



Prescribing Physical Activity and Exercise for People with CKD

A Practical Guide by the Global Renal Exercise Network

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Abstract

Physical activity (PA) and exercise are fundamental to optimizing and maintaining health. The evidence on the benefits of PA and exercise in people with CKD is well-established. Yet patients remain inactive, partly driven by a lack of knowledge and confidence from the healthcare providers involved in their management. A potential key element in improving PA in CKD includes better provisions around education, tools, and training resources among nephrology healthcare providers on PA recommendations, counseling, prescription, and referral to appropriate professionals for assessment, implementation, and monitoring. Much like other pharmacologic therapies, an effective prescription should be prescribed at the correct dose, strength, and frequency to the individual, titrated (and progressed) to optimize adherence and safety, and reviewed regularly to ensure maximum effectiveness. Aside from a formal prescription of exercise, many people would benefit from modest improvements in daily PA, and an emphasis on reducing sedentary behavior is likely to confer beneficial effects on outcomes. The purpose of this article is to outline the key components of successful PA and exercise prescriptions, including understanding the barriers and facilitators individuals may have, taking a PA history, and how to tailor exercise “dose” to each patient with the ultimate goal of increasing accessibility of PA for all people living with CKD. To do this, we will use worked examples to demonstrate what an exercise prescription may consist of across each of the major CKD stages.

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Introduction

Physical activity (PA) and exercise are fundamental to optimizing and maintaining health. The evidence on the benefits of PA and exercise in people with CKD is well-established, and the reader is encouraged to read around the excess of meta-analyses and reviews in the area.^{1–6} PA and exercise are widely recommended and have been adopted by clinical practice guidelines (Table 1) because of the potency of their effect on health-related outcomes; nonetheless, despite the plethora of evidence gleaned over 30 years, PA levels remain extremely poor,^{1,7,8} and although most nephrology healthcare providers (HCPs) consider PA counseling within their scope of practice

and beneficial, they often do not regularly advise patients.^{9,10} Key contributions to this include inadequate knowledge of specific exercise prescriptions and a perception that patients know they lack expertise in exercise.⁹ Consequently, crucial elements to improving PA in patients include better provisions around education, tools, and training resources among nephrology HCPs on PA recommendations, counseling, prescription, and referral to appropriate professionals for assessment, implementation, and monitoring.^{9–12}

The purpose of this review article is to outline the key components of successful PA and exercise prescriptions, including understanding the barriers and facilitators

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Table 1. Exercise and physical activity-specific clinical guidelines, statements, and recommendations

Title	Location	Stage	Year
The role of exercise training on cardiovascular risk factors and heart disease in patients with CKD G3–G5 and G5D: a clinical consensus statement of the European Association of Preventive Cardiology of the ESC and the European Association of Rehabilitation in CKD	Europe	NDD, hemodialysis	2024 ³⁴
PA and exercise in PD: International Society for PD and the GREX practice recommendations	International	PD	2022 ²⁵
UKKA clinical practice guideline exercise and lifestyle in CKD	the United Kingdom	NDD, hemodialysis, KTR	2022 ¹⁹
PA and exercise recommendations for people receiving dialysis: a scoping review	International	PD	2022 ⁵⁵
Clinical practice guideline for renal rehabilitation: systematic reviews and recommendations of exercise therapies in patients with kidney diseases	Japan	NDD, hemodialysis, KTR	2019 ⁶⁷
Exercise and Sports Science Australia (ESSA) position statement on exercise and CKD	Australia	Hemodialysis	2013 ²³
Physical exercise programs in CKD: lights, shades and perspectives: a position paper of the “physical exercise in CKD study group” of the Italian Society of Nephrology (updated in 2024, see below)	Italy	All	2015 ⁷⁷
PA and exercise in CKD: consensus statements from the physical exercise working group of the Italian Society of Nephrology	Italy	All	2024 ⁷⁸

ESC, European Society of Cardiology; ESSA, Exercise and Sports Science Australia; GREX, Global Renal Exercise Network; KTR, kidney transplant recipient; NDD, non-dialysis dependent; PA, physical activity; PD, peritoneal dialysis; UKKA, UK Kidney Association.

individuals may have, taking a PA history, and how to tailor exercise “dose” to each patient with the ultimate goal of increasing accessibility of PA for all people living with CKD. To do this, we will use worked examples to demonstrate what an exercise prescription may consist of across each of the major CKD stages. Although this guide is primarily aimed at clinical HCPs, it is hoped that people with CKD may also find it beneficial.

Taking the First Steps: Initiating the Discussion around Exercise

PA versus Exercise: What is the Difference?

Although often used interchangeably, misinterpretation around PA and exercise can have important implications for how HCPs speak to patients about promoting PA^{13,14}; we may ask how much “exercise” someone does, but what we really want to assess is their overall PA. Patients may also not consider everyday tasks (e.g., household chores) as PA.¹⁵ PA refers to any bodily movement by skeletal muscles that requires energy expenditure; this includes all movement, be it gardening, occupational activity, or exercise. Exercise is a subtype of PA that is planned, structured, and repetitive to improve or maintain physical and health-related fitness.^{14,16} Light-intensity PA is between 1.5 and 3 metabolic equivalents of task (METs) and includes activities of daily living or those just above resting energy expenditures. By contrast, moderate-to-vigorous intensity PA (MVPA) is >3 METs and activities range from brisk walking to running or other activities that involve heavy breathing and perspiration.¹⁷ All exercise is PA, but not all PA is exercise. In this review, we will mostly use the term “PA” but acknowledge that this may involve exercise to achieve PA.

