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The Role of Physical Activity and Exercise Training in Patients Undergoing Hemodialysis

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ABSTRACT

Purpose: Patients undergoing hemodialysis experience muscle weakness and limited exercise ability, making it difficult to perform everyday activities. This article discusses the impact of physical activity and exercise training on these patients' physical function and health-related quality of life, as well as their potential preparation for kidney transplantation. **Materials and Methods:** We reviewed the selected literature available in PubMed/MEDLINE, the Cochrane Library, and Scopus. The search terms used for this review were: hemodialysis, physical activity, exercise training, and kidney transplantation. Most of the articles were systematic reviews, meta-analyses, randomized controlled trials, and clinical practice guidelines. **Results:** Exercise programs during dialysis sessions improved patients' functional ability and quality of life. Some studies also found small reductions in blood pressure and improvements in lipid levels among patients who exercised during dialysis. Results for dialysis adequacy and inflammation also differed across studies. Exercise did not appear to increase adverse-event rates. Patients awaiting kidney transplantation who exercised during dialysis sessions walked farther in the six-minute walk test than those who did not exercise during dialysis. Patients who exercised during dialysis sessions also showed improvements in handgrip strength and body composition measurements. **Conclusions:** Exercise customized to the patient's condition, including training performed during dialysis sessions, could become a regular part of hemodialysis treatment. Making these programs more widely available will require trained staff, clear patient information, and practical delivery procedures.

Keywords: Hemodialysis; Exercise; Intradialytic Exercise; Quality of Life; Kidney Transplantation

1. INTRODUCTION

Patients starting hemodialysis after advanced chronic kidney disease often have a high symptom burden, poor physical performance, limited exercise capacity, and reduced health-related quality of life (Deligiannis et al., 2021; Kim et al., 2014;

O'Hare et al., 2003). Less active patients tend to have poorer physical function. Low daily activity is also associated with higher cardiovascular risk and shorter survival (Kim et al., 2014; Matsuzawa et al., 2012). In addition to other factors that contribute to muscle weakness and reduced cardiovascular function, aging itself contributes to both conditions. Retained uremic toxins and the inflammation that results from the disease can both impair muscle function. Anemia and metabolic acidosis leave dialysis patients with little circulatory reserve to handle the physical strain of treatment (Deligiannis et al., 2021; Kim et al., 2014). Several ways can measure an individual's level of physical ability. For instance, walking is a form of basic activity. However, to improve fitness levels, the activity must have a goal and structure (Dasso, 2019).

In hemodialysis care, a patient's report of being active does not establish that they follow an exercise program. Walking and household tasks count as physical activity because they involve movement generated by skeletal muscles. However, people need to exercise, follow a plan, and repeat it to maintain or improve fitness (Dasso, 2019). Higher activity has been associated with better quality of life in patients receiving hemodialysis (Filipic et al., 2021; Hu et al., 2024). A patient may manage household chores yet exercise too little, or at too low an intensity, to improve cardiorespiratory fitness or performance on standardized physical tests (Bakaloudi et al., 2020; Kim et al., 2014).

Studies of structured exercise in hemodialysis patients have found improvements in skills such as walking performance and muscle strength (Bernier-Jean et al., 2022; Hu et al., 2023; Ren et al., 2023). Most intradialytic programs are scheduled during the first half of the session, when patients tend to be more hemodynamically stable. The benefit is that the training uses time already spent in the dialysis unit and can be supervised directly by staff (Anding-Rost et al., 2023; Clyne and Anding-Rost, 2021). Even so, many centers do not routinely offer it. Patients who exercise on their own usually opt for light walking rather than a structured training program, so there is a need for all sorts of programs. (Hu et al., 2024; Li et al., 2021).

Unlike the general population of patients undergoing hemodialysis, transplant candidates must have sufficient physical function to survive the physiological stress of surgery and immunosuppression. The physical function of patients before undergoing a kidney transplant has been more and more acknowledged as a factor that affects both their placement onto the waiting list for transplantation and their recovery following transplantation (Michou et al., 2023; Yang et al., 2020). So, incorporating rehabilitation programs for dialysis patients into pre-transplant conditioning protocols is increasingly important in nephrology.

