL	↑ Aerobic capacity, strength, QOL; No sig. changes in lipid/glucose/body comp
5	Clinical practice guidelines for renal rehab[10]	Systematic review	• Exercise+lifestyle modification. based on multiple protocols: combined aerobic/resistance, ≥2 sessions/week, aerobic >60% HRmax; sessions typically 4–12 weeks, frequency 3–7/week ;Aerobic >60% HRmax or VO_2max, resistance >60% 1RM	Physical function, QOL, metabolic/cardiac outcomes	Supports integration of structured exercise in standard care

Table 1 (continued)

No.	Study title	Design & sample	Intervention	Outcomes	Key findings
6	Physical activity & intermediate outcomes: a systematic review[21]	Review, 21 studies	• Structured physical activity. • Intervention– combined aerobic+resistance programs (center– or home–based, tailored) • Frequency and duration– 20–60 min/session; 2–3×/week over 3–6 months • Intensity– moderate intensity, individualized & progressive	Strength, aerobic capacity, metabolic/kidney/immune	↑ Strength (10.0–22.0%), aerobic fitness (10.0–114.0%); minimal other effects
7	QOL optimization through structured Exercise[16]	Systematic review of 5 RCTs	• Structured exercise programs. • Intervention– structured exercise training (combining aerobic and resistance elements) across 5 RCTs • Frequency and duration– typically 30–60 min/session, 3–5 times/week as per guidelines • Intensity– moderate intensity, tailored to individual capacity; resistance at ≥60% 1RM	Postoperative recovery, mental health, QOL	↑ Mental well–being, QOL; faster recovery post–transplant
8	Exercise efficacy in KTRs (meta–analysis)[11]	Meta–analysis of 6 RCTs	• Exercise interventions– aerobic, resistance, or combined programs • Frequency and duration– 20–60 min/session; 2–3×/week; duration ~3–6 months • Intensity– moderate intensity (often by standardized protocols); resistance prioritized	VO2 peak, QOL, renal function	↑ VO2 peak (+2.42), QOL (+7.23); no sig. improvement in renal function
9	Exercise & Cardiovascular risk in KTRs: a systematic review[12]	Systematic review & meta–analysis, 12 RCTs	• Exercise Intervention– aerobic and/or resistance training aimed at CVD risk reduction • Frequency and duration– sessions around 30–60 min; frequency 2–5×/week; ~12 weeks or more • Intensity– moderate intensity (e.g., HR–based, RPE); tailored per individual	BP, lipids, BMI, VO2 peak, QOL	↓ Arterial stiffness (p–value=0.03), ↑ VO2 peak & QOL; no sig. impact on BP, BMI, renal/metabolic function
10	Exercise in solid organ transplants: a systematic review[15]	Systematic review	• Intervention– structured exercise (mostly combined aerobic+resistance), few combined with diet • Frequency and duration– varies by transplant type; typically, ≥12 weeks, ≥3×/week • Intensity– Moderate intensity	VO2 peak, strength, QOL	↑ Strength, function, aerobic capacity, QOL; safe and feasible
11	Impact of organized physical activity program & body composition in CKD and in kidney transplant recipients[17]	Multicenter RCT, n=221	• Exercise intervention– habitual activity and structured physical activity including mobility drills and resistance • Frequency and duration– implementation over several weeks/months; frequency often daily mobility + 2–3× resistance/week • Intensity– graded mobility and strengthening at patient tolerance	HRQoL (SF–36), body composition	Short–term ↑ HRQoL (p–value=0.018); long–term unclear; both interventions safe

Table 1 (continued)

No.	Study title	Design & sample	Intervention	Outcomes	Key findings
12	Effect of graded exercise post-transplant[19]	RCT, n=104	• Intervention- early, graded exercise training: walking, quadriceps resistance, functional tasks • Frequency and duration- 12 weeks; ~3×/ week supervised or guided • Intensity- moderate progression; intensity ramped as tolerated	6MWT, strength, fatigue	↑ 6MWT (+255m), strength (+9.27kg), ↓ fatigue; sig. better than control
13	Active care after renal transplantation: an RCT (diet+exercise)[13]	RCT, n=39 (15 CKD, 24 KTRs)	• Intervention- combined aerobic+resistance training with dietary counseling • Frequency and duration- typically daily during initial phase, then taper to 3–5×/week; ~12 weeks or longer • Intensity- moderate intensity (e.g., HR targets, resistance load via bands)	Daily activity, body composition, eGFR	↑ Activity (+74 min/day), ↓ fat mass, ↑ eGFR; supports long-term integration

↑=increase, ↓=decrease, RCT=randomized controlled trial, Exp=experimental, CTRL=control, QOL=quality of life, vs.=versus, VO_2 peak=peak oxygen uptake, HDL=high-density Lipoprotein, BP=blood pressure, 6MWT=6 minute walk test HRmax=maximum heart rate, KTRs=kidney transplant recipients BMI=body mass index, HRQoL (SF-36)=health-related quality of life (short form-36 health survey), PA=physical activity, eGFR=estimated glomerular filtration rate, Sig.=significant, Diff=difference, CKD=chronic kidney disease

mechanisms, including enhanced endothelial function, reduced systemic inflammation, improved autonomic regulation, and decreased arterial stiffness[10,11,13]. Aerobic exercise stimulates nitric oxide production, leading to vasodilation and improved blood flow, while resistance training promotes muscle protein synthesis, counters muscle wasting, and improves glucose uptake[14,15]. These adaptations contribute to increased VO2 peak, better functional performance, and metabolic balance[10,11,13,14].

However, the evidence on improvements in metabolic parameters (such as blood glucose and lipid levels) and graft function is mixed and often statistically nonsignificant[11,12,18]. Overall, the available literature supports the feasibility, safety, and partial efficacy of structured rehabilitation in enhancing physical outcomes and QOL post-transplantation[10,16,18,20]. Nonetheless, the scarcity of long-term, large-scale RCTs limits the generalizability of findings[10,16,20,21]. Furthermore, most studies are concentrated in high-income countries, creating a need for more inclusive research that addresses regional and socioeconomic diversity[10,15,16].

Conclusion

Physiotherapy-based rehabilitation demonstrates significant potential in improving physical function, cardiovascular fitness, and quality of life among kidney transplant recipients. Evidence from the reviewed studies suggests that combined aerobic and resistance training is the most effective approach. The optimal exercise programs typically involve moderate-intensity training, performed 3 to 5 times per week, with each session lasting 30 to 60 minutes. These programs were found to be safe, feasible, and well-tolerated across different clinical settings. Improvements were consistently noted in VO2 peak, muscle strength, 6-minute walk distance, and health-related quality of life, particularly when exercise was initiated early and combined with dietary and behavioral interventions. To better understand the long-term impact, especially on metabolic health and graft longevity, further high-quality, large-scale studies are essential. Incorporating structured physiotherapy into routine post-transplant care could play a vital role in enhancing patient outcomes and overall recovery.

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