Taking an Effective PA History

The first step toward designing any personalized PA intervention is to obtain an effective PA history, which can be achieved through a combination of structured/

subjective interviews and physical function assessments.¹⁴ Considering that prior medical clearance has been obtained, patient demographics and CKD/health information available from medical records (e.g., etiology of kidney condition, other comorbidities and risk factors, recent hospitalizations/procedures, relevant medications, recent blood analysis, and current BP, heart rate, and blood glucose) can be used to understand any contraindications to exercise (see below for more detail). Questionnaires, such as the PA Readiness Questionnaire, can be used to identify individuals who are at higher risk of adverse outcomes related to exercise.¹⁸

Current PA behavior can be measured subjectively by self-reported questionnaires¹⁹ and objectively by accelerometers²⁰ or smart watches; even simple questions can be useful (e.g., “How many days do you engage in moderate or vigorous PA?”).²¹ Past PA should explore the individual's previous sports/exercise participation, changes in PA over time (particularly concerning CKD progression or treatment but also other health conditions or life events), and any previous experience with exercise programs or interventions. It is important to determine the home environment and available resources, including available exercise equipment.

Identifying perceived barriers (discussed later) that may hinder PA participation can help develop an appropriate prescription later; in particular, discussing the individual's PA goals/motivations and exploring preferences for types of activities, social settings (e.g., group activities), locations (indoor versus outdoor), and times of day for exercise/PA is key. Determining baseline physical function and fitness is essential for an effective exercise prescription. The gold standard methods for assessing cardiorespiratory or musculoskeletal fitness require expensive equipment, are time consuming, and are challenging for the patients. However, simple physical function tests (e.g., sit-to-stand test and gait speed) have been widely used in CKD research and clinical practice²² and will allow the identification of what areas to target when formulating a PA and exercise prescription.

Contraindications

General contraindications for people living with CKD include (1) decompensated heart failure; (2) recent changes to electrocardiogram, especially symptomatic tachy or brady arrhythmias; (3) electrolyte abnormalities (e.g., hypo/hyperkalaemia); (4) pulmonary congestion; (5) unstable angina; (6) peripheral edema; (7) uncontrolled hypertension and/or systolic BP >200 mm Hg or diastolic BP >110 mm Hg (in the nonfistula arm); and (8) uncontrolled diabetes and/or blood glucose levels >13.9 or <5.5 mmol/L.²³ Known cardiovascular disease is not an absolute contraindication to exercise, particularly for individuals with diabetes or hypertension, unless uncontrolled (e.g., decompensated heart failure).²⁴ Specifically for people receiving dialysis, excess interdialytic weight gain (>4 kg since last dialysis or exercise session), instability on dialysis treatment, anemia, and infection at the access site are contraindications while activities that may cause physical/traumatic damage to the catheter, fistula, or transplanted kidney site should be avoided.^{19,21,23,25} Considerations must be made for additional comorbidities; therefore, risk assessment and pre-screening must be performed on an individual basis to determine the appropriate PA to commence.

Barriers and Facilitators

People with CKD face several physical, psychologic, personal, and environmental barriers to PA (summarized in Figure 1). The most consistently reported physical barriers include symptom exacerbation and muscle weakness.²⁶ Cardiovascular and musculoskeletal limitations, anemia, fluid retention, and comorbidities further complicate exercise efforts.²⁶ Psychologically, depression, anxiety, and fear of injury are identified as key barriers.^{26–28} Aside

from these, other barriers such as lack of time, access, adequate built environment (e.g., transport, green space, and safety), finances, and social support can reduce PA engagement.^{26,29,30}

Key motivators for people to engage in PA include the perceptions of improved health outcomes and enhanced quality of life (QoL) gained.³¹ Patients generally acknowledge that regular PA can reduce fatigue and improve cardiovascular and muscular strength.²⁷ Psychologic factors, such as reduced feelings of anxiety, depression, and stress, also drive motivation, along with the sense of accomplishment from setting and achieving health goals.^{28,31} Support from HCPs, family, and peers further encourages participation, while the potential for better disease management and slower progression of CKD are identified as long-term incentives.³²

Right Exercise at the Right Dose: Fundamentals of Effective Exercise Prescription

General PA Recommendations: Every Little Bit Helps

Currently, the World Health Organization recommends that all adults should undertake 150–300 minutes of MVPA, or 75–150 minutes of vigorous-intensity PA, or some equivalent combination, per week. This should be combined with regular muscle-strengthening activity on two or more days.³³ While broad, these recommendations are consistent with kidney-specific clinical guidelines including the “United Kingdom Kidney Association Clinical Practice Guidelines for Exercise and Lifestyle”¹⁹ and others.³⁴ Although 150–300 minutes of PA may sound overwhelming, explaining that most of this can be achieved within their daily routine may make it more realizable. Evidence shows that even small amounts of light PA