The purpose of this review was to provide an overview of the literature related to physical activity and exercise among adults who receive maintenance hemodialysis. This review focused on intradialytic exercise and its use among patients preparing for kidney transplantation. The review also examined the relationship between physical activity and quality of life among these patients. In addition, the review examined changes in physical performance, body composition, cardiovascular and metabolic measures, dialysis adequacy, and inflammatory markers resulting from physical activity among patients undergoing hemodialysis. Finally, the review discussed the physical function of these patients before undergoing kidney transplantation, as well as the challenges associated with implementing physical activity programs into the routine care of patients with end-stage renal disease undergoing hemodialysis.

2. REVIEW METHODS

We conducted a literature search using databases such as PubMed, the Cochrane Library, and Scopus. Also, references from identified articles were searched for extra studies and clinical guidelines published by organizations such as the KDIGO initiative. Terms were combined with Boolean operators and included "hemodialysis" or "haemodialysis"; "physical activity"; "exercise training"; "intradialytic exercise"; "resistance exercise"; "aerobic exercise"; "quality of life"; "functional capacity"; "frailty"; "sarcopenia"; "muscle strength"; "body composition"; "lipid profile"; "cardiovascular"; "inflammation"; "dialysis adequacy"; "Kt/V"; and "kidney transplantation" or "kidney transplant candidates". No fixed publication-date limit was applied. We focused mainly on work from the past 10-15 years, especially the most recent five years. Still, we retained earlier cohort studies that established the association between sedentary behavior and mortality among dialysis patients.

This article is a narrative review, in keeping with published guidance on the appropriate use of each format. We did not use a preregistered protocol or conduct a meta-analysis. We chose a descriptive approach because the evidence spans functional, psychosocial, biochemical, and dialysis-related outcomes and includes mechanistic work, randomized trials, observational studies, and clinical guidelines. It also allowed us to consider evidence for kidney transplant candidates alongside studies of the wider hemodialysis population.

Information sources and search strategy

A literature review was conducted in the PubMed database, covering English- language publications from 2015 to 2026. Our review included clinical trials, systematic reviews, and meta-analyses. Exclusion criteria: lack of full text, publications in languages other than English, pediatric population trials. During the selection, we made decisions based on titles, abstracts, and full texts. We grouped the results by therapy type. The article screening process followed the PRISMA guidelines (Figure 1).