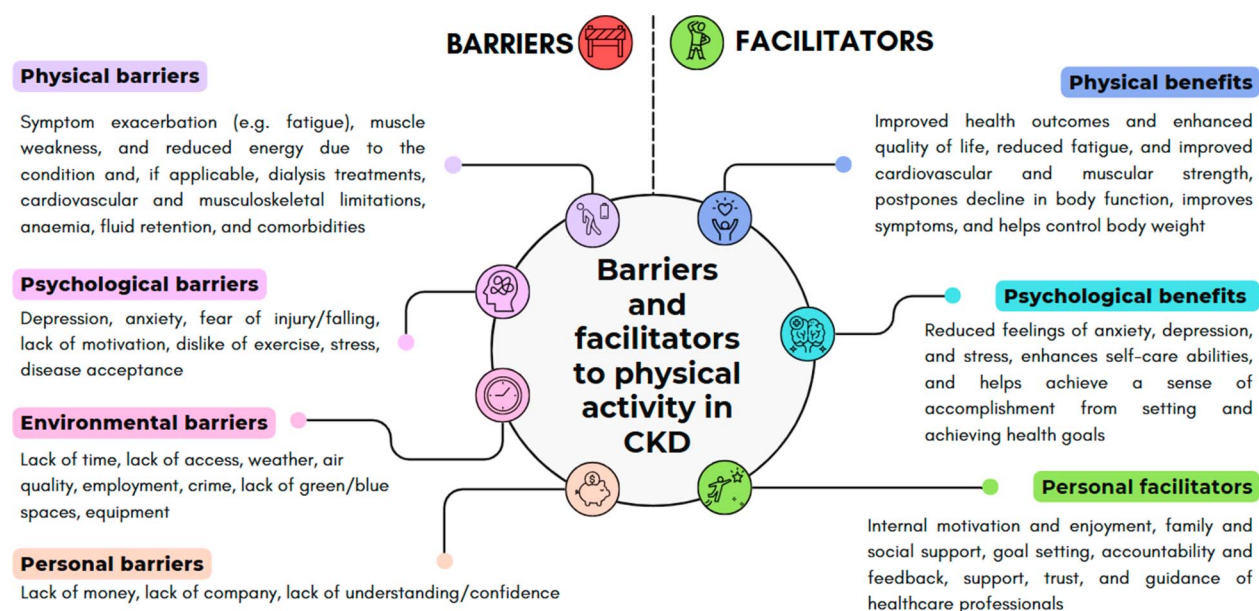


Figure 1. Figure summarizes the major barriers and facilitators to PA and exercise in people living with CKD stratified into physical, psychologic, environmental, and personal factors. PA, physical activity; 1RM, one-repetition maximum; RPE, rating of perceived exertion.

(e.g., >4000 steps per day) have beneficial effects on outcomes, including cardiovascular disease risk factors and QoL, in people with CKD.^{34–36}

Sit Less to Move More? The Role of Sedentary Behavior

Sedentary behavior is any activity performed in a seated or reclined posture that requires low energy expenditure (<1.5 METs).^{33,37} Sedentary behavior is distinct from physical *inactivity*, as it is possible to engage in recommended PA and still accrue a high volume of sedentary time.¹⁷ Sedentary behavior, independent of PA, is associated with adverse outcomes in CKD,^{38,39} and even high levels of PA may not fully mitigate its risk.⁴⁰ For people with CKD, engaging in MVPA may not be attainable, and as such, initially placing a greater emphasis on reducing sedentary behavior could be a more realistic, strategic, and tailored pathway to increasing PA.^{17,34,41} This could involve simple changes such as parking the car further away to encourage walking, taking the stairs over the lift, or standing while undertaking meetings at home.¹⁴

Exercise Prescription 101: The Basic Principles

An exercise prescription is much like any other pharmacologic therapy; it should be of the right class, the benefits should outweigh the risks, and it should be prescribed by the appropriate exercise professional⁴² at the correct dose, strength, and frequency; titrated (or progressed) to optimize compliance; and reviewed regularly. Importantly, any prescription should aim to integrate PA back into the individual's daily life so that it becomes a habit, rather than an inconvenience. The American College of Sports Medicine^{21,43} recommends some basic principles, known as the Frequency, Intensity, Time, Type, Volume, and Progression acronym, to help formulate an effective exercise prescription. Table 2 summarizes these principles, providing examples of practical applicability and additional considerations for people with CKD.

Other Considerations

Along with aerobic and resistance activities, flexibility exercises that develop a range of motion in the major muscle-tendon groups are also beneficial in improving postural stability and balance and reducing fall risk. Flexibility exercises can be static (e.g., bending over to touch your toes) or dynamic (e.g., high knees). Flexibility exercises should be encouraged at least 2–3 times a week, and the stretch should be held to the point of feeling tightness or slight discomfort for 10–30 seconds is recommended for most adults. In older persons, holding a stretch for 30–60 seconds may confer greater benefit. Repeating each flexibility exercise two to four times is recommended and is most effective when the muscle is warmed through light to moderate aerobic activity.⁴³