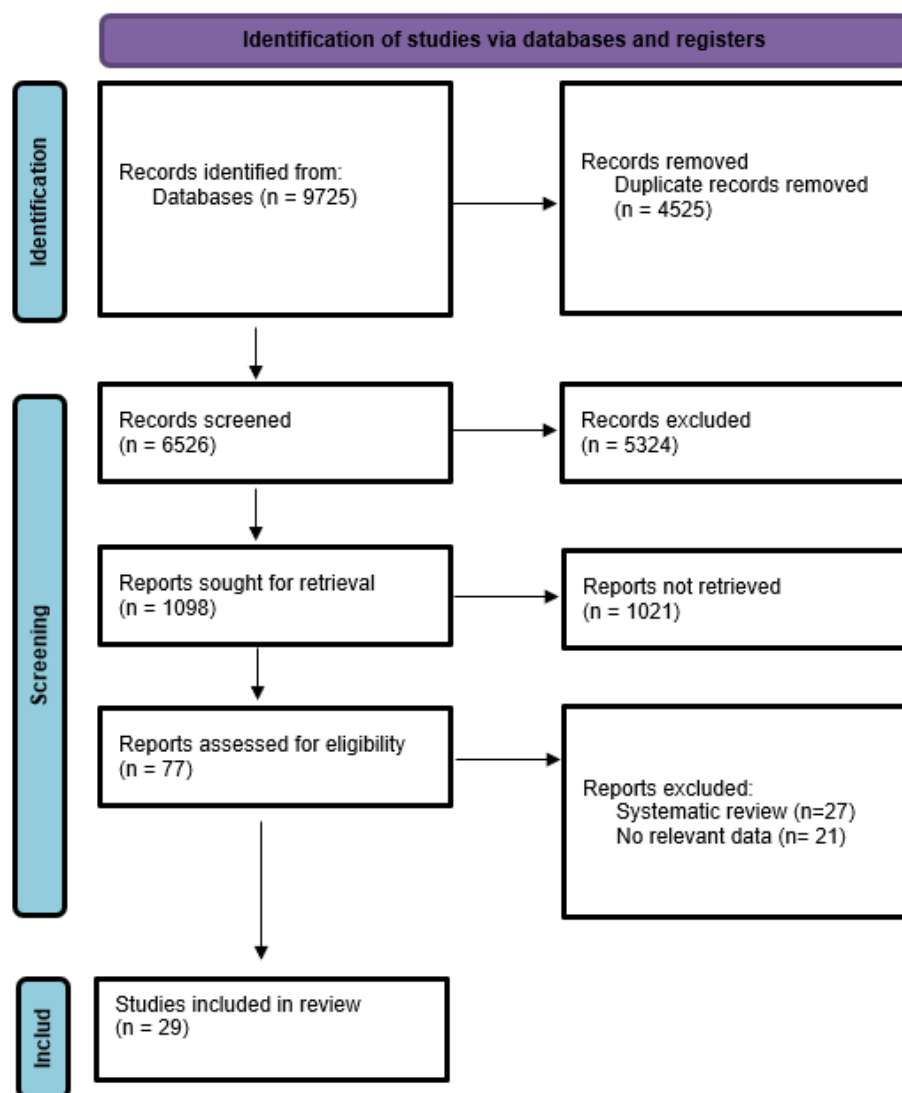


Figure 1. PRISMA flow diagram.

Inclusion and exclusion criteria

For this article, participants had to be at least 18 years old and receiving maintenance hemodialysis. Peer-reviewed articles were limited to those published in English. The transplantation section included studies of patients undergoing assessment for a kidney transplant or already on the waiting list. We prioritized systematic reviews and meta-analyses of randomized trials. We also included individual randomized trials, preferring larger trials conducted at multiple centers. We also included prospective cohort studies and cross-sectional studies to determine physical activity levels in patients with ESRD and identify barriers to physical activity in these populations. We consulted international guidelines for physical activity to interpret the clinical importance of the findings. We excluded studies involving children, animals, or in vitro experiments. Studies on peritoneal dialysis were included only if there was a control group undergoing hemodialysis.

3. RESULTS

Physical activity levels and quality of life

Patients undergoing hemodialysis are less physically active than healthy adults. Less physically active patients also tend to have poorer physical function and quality of life (Filipic et al., 2021). For instance, Filipic et al., (2021) found that higher HAP scores were associated with higher physical-domain quality of life among patients undergoing dialysis compared with healthy adults. After adjusting for other variables, patients undergoing hemodialysis had 32% of their physical component quality-of-life scores explained by their level of physical activity. In comparison, physical activity levels explained only 15% of the physical component of quality of life among healthy adults (Gregory and Denniss, 2018).

Most patients fell short of the World Health Organization's physical activity recommendations: 69.0% of the 827 people receiving maintenance hemodialysis in this multicenter study. More than one third had low activity levels. Patients with moderate or high activity rated their physical and mental quality of life more favorably, and accounting for other factors did not remove this association. Regular exercisers felt less burdened by kidney disease and reported greater vitality. They also rated physical functioning and general health higher (Hu et al., 2024).

However, most of these people did not participate in any training programs. While 62.4% of these patients reported regular exercise, 92.6% did so only at low intensity, such as walking or jogging. Only 1.6% of these patients performed resistance exercises. These exercises are not typically incorporated into training programs for these patients (Hu et al., 2024). According to the 2024 KDIGO guidelines, people with chronic kidney disease should perform at least 150 minutes of moderate-intensity exercise per week. However, exercise intensity and duration may need to be adjusted based on each patient's cardiovascular and physical abilities (KDIGO CKD Work Group, 2024).

Functional capacity and physical performance

The DiaTT (Dialyze Trainings-Therapie) study included patients who exercised during dialysis sessions for 12 months. The program consisted of 30 minutes of aerobic exercise and 30 minutes of resistance training. The study included 21 German hemodialysis centers and 917 patients. The patients who participated in the exercise program had improved results on the 60-second sit-to-stand test (adjusted mean difference 3.85 repetitions; 95% CI 2.22 - 5.48; $p < 0.0001$) and walked farther in six minutes (adjusted mean difference 37.5 m; 95% CI 14.7 - 60.4) compared to the control group. Also, the median time spent in the hospital over the year was 2 days for the exercise group and 5 days for the control group ($p = 0.036$). The two groups did not differ in mortality or cardiovascular events (Anding-Rost et al., 2023).