Using Existing Resources to Help Facilitate PA

Access to targeted PA interventions remains undersupported because of limited funding and specialized staff. Digital health interventions (DHIs) may address some of these factors and thus are gaining increasing attention because of the ability to deliver PA information and

support to a larger audience/population in a potentially equitable and cost-effective way.⁴⁴ Moreover, these resources are not dependent on high levels of specialized workforce. Although there are a variety of generic online resources available that could be shown to patients, two such theory-based and evidence-based DHIs designed for people with CKD include Kidney Beam⁴⁵ and My Kidneys and Me,^{46,47} both designed to provide education and support for people with CKD to help improve PA and exercise behaviors. A multicenter trial demonstrated that Kidney Beam is clinically effective and cost-effective for improving mental health-related QoL and self-management behavior for people with CKD.^{45,48} The platform provides both live and on-demand sessions, coupled with education and motivational features such as real-time feedback, reminders, and scheduling features. My Kidneys and Me provides PA and exercise educational information presented in a multiformat and interactive way, alongside action sessions, underpinned by behavior change techniques, designed to put learning into action. My Kidneys and Me also provides exercise trackers (including strength training), social support, and goal-setting functions to support the initiation and maintenance of PA behaviors. Both Kidney Beam and My Kidneys and Me have demonstrated positive effects on patient outcomes.^{45,47,49} Interestingly, the effect of DHIs ability to increase PA is limited and likely due to the use of self-reported tools.⁴⁴ It is important to consider the use of DHIs in some groups, and in some cases, DHIs may not be the most appropriate means to support PA behavior change.

Special Populations and Their Considerations

Patients with CKD stages 3–5 not requiring KRTs have been shown to benefit from standard PA and exercise prescriptions for the general population, so long as individuals are screened properly and progress gradually. This group will likely tolerate greater intensity and volume of exercise⁵⁰; however, every patient must be considered individually (Figure 2, case study 1).

When prescribing exercise for patients on dialysis (Figure 2, case study 2), it is important to appreciate that multiple barriers to exercise may exist. These include fatigue, treatment burden, and adaptation of lifestyles to low function. Although demonstrating somewhat modest efficacy,^{51–53} intradialytic exercise (IDE) is recommended for hemodialysis patients⁵⁴ as it is relatively safe, convenient, and time efficient.⁵² IDE is generally advised within the first 2 hours of dialysis to reduce the risk of hypotension.^{51,55,56} Although a role exists for both intradialytic and interdialytic (out-of-center) exercise,^{54,55} adherence tends to be greater in the former due to increased supervision.⁵⁷ Yet, IDE, often in the form of continuous mandated recumbent cycling, inhibits the type, volume, intensity (and enjoyment) of exercise that can be performed,⁵² and the overall benefits of intradialytic and interdialytic exercise are comparable.^{3,52} In patients on hemodialysis, IDE programs should combine endurance and resistance exercises.^{34,53} Of additional note, in many patients, heart rate prescriptions are often inaccurate and the use of rating of perceived exertion is recommended.⁵⁵ One-repetition maximum testing for strength is not

Table 2. Exercise training principles (frequency, intensity, time, type, volume, and progression) for aerobic and resistance activities, their prescription, and their application to CKD

Principle and Definition	Prescription and Applicability to CKD		Considerations
	Aerobic	Resistance/Strength	
Frequency How often a patient will exercise. Typically refers to the number of days/sessions per week	At least 3 d/wk, but for deconditioned patients or beginners, 1–2 sessions/wk are encouraged	Each major muscle group should be trained at least 2–3 d/wk, but for deconditioned patients or beginners, 1–2 sessions/wk are encouraged If the session is combined (aerobic+resistance), caution should be taken in the choice of the major muscle group (<i>e.g.</i>, avoid quadriceps exercises when cycling) to minimize excessive muscle soreness	Weekly frequency should be progressively increased based on patients' availability and preference. In patients undergoing in-center IDE programs, non-dialysis days can be used to optimize a higher frequency
Intensity How much effort a patient requires for the exercise. This could be objectively or subjectively measured depending on available resources	Objective measures VO_{2peak}: the maximal oxygen uptake estimated by graded exercise tests; HR_{max}^a: the maximum HR estimated by graded exercise tests or predicted by equations (220–age or 208–[0.7×age])⁷⁹; in both VO_{2max} and HR_{max}, a relative % is usually adopted for prescription; RPM: the repetitions per minute during a cyclic exercise, for walking, a step count per minute can be used Subjective measures RPE: How hard the exercise feels to the patient; typically scale ranges from little exertion to maximal effort (<i>e.g.</i>, CR10 scale) General recommendations Light intensity: 37%–45% VO_{2max}; HR_{max}: 57%–63%; RPE 1–2.5 (CR10 scale) Moderate intensity: 46%–63% VO_{2max}; HR_{max}: 64%–76%; RPE 3–4 (CR10 scale) Vigorous intensity: 64%–90% VO_{2max}; HR_{max}: 77%–95%; RPE 5–9 (CR10 scale)	Objective measures RM^b: the maximum weight lifted for one or multiple repetitions; a relative % is usually adopted; however, the application is commonly unfeasible Repetition-range intensity zone^c 80: each exercise session can be performed in a repetition-range zone (<i>e.g.</i>, min 8 and max 12 repetitions) that avoids going to failure or until volitional fatigue, depending on the patient's level (beginner or intermediate) Subjective measures RPE: How hard the exercise feels to the patient; typically scale ranges from little exertion to maximal effort (<i>e.g.</i>, CR10 scale) General recommendations It is recommended that novice to intermediate individuals train with loads corresponding to 60%–70% of 1RM (for 8–12 repetitions) and advanced individuals cycle training loads of ≥80% of 1RM to maximize muscular strength.^{43,81} For older adults/sedentary people, 40%–50% 1RM (light intensity) may be beneficial⁴³ Usually not applied for resistance exercises, but the time under tension⁷³ (<i>i.e.</i>, the sum of the tempos–seconds—for the concentric, isometric, and eccentric phases) has been recently recommended for monitoring Rest intervals of 2–3 min between each set of repetitions are effective	Exercise below a minimum intensity will not promote sufficient physiological adaptations Intensity should be progressively increased to minimize injury risks and excessive muscle soreness that may cause loss of interest and low adherence/compliance A relative measure of intensity (%) may be more appropriate for deconditioned patients When objective metrics are unavailable, the prescriber should be aware of the potential underestimation of the proposed intensity
Time How long is the duration of each bout/session of exercise. The prescribed time could be performed continuously (<i>i.e.</i>, one session) or intermittently	Engage in 20–60 min of continuous activity; however, if this is not tolerable, 3–5 min bouts of intermittent exercise with the goal of accumulating 20–60 min are encouraged	Usually not applied for resistance exercises, but the time under tension⁷³ (<i>i.e.</i>, the sum of the tempos–seconds—for the concentric, isometric, and eccentric phases) has been recently recommended for monitoring Rest intervals of 2–3 min between each set of repetitions are effective	To reach the recommended time of aerobic PA, short bouts (<i>i.e.</i>, exercise snacks) on the same day may be appropriate, even if shorter than 10 min⁴ Time for short intermittent exercise with intervals should follow a 1:1 work-to-rest ratio (<i>i.e.</i>, 1 min of exercise and 1 min of rest) Time under tension may be an alternative for monitoring training load when objective metrics for intensity are unavailable

Table 2. (Continued)

Principle and Definition	Prescription and Applicability to CKD		Considerations
	Aerobic	Resistance/Strength	
Type Mode or kind of exercise chosen for the session	Prolonged endurance and rhythmic activities involving large muscle groups (<i>e.g.</i> , walking, cycling, swimming); or recreational sports (<i>e.g.</i> , racquet sports and soccer)	Machines, free weights, body weight, or bands Include types that target major muscle groups through multi-joint movements, (<i>e.g.</i> , chest press, shoulder press, pulldown, rows, squats, and lunges) Resistance training performed at fast movement velocities (<i>i.e.</i> , ≤ 1 s concentric; ≤ 1 s eccentric) using moderate intensities may be superior for muscular strength gains as compared to moderate-slow resistance training ⁸²	Physiologic adaptations are specific to the type of exercise performed, <i>e.g.</i> , if the patient needs to increase strength in the legs, then lower-limb resistance exercises should be preferable (<i>e.g.</i> , squats and leg extension) Recreational sports with trauma risk should be avoided in patients with vascular access to dialysis For patients undergoing IDEs, new devices incorporated into the dialysis bed/chair have been recently proposed
Volume Total amount of exercise. It is the product of the frequency, intensity, and time of the exercise session. It could be calculated per session, weekly, or monthly	General recommendations are to accumulate 150 min/wk of moderate-intensity; or 75 min/wk of vigorous-intensity; or an equivalent combination of moderate and vigorous intensity to attain the recommended volume	A minimum of 1 set of 8–12 or 10–15 repetitions, with a goal in most patients to achieve multiple sets (2–3) Choose 8–10 different exercises targeting the major muscle groups	Exercise volume in aerobic sessions may be used to calculate an index of energy expenditure, <i>i.e.</i> , METs Resistance exercise volume may be calculated by multiplying sets $\times$ repetitions $\times$ intensity. Multiple methods are available depending on the adopted metrics ⁸³
Progression Exercise advancement. Progression of principles throughout the course of the training intervention, especially volume	Includes adjustments to frequency, intensity, and time (duration) May also include more complex components within the sessions, such as high/moderate intensity interval training, <i>i.e.</i> , intermittent exercise with higher intensity	Includes an increase in repetitions per set, greater load (<i>e.g.</i> , weight or band), or higher frequency An initial increase in the number of repetitions if recommended before increasing the load For example, when the patient can comfortably achieve the upper limit of the repetition-range intensity zone (<i>e.g.</i> , 8–12), weight may be increased by 5% so that no more than 12 repetitions are completed, with or without volitional fatigue, depending on the patient's level (beginner or intermediate)	Progression should be gradual to allow for adaptations to the increased volume, with the potential to lower the risk of injury and promote adequate adherence The rate at which a program is progressed should be individualized based on the patient's responses to training and clinical goals Progression may consist of increasing any of the components of the basic FITT principles
1RM, one-repetition maximum; FITT, frequency, intensity, time, type; FITT-VP, frequency, intensity, time, type, volume, and progression; HR, heart rate; HR _{max} , maximal heart rate; HRR, heart rate reserve; IDE, intradialytic exercise; MET, metabolic equivalents of task; PA, physical activity; RM, repetition maximum; RPE, rating of perceived exertion; RPM, repetitions per minute; VO _{2peak/max} , maximal/peak oxygen consumption.			
^a Many patients may take anti-hypertensive drugs that affect heart rate; this should be carefully taken into consideration.			
^b One-repetition maximum testing may be of injury risk in some patients and should be avoided.			
^c In deconditioned patients or beginners, the repetition-range intensity zone should avoid volitional failure to reduce joint stress and muscle soreness.			
^d Mostly recommended for intermediate or advanced practitioners, preferably in different day shifts (<i>e.g.</i> , morning and evening).			