The walking gains in DiaTT agree with the findings of the 2022 Cochrane review. Bernier-Jean et al. included 89 randomized or quasi-randomized trials involving 4,291 participants; 77 trials with 3,846 participants contributed to the quantitative analyses. After 2–6 months of training, the exercise groups covered about 50 m more than the controls in the six-minute walk test (mean difference of 49.91 m; 95% CI, 37.22–62.59). The difference on the 30-second sit-to-stand test averaged 2.33 repetitions in favor of exercise (95% CI, 1.71–2.96). Evidence for both outcomes was rated as moderate certainty. When combining aerobic and resistance exercises, the outcomes were similar to those of performing each type of exercise alone (Bernier-Jean et al., 2022). Reviews of the current research on patients with ESRD who are undergoing hemodialysis have found that incorporating forms of aerobic exercise and physical activity into these patients' routines can lead to improvements in their levels of aerobic fitness and their participation in those physical activities (Bernier-Jean et al., 2022; Hu et al., 2023; Ren et al., 2023).

The combined training regimen received the highest ranking for the six-minute walk test in the network meta-analysis by Ren et al., (2023) of 58 randomized trials involving 2,731 participants. This regimen was associated with improved walking performance versus usual care. Also, aerobic exercise and respiratory muscle training were both associated with benefits in walking performance. Hu et al., (2023) reviewed 15 exercise approaches from 90 studies involving 4,084 patients undergoing dialysis. The results indicated that adding either aerobic or resistance exercise to dialysis sessions for patients with end-stage renal disease improved walking performance. Adding aerobic and resistance exercises to dialysis sessions for patients with end-stage renal disease also improved walking performance and peak oxygen uptake. Patients also experienced improved quality of life. Including both aerobic and resistance exercises in dialysis sessions for patients with end-stage renal disease had the greatest positive effect on patient outcomes.

The largest gain in six-minute walk distance was observed after aerobic exercise with blood flow restriction. The gain was 97.35 m compared to the control conditions. Few trials have investigated this type of exercise, and the 95% confidence interval for the gain in walk distance is between 11.89 and 182.81 m (Hu et al., 2023).

Effects on quality of life

Patients who undergo hemodialysis often prioritize their feelings of well-being over other measures of their health. While various studies have investigated the effects of exercise on patients with end-stage renal disease, they have found that patients experience improvements in physical well-being. However, studies investigating the effects of hemodialysis on these patients' mental health have produced mixed results (Bernier-Jean et al., 2022; Hu et al., 2023; Ren et al., 2023).

Patients who performed aerobic exercises showed significant improvements in quality of life compared with those who received standard care for ESRD. However, stretching exercises did not affect these patients' quality of life (Ren et al., 2023). Hu et al., (2023) found that performing aerobic exercise had the greatest effect on the physical component of quality of life in patients with ESRD. Other forms of exercise performed outside dialysis sessions can also improve the mental component of quality of life in patients with ESRD. Other programs outside of dialysis days also showed improvements in mental components of quality of life. A Cochrane review of the literature on exercise among patients undergoing hemodialysis found that exercise lasting between two and twelve months appeared to improve the physical component of quality of life (17 studies, 656 participants; mean difference 4.12 points on a 100-point scale; 95% CI 1.88-6.37). Moderate-certainty evidence also showed a reduction in depressive symptoms (10 studies, 441 participants; standardized mean difference, -0.65; 95% CI, -1.07 to -0.22), especially in programs lasting more than 4 months. However, the evidence for the mental component of quality of life, mortality rates, and the incidence of cardiovascular events was very uncertain (Bernier-Jean et al., 2022).

The DiaTT trial also found that the intervention improved the physical health summary score and vitality subscale of the 36-item Short Form Health Survey. The other survey subscales, such as mental health, did not differ significantly from those of the usual care group (Anding-Rost et al., 2023). These results show that even when laboratory measures of the patient's condition show little change, physical health and quality-of-life aspects can improve (Bernier-Jean et al., 2022; Hu et al., 2024).

Body composition, muscle strength, and frailty

The loss of muscle mass and strength, along with frailty, is common among patients receiving dialysis. These outcomes have been associated with poorer outcomes for these patients (Hwang et al., 2019; Kim et al., 2013). Several factors can contribute to muscle loss and weakness, including inadequate dietary intake, chronic acidosis, resistance, hormonal abnormalities, and physical inactivity. Muscle loss can make it difficult to perform daily activities, resulting in a decline in the patient's health (Bakaloudi et al., 2020; Kim et al., 2013). Exercise can help maintain muscle mass and strength and improve the patient's overall fitness.