Case study 1 Non-dialysis

Mrs C is a 54-year-old person living with CKD stage 3a. Her eGFR has been clinically stable for the last 5 years. She has recently retired from an active job and never exercised regularly before. She has put on significant weight over the last few years since her retirement, and her goal is to lose weight so she can go walking with her friends and play with her grandchildren. She has access to her local park and lives near a sports centre, which she has used a little in the past. She has some elastic resistance bands to use at home.

You recommend an 8-week programme for Mrs C with a focus on building aerobic capacity through a range of moderate-intensity activities

	Weeks 1-4	Weeks 5-8
Frequency	- Begin aerobic exercise 2x week - Begin flexibility exercises 1-2 days per week - Encourage a reduction in sedentary behaviour	- Building up aerobic exercise to 3x a week and flexibility exercises building up to 2-3 days per week - Introduce resistance exercise 1-2x week on non-consecutive days
Intensity	Any activity should be performed at a moderate intensity: a RPE (on the CR10) of 3 to 4 or 64 to 76% of maximum heart rate (HRmax)	- Walking/swimming should continue at a moderate intensity - Resistance exercise should be light to begin with (40-50% of 1-repetition maximum); this can progress towards 60-70% 1RM as strength improves
Time	Aiming for 30 minutes, using intervals to help build up to this duration if needed	- Build up duration to 30-45 minutes per session; this can still involve interval-based training 3 sets of 8-10 repetitions on 8-12 exercises involving the major muscle groups should be performed
Type	Exercises like walking, swimming, and gardening	Each session of resistance exercise should involve a combination of the major upper and lower body muscle groups (legs, hips, chest, back, shoulders, and arms)
Other	Patients are often fearful of overexertion; thus, gradual progression should be stressed	



Case study 2 Hemodialysis

Mr W is a 72-year-old retired bus driver with a history of diabetic neuropathy undergoing hemodialysis for the past 12 years. He has weakness, poor balance, a fear of falling, and poor exercise capacity which means when he goes home he is sedentary and struggles with walking. He is interested in cycling whilst having his dialysis at the hospital, having seen others do the same. He is clinically stable and safe to commence activity

You recommend an 8-week programme for Mr W with the first 4 weeks focusing on building some aerobic capacity, before introducing some strength components in week 5 to help reduce weakness

	Weeks 1-4	Weeks 5-8
Frequency	- Begin intradialytic cycling 3x week - Begin flexibility exercises 1-2 days per week - Encourage interdialytic physical activity (e.g., walking) and a reduction in sedentary behaviour	- Continue intradialytic cycling 3x a week and flexibility exercises building up to 3 days per week - Introduce resistance exercise 1-2x week on non-consecutive days, building up to 2-3x week
Intensity	Cycling should be performed at a moderate intensity: a RPE (on the CR10) of 3 to 4 or 64 to 76% of maximum heart rate (HRmax)	- Cycling should continue at a moderate intensity - Resistance exercise should be light to begin with (40-50% of 1-repetition maximum); this can progress towards 60-70% 1RM as strength improves
Time	Begin with intervals of several minutes, building up slowly in duration	- Build up duration to 20-30 minutes per session; this can still involve interval-based training 3 sets of 8-10 repetitions on 8-12 exercises involving the major muscle groups should be performed
Type	- Intradialytic cycling - Walking	Each session of resistance exercise should involve a combination of the major upper and lower body muscle groups (legs, hips, chest, back, abdomen, shoulders, and arms)
Other	There are no contraindications to performing exercise in the last half of the treatment. However, you should wait until the patient is stable on dialysis before commencing exercise	

Figure 2. Example exercise prescription for someone with NDD CKD (case study 1) and someone on hemodialysis (case study 2). Each prescription is stratified by the FITT principles along with other considerations that could be taken into account for the individual. FITT, frequency, intensity, time, type; NDD, non-dialysis dependent.

recommended because of secondary hyperparathyroidism-related bone and joint problems; however, submaximal prediction equations can be used to estimate the one-repetition maximum with minimal risk.⁵⁸ There are no known contraindications to moderate to heavy resistance training in patients with mature vascular access, although patients should avoid exercising the upper limb with temporary or healing arterio-venous fistulas.⁵⁵

Patients with a peritoneal catheter should avoid full sit-ups and activities that involve full flexion at the hip. They can accomplish abdominal strengthening by performing isometric contractions and partial sit-ups or crunches. Swimming may be a challenge for those

with peritoneal catheters because of infection risk, and the catheter should be covered with protective tape and cleaned after swimming. Patients perform exercise more comfortably with abdominal cavities emptied of dialysis fluid, reducing diaphragmatic pressure, breathlessness, and chest discomfort^{25,55,59} (Figure 3, case study 3).

Those with a transplant (Figure 3, case study 4) are often fearful of overexertion; thus, gradual progression should be stressed. Exercise should be decreased in intensity and duration during episodes of rejection, not eliminated. As patients are immunosuppressed, effort must be made to avoid infectious situations. Patients should avoid traumatic damage to the transplanted kidney and participation in



Case study 3 Peritoneal dialysis

Mrs M is a 55-year-old part-time accountant. She has been on peritoneal dialysis for over a decade and is quite active in her day-to-day life. She is a regular walker but wishes to add in more strength and resistance exercises as she feels this may help with her outdoor walking. She has access to a gym in her local town which she would like to use. She is concerned about putting too much stress on her abdominal area and has avoided going to the gym because she is unsure what to do. She is clinically stable and safe to commence activity.

You recommend an 8-week programme for Mrs M focusing on building in strength exercises throughout her usual activity.

	Weeks 1-4	Weeks 5-8
Frequency	Perform aerobic exercise spread out at least 3 days during the week, with no more than two consecutive days between bouts of activity	Undertake resistance exercise at least twice weekly on non-consecutive days, but more ideally 2-3 times a week, along with regular aerobic exercise as per regular physical activity guidelines
Intensity	Any activity should be performed at a moderate intensity: a RPE (on the CR10) of 3 to 4 or 64 to 76% of maximum heart rate (HRmax)	- Walking/jogging/swimming should continue at a moderate intensity - Resistance exercise should be light to begin with (40-50% of 1-repetition maximum); this can progress towards 60-70% 1RM as strength improves
Time	- Aiming for 30 minutes, using intervals to help build up to this duration if needed - In deconditioned patients unable to maintain sustained exercise, intervals of several minutes could be used	- Build up duration to 30-45 minutes per session; this can still involve interval-based training 3 sets of 8-10 repetitions on 8-12 exercises involving the major muscle groups should be performed
Type	- Exercises like walking, swimming or cycling that do not impose undue stress on the feet are some appropriate choices - Core strengthening exercises are recommended	Each session of resistance exercise should involve a combination of the major upper and lower body muscle groups (legs, hips, chest, back, shoulders, and arms)
Other	- Patients with a peritoneal catheter should avoid full sit-ups and activities that involve full flexion at the hip. They can accomplish abdominal strengthening by performing isometric contractions and partial sit-ups, or crunches - Patients perform exercise more comfortably with abdominal cavities emptied of dialysis fluid, reducing diaphragmatic pressure, breathlessness and chest discomfort	



Case study 4 Kidney transplant recipient

Mrs C is a 35-year-old kidney transplant recipient. She had her transplant 6 months ago. She has recently returned to work as a teacher full-time. She has put on significant weight following her transplant and as a result of the medication she now takes. Her goal is to lose weight and return to running; her favourite exercise as she has access to her local park. She has some elastic resistance bands to use at home. She is clinically stable and safe to commence activity.

You recommend an 8-week programme for Mrs C with a focus on building aerobic capacity through a range of moderate-intensity activities.

	Weeks 1-4	Weeks 5-8
Frequency	- Begin aerobic exercise 2x week - Begin flexibility exercises 1-2 days per week - Encourage a reduction in sedentary behaviour	- Building up aerobic exercise to 3x a week and flexibility exercises building up to 2-3 days per week - Introduce resistance exercise 1-2x week on non-consecutive days
Intensity	Any activity should be performed at a moderate intensity: a RPE (on the CR10) of 3 to 4 or 64 to 76% of maximum heart rate (HRmax)	- Walking/jogging/swimming should continue at a moderate intensity - Resistance exercise should be light to begin with (40-50% of 1-repetition maximum); this can progress towards 60-70% 1RM as strength improves
Time	Aiming for 30 minutes, using intervals to help build up to this duration if needed	- Build up duration to 30-45 minutes per session; this can still involve interval-based training 3 sets of 8-10 repetitions on 8-12 exercises involving the major muscle groups should be performed
Type	- Jogging - Walking - Swimming	Each session of resistance exercise should involve a combination of the major upper and lower body muscle groups (legs, hips, chest, back, shoulders, and arms)
Other	- Patients are often fearful of overexertion; thus, gradual progression should be stressed - Patients should avoid traumatic damage to the transplanted kidney and participation in contact sports (e.g., rugby, American football, martial arts, ice hockey, boxing) and/or prolonged extreme exercise (e.g., marathons, Ironman triathlons) must be considered carefully	

Figure 3. Example exercise prescription for someone on PD (case study 3) and with a kidney transplant (case study 4). Prescription is stratified by the FITT principles along with other considerations that could be taken into account for the individual. PD, peritoneal dialysis.

contact sports (e.g., American football, martial arts, and boxing) or extreme sports (mountain biking) and/or prolonged extreme exercise (e.g., marathons) must be considered carefully.¹⁹

Sticking with It: Promoting Adherence and Maintenance of Exercise

Sustaining Motivation

Promoting adherence and maintenance of exercise in people with CKD requires a multifaceted approach to sustain long-term motivation. It is essential to provide

personalized exercise plans tailored to the patient's physical capacity and health status and ensure that activities are realistic and enjoyable. It is also imperative that any prescribed routines are safe, manageable, and will benefit cardiovascular and kidney health. Educating patients about the benefits of regular PA, such as improving cardiovascular health, reducing fatigue, and enhancing overall QoL, can sustain engagement. Incorporating motivational tools such as goal setting, progress tracking, and rewards can foster long-term engagement. In addition, providing social support through group exercise programs or virtual communities can help

combat feelings of isolation and boost adherence. Measures to increase adherence to PA are advisable, such as group or individual education, behavior change techniques, wearable activity sensors, and telemedicine.³⁴ Furthermore, continuous feedback from HCPs or digital resources, coupled with positive reinforcement and regular assessments of progress, helps reinforce the importance of exercise, making it a sustainable part of a person living with CKD's routine.