Reviews indicate that exercise can improve muscle fitness, nutritional status, and some measures of body composition, with the clearest effects seen when resistance training is included (Bakaloudi et al., 2020). In Bakaloudi et al., (2020), resistance and combined programs were more likely than aerobic exercise alone to increase muscle strength and lean mass. Changes in body weight and fat mass were less consistent. These data are particularly relevant to patients with sarcopenia or protein-energy wasting.

Michou et al., (2023) conducted a study on the effects of a combined intradialytic program on patients undergoing hemodialysis who were waiting for a kidney transplant. The results indicated that after four months, patients who participated in the exercise program showed improvements in handgrip strength and six-minute walk distance. Also, bioimpedance measurements of the patients revealed changes in their lean mass, total body water, phase angle, and body fat percentages. Researchers also found that patients' handgrip strength was correlated with both their fat-free mass index and phase angle, a measure used to assess protein-energy wasting and frailty in patients undergoing maintenance hemodialysis.

Assessing a patient's grip strength is a simple process that requires no time or equipment. A study by Hwang et al., (2019) found that patients with lower grip strength were more likely to die from any cause than those with higher grip strength. Maintaining muscle strength is therefore an important goal for these patients. Also, transplant candidates' physical condition before the procedure may affect their ability to undergo it, their need for rehabilitation afterward, and their recovery (Michou et al., 2023; Yang et al., 2020).

Cardiovascular and metabolic effects

Beyond improving walking performance, physical activity provides many overall health benefits. For example, physical inactivity is associated with increased levels of inflammation, oxidative stress, insulin resistance, dyslipidemia, and endothelial dysfunction, all of which have been linked to the high rates of cardiovascular disease among people undergoing hemodialysis (Deligiannis et al., 2021; Imamura et al., 2012). Many people who undergo hemodialysis have diabetes as a result of their chronic kidney disease. Regular physical exercise has been shown to improve glycemic control and blood pressure in people with diabetic kidney disease, reducing the risk of complications (Poborowska et al., 2024).

Imamura et al., (2012) have published research regarding the effects of physical activity on patients undergoing dialysis. The researchers found that patients who engaged in regular physical exercise had lower blood triglyceride levels, higher HDL cholesterol levels, and improved insulin sensitivity.

In a network meta-analysis by Ren et al., (2023), exercise did not increase blood pressure. Some studies that included range-of-motion exercises, aerobic exercises, or combined exercise programs found that participants had lower blood pressure than those who did not perform these types of exercises. A separate meta-analysis of intradialytic exercise found that patients who performed intradialytic exercise had significantly lower systolic (mean difference -4.87 mmHg; 95% CI -9.20 to -0.55) and diastolic (mean difference -4.11 mmHg; 95% CI -6.50 to -1.72) blood pressures than those who did not perform any exercise during their dialysis sessions. These patients also showed improvements in dialysis adequacy and peak oxygen uptake during dialysis, with no differences in the incidence of adverse events (Pu et al., 2019). Other studies have reported additional benefits of performing intradialytic exercise, including improvements in autonomic function, arterial stiffness, and cardiorespiratory adaptation (Deligiannis et al., 2021).

Dialysis adequacy and inflammation

While there is evidence of the impact of physical activity on the physical functions of patients undergoing dialysis, its impact on dialysis adequacy is less consistent. For instance, Salhab et al., (2019) found no significant difference in Kt/V values between patients undergoing dialysis assigned to exercise programs and those not. However, more recent network meta-analyses have found small benefits of incorporating aerobic exercise into dialysis (Hu et al., 2023). Also, studies such as that conducted by Pu et al., (2019) found that patients who participated in intradialytic exercise experienced a small increase in their Kt/V values relative to patients who did not participate in any exercise program (mean difference 0.07; 95% CI 0.01-0.12; $p = 0.02$). The proposed reason for the increase in Kt/V values is that exercise increases blood flow to the areas of the body where dialysis occurs, allowing more waste products to be removed during dialysis.

Results for inflammatory markers are mixed. Ren et al., (2023) found no increases in C-reactive protein (CRP) or interleukin-6 (IL-6) with exercise but noted that resistance training may reduce CRP. Also, Dong et al., (2019) found improvements in inflammatory markers with resistance exercise among patients undergoing maintenance hemodialysis diagnosed with sarcopenia. Because these patients are at risk of muscle catabolism and cardiovascular disease due to their condition, these results may benefit these groups (Deligiannis et al., 2021).

Despite the differences in the biochemical measurements that were taken as a result of the exercise interventions, the majority of the studies indicated that the exercise was well-tolerated by the patients with end-stage renal disease (Anding-Rost et al., 2023; Hu et al., 2023; Pu et al., 2019; Ren et al., 2023). Adverse event rates during or after dialysis sessions were similar to those observed without exercise in the treatment protocol (Anding-Rost et al., 2023; Pu et al., 2019).

Relevance for kidney transplant candidates

Physical function has become an important part of assessing and preparing kidney transplant candidates. It may also be improved before surgery. Yang et al., (2020) reported that many transplant programs already include performance tests or frailty scores in their assessment process. Poor physical function does not rule out substantial benefit from transplantation in carefully selected patients. It may, however, make access to the waiting list more difficult and has been associated with delayed graft function, longer hospitalization, and higher post-transplant mortality.

Patients awaiting transplantation spend many hours each week in dialysis units, so intradialytic exercise affords a practical way to improve function before surgery. The study of Michou et al., (2023) revealed that four months of combined aerobic and resistance training during dialysis sessions resulted in important improvements in measures of handgrip strength, six-minute walk distance, and body composition as measured by bioimpedance analysis, when compared to people who did not perform any form of exercise during their dialysis sessions. The results are consistent with the concept of prehabilitation: increasing physical reserve before major surgery may reduce complications and promote recovery (Yang et al., 2020). The issue also goes beyond the waiting period. Although people who receive a kidney transplant tend to have lower levels of physical activity than the general population, studies have shown that exercise after a kidney transplant can improve strength, physical function, and cardiorespiratory performance (Skweres et al., 2024).

In addition to the benefits of intradialytic exercise for people currently undergoing dialysis, this type of exercise may also help preserve the functional and nutritional reserves of kidney transplant candidates (Michou et al., 2023; Yang et al., 2020). Table 1 summarizes the main findings across outcome domains.

Table 1. Summary of findings on physical activity and exercise in adults receiving maintenance hemodialysis.

Habitual physical activity	In a multicenter sample of 827 patients, 69.0% did not meet physical activity recommendations. Higher activity was associated with better physical and mental quality of life.	(Filipic et al., 2021; Hu et al., 2024)
Functional performance	Compared with control, exercise increased six-minute walk distance by 49.91 m (95% CI 37.22–62.59) and 30-second sit-to-stand performance by 2.33 repetitions (95% CI 1.71–2.96). Both estimates had moderate-certainty evidence.	(Bernier-Jean et al., 2022)
Health-related quality of life	Physical component scores were 4.12 points higher on a 100-point scale (95% CI 1.88–6.37; low-certainty evidence). Depressive symptoms also improved; effects on mental component scores were uncertain.	(Bernier-Jean et al., 2022)
Muscle strength and body composition	Resistance and combined training improved muscle strength and selected lean-mass measures. Changes in body weight and fat mass were less consistent.	(Bakaloudi et al., 2020)
Cardiovascular and metabolic measures	One meta-analysis reported reductions of 4.87 mmHg in systolic and 4.11 mmHg in diastolic blood pressure. Lipid and other metabolic findings varied across studies.	(Imamura et al., 2012; Pu et al., 2019)
Dialysis adequacy	Intradialytic exercise increased Kt/V by 0.07 (95% CI 0.01–0.12) in one meta-analysis. Other reviews reported no clear benefit or small improvements.	(Hu et al., 2023; Pu et al., 2019; Salhab et al., 2019)
Inflammatory markers	Findings for C-reactive protein and interleukin-6 were inconsistent. But some analyses did show that resistance training reduced inflammatory markers.	(Dong et al., 2019; Ren et al., 2023)
Kidney transplant candidates	Four months of combined intradialytic training improved handgrip strength, six-minute walk distance and selected bioimpedance measures of body composition compared with no exercise.	(Michou et al., 2023)

4. DISCUSSION

Synthesis of findings

Exercise programs have been proven to improve the physical performance of patients with ESRD. Six-minute and sit-to-stand tests show that patients with ESRD improve their physical performance after implementing exercise programs as part of their treatment plan (Anding-Rost et al., 2023; Bernier-Jean et al., 2022; Hu et al., 2023; Ren et al., 2023). Though the benefits of these programs may be smaller than those experienced by people in the general population, people with intellectual disabilities have also been reported to experience improvements in their quality of life in relation to factors such as physical health, depressive symptoms, and vitality (Anding-Rost et al., 2023; Bernier-Jean et al., 2022). Also, programs incorporating resistance exercises have been reported to improve muscle strength and body composition in people with intellectual disabilities (Bakaloudi et al., 2020; Hwang et al., 2019; Michou et al., 2023). In contrast, the impact of exercise on cardiovascular risk factors, dialysis adequacy, and inflammation is less consistent due to the small size of most studies that investigated these outcomes (Hu et al., 2023; Imamura et al., 2012; Pu et al., 2019; Ren et al., 2023; Salhab et al., 2019). No reports describe adverse effects of exercise during dialysis (Anding-Rost et al., 2023; Pu et al., 2019).

Systematic reviews and meta-analyses in this area include the same primary trials. For instance, Ren et al., (2023) and Hu et al., (2023) both used partially overlapping sets of randomized controlled trials to determine the effectiveness of different exercise programs for patients undergoing maintenance hemodialysis. Both publications concluded that performing aerobic and resistance exercises during dialysis sessions was among the most effective forms of exercise for patients undergoing dialysis (Hu et al., 2023; Ren et al., 2023). So, while these data support the main conclusion of this review, they do not constitute evidence from independent patient populations.

Barriers to implementation in clinical practice

Physical activity and exercise are not routine components of care in many dialysis units. Dialysis patients experience symptoms like fatigue, multimorbidity, lack of time or space to exercise, fear of falls or cardiovascular events, fear of damaging their vascular access sites, lack of social support, and uncertainty about exercising safely with kidney failure (Li et al., 2021; Michou et al., 2019). These same concerns are often shared by healthcare professionals caring for dialysis patients. For instance, Michou et al., (2019) surveyed hemodialysis patients and clinical staff members. The results indicated mixed attitudes towards exercise among patients and uncertainty among staff members regarding safe exercise prescriptions for patients with kidney failure.

The dialysis units face multiple practical constraints. These units frequently lack sufficient staff, physiotherapists, or space for patients around the treatment stations (Clyne and Anding-Rost, 2021; Ma et al., 2012). Also, Ma et al., (2012) found large variation among dialysis centers in Ontario in whether they offered any form of exercise program for their patients. These low uptake rates may be due to a lack of staff and resources within these units. Intradialytic exercise is easier to implement because it occurs during dialysis treatment and is supervised by healthcare professionals. Adherence to these programs may also be higher than for those prescribed for home or non-dialysis days (Clyne and Anding-Rost, 2021; Hu et al., 2023).

The cost of carrying out such a program may also be a limiting factor. Intradialytic programs have been found to be relatively low-cost compared with other forms of dialysis care. For instance, the DiaTT program cost approximately EUR 25 per training session per enrolled patient, and patients who participated in the program had fewer hospital days than those who did not (Anding-Rost et al., 2023). However, these programs are not reimbursed, and the local initiative must provide the staff required to implement them.

Practical consequences for individualized intradialytic programs

Exercise can also be incorporated into the treatment of patients with ESRD who are undergoing hemodialysis. Guidelines from various countries recommend incorporating exercise into the treatment plan for patients with CKD, taking into account the patient's cardiovascular health (KDIGO CKD Work Group, 2024). Patients undergoing dialysis can use exercise cycles for cardiovascular workouts. Patients can also incorporate resistance exercises into their workout during hemodialysis treatment. Patients can also perform exercises targeting lung muscles, as well as balance and function, during hemodialysis (Anding-Rost et al., 2023; Hu et al., 2023; Ren et al., 2023).

The type and intensity of exercise appropriate for patients with kidney failure generally depend on the patient's clinical status, symptoms, and exercise goals (KDIGO CKD Work Group, 2024). For example, frail patients may want to focus on exercises that improve gait and strength. However, studies also indicate that even low and moderate levels of exercise can benefit these patients (Bernier-Jean et al., 2022; Hwang et al., 2019). For patients who are awaiting a kidney transplant, the goal of exercising is generally to increase the patient's strength and nutritional reserves prior to undergoing kidney transplant surgery (Michou et al., 2023; Yang et al., 2020).

Exercise intensity should be moderate and adjusted to patients' symptoms and tolerance. High-intensity exercise can reduce the glomerular filtration rate and alter urine composition, even in people with normal kidney function (Żołądkiewicz, 2019). Therefore, people with limited renal or cardiovascular reserve should be treated cautiously during this program. Trained staff should conduct the program and have access to the equipment available to the participants. Each participant should undergo a preliminary evaluation before the program to ensure they are safe to participate. The evaluation should include questions regarding unstable angina, arrhythmias, and other potential complications related to vascular access. Patients and staff should also receive information on the safety and practical aspects of exercising during dialysis treatment (Clyne and Anding-Rost, 2021; Li et al., 2021; Michou et al., 2019).

Limitations of the evidence base and of this review

Each study used different designs, participants, exercises, and durations. Some programs lasted for around eight weeks, while others lasted for over a year. Each study included aerobic training, resistance training, or both. Participants performed the exercises during dialysis, separately. Most of these studies measured outcomes after a short period, such as six minutes of walking, quality-of-life scores, Kt/V measurements, and blood pressure measurements. Few of these studies measured outcomes over longer periods, such as mortality rates, cardiovascular event rates, hospitalization rates, and transplant success rates. Many randomized trials were small and conducted at a single center. Differences in age, comorbidities, dialysis vintage, baseline physical function, and observance also limit

comparisons between studies and make it difficult to identify the best program for a particular patient. Table 2 summarizes the clinical implications and remaining evidence gaps.

Table 2. Clinical implications, implementation aspects and evidence gaps

Exercise selection	Combined aerobic and resistance training is a practical option during dialysis (Anding-Rost et al., 2023; Hu et al., 2023).	Differences in exercise dose, duration and adherence limit comparisons. The optimal regimen remains uncertain.
Individualization and frailty	Adapt workload to function, symptoms and comorbidities; prioritize transfers, gait stability and strength when appropriate (KDIGO CKD Work Group, 2024).	Studies differ in baseline function and comorbidity. The best approach for specific patient subgroups requires further study.
Outcome assessment	Include walking performance, sit-to-stand ability, muscle strength and patient-reported well-being among treatment goals (Bernier-Jean et al., 2022).	Short-term functional gains do not establish reductions in mortality or cardiovascular events. Longer follow-up is needed.
Transplant preparation	Exercise may help preserve functional and nutritional reserve before transplantation (Michou et al., 2023; Yang et al., 2020).	Effects on waitlisting, surgical complications, graft outcomes and post-transplant survival require confirmation.
Safety and supervision	Use clinical assessment, symptom monitoring and trained supervision to support individualized delivery (Clyne and Anding-Rost, 2021).	Similar adverse-event rates in available studies must be interpreted in light of trial size, duration and participant characteristics.
Implementation and adherence	Provide staff training, basic equipment and patient education; address fatigue and exercise-related concerns (Li et al., 2021; Michou et al., 2019).	Staffing, space and reimbursement may limit uptake. Program sustainability and economic impact need further evaluation.
Interpretation of the evidence	Consider overlap between reviews when assessing the consistency of their findings (Hu et al., 2023; Ren et al., 2023).	Small, heterogeneous studies and overlapping trials limit inference. This narrative review did not formally assess risk of bias.

5. CONCLUSION

People who receive hemodialysis treatments can benefit from physical activity and participation in planned exercise. These improvements are most commonly observed in functional ability, physical performance, and health-related quality of life. In addition, some people may also experience improvements in muscle strength and certain aspects of body composition. However, the effects of physical activity on various other aspects of an individual's health, such as their cardiovascular and metabolic functions, the effectiveness of their dialysis treatment, their levels of inflammation, and their physical function prior to undergoing a kidney transplant, have been found to be variable among different studies. An exercise program that combines aerobic and resistance exercises for patients undergoing dialysis may be the most practical option. The program would occur during the patient's scheduled dialysis sessions, be supervised by the patient's dialysis staff, and be as safe as the dialysis treatment itself. Such an exercise program would require trained personnel, patient education, simple equipment, and defined protocols. Also, studies of such a program would need to run long enough to evaluate its impact on patients' mortality rates, cardiovascular events, hospital admissions, and even organ transplantations. More studies are needed to determine how such a program could be introduced and maintained as part of the patient's dialysis routine.

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Informed consent

Not applicable.

Ethical approval

Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

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Conflict of interest

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Data and materials availability

All data associated with this study are present in the paper

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