Promoting Autonomy

As described, a limitation of most trials in CKD is that they typically rely on simplistic, "one-size-fits-all" PA prescriptions, such as IDE, cycling, walking, or strength training that many find boring.^{8,52} Although prescriptions like this often provide modest benefits in the short term, long-term adherence is poor, so benefits are typically not maintained. An alternative approach is to design interventions that allow patients more autonomy to choose activities that are important to them. For example, Tawney *et al.* implemented an intervention in which hemodialysis patients worked with counsellors to develop strategies to accumulate at least 30 min/d of self-selected lifestyle-type physical activities (*e.g.*, housework and gardening) into their daily lives.⁶⁰ Holliday *et al.* used a similar approach in a weight loss trial in overweight women⁶¹ where participants earned "points" for engaging in self-selected exercises on the basis of the MET values associated with each activity.⁶² Providing participants with the autonomy to choose preferred activities that meet intervention goals may result in greater participation and more sustained changes in patient's lifestyles.

Mind the Gap: Implementation into Practice Role and Scope of Exercise Professionals

Despite decades of evidence documenting the health benefits of exercise across the CKD stages, access to dedicated PA/exercise programs remains outside the realm of the standard of care for most kidney care programs across the globe.⁸ To date, the most successful strategy to ensure the delivery of safe, individualized, and effective PA/exercise programs across a range of in-center, community, and home-based settings has been the policy to include exercise professionals in kidney programs (exercise physiologists, kinesiologists, physical therapists, rehabilitation specialists, occupational therapists, athletic trainers, personal trainers, student clinical placements *etc.*).¹¹ However, a recent scoping review summarizing all the available evidence about how PA/exercise is being prescribed for hemodialysis patients highlighted that exercise professionals reportedly supervised only a few of the interventions, and less than half of the exercise protocols described the progression and/or modification of the training programs during the interventions.⁶³ Although simple PA programs can be successfully implemented by the existing clinic staff, long-term sustainability requires dedicated and qualified exercise professionals.⁶⁴ Besides their capacity to deliver effective and individualized exercise assessment and

prescription (using the principles discussed above), exercise professionals also play a vital role in educating patients on the benefits of PA/exercise for their particular condition, and in providing motivational support to help patients adhering to their routines as well as overcoming barriers to PA.

Improving Implementation into Practice

Translating research findings into routine clinical practice is a slow and, in many cases, complex and difficult endeavor.⁶⁵ Many studies that have demonstrated efficacy when it comes to exercise-based interventions have been rarely translated into practice (so-called "research-to-practice gap"). This is particularly evident in the field of renal rehabilitation, where apart from pockets of excellence,^{11,64,66,67} interventions are scarcely available⁶⁸ and remain incomparable to models in other conditions (*e.g.*, cardiac rehabilitation).⁶⁹ The reasons behind this gap are many, but notwithstanding the practical aspects of implementation that necessitate services to allocate appropriate expertise, funding,⁷⁰ and time to support the uptake and continued use of exercise-based interventions,¹¹ there remains a lack of high-quality implementation-focused research.^{8,65} A key element of this is that (often small-numbered) efficacy studies in CKD include (poorly described) exercise protocols that are impractical to replicate in real-world practice,⁷¹ a lack of data on the optimal "dose" of exercise, and a lack of technical expertise and knowledge.

Although it is beyond the scope of the article to fully address the role of "implementation science" in this area, there is great scope to augment exercise interventions into practice:

1. Improving the use of research designs that address nuances associated with real-world services, *e.g.*, conducting pragmatic trials while simultaneously addressing factors influencing implementation and considering the contextual factors in which the intervention may work (or not work).⁶⁵
2. Ensuring that the exercise prescription protocols are detailed in standardized means,^{72,73} and how any intervention may adapt throughout the study.⁶⁵
3. Evaluating implementation strategies, or combination of strategies, that are most effective to improve the uptake of exercise interventions. There are a multitude of implementation strategies that researchers may wish to explore, including the Consolidated Framework for Implementation Research.⁷⁴

Pockets of successful cases of sustained implementation of PA into practice can be found worldwide, including in Portugal, Canada, Mexico, and Germany. Although these programs differ in many regards, such as funding, location, and management, a consistent theme is that they each have substantial and committed support from the entire clinic staff.⁶⁴ Implementation science may benefit in expanding the research agenda, reducing research waste, and increasing the relevance of exercise research in CKD. Yet, without a larger focus on implementation research and the factors in which interventions may work, the vast

amount of money, time, and resources that have been spent trying to address the efficacy of exercise will be squandered if we fail to apply this knowledge in real-world clinical settings.

Conclusions

Based on a constant epidemiologic foundation and numerous randomized controlled trials, the evidence for PA and exercise in people with CKD is well-recognized. Yet patients remain inactive, partly driven by a lack of knowledge and confidence from the HCPs involved in their management. Efforts to improve education in this area are growing and include the recent development of a free training program for healthcare professions by the Global Renal Exercise Network (GREX).⁷⁵ Much like other pharmacologic therapies, an effective prescription should be prescribed at the correct dose, strength, and frequency to the individual, titrated (and progressed) to optimize adherence and safety, and reviewed regularly to ensure maximum effectiveness. Aside from a formal prescription of exercise, many people would benefit from modest improvements in daily PA, and an emphasis on reducing sedentary behavior is likely to confer beneficial effects on outcomes. Although some exercise, such as IDE, can be embedded into clinical practice, it is likely that the biggest benefits will be gleaned from increasing PA outside the grounds of a hospital and integrating enjoyable PA back into the individual's daily life.

Although progress has been made, there is much to be done. More interventions that target a reduction in sedentary behavior and its effect on long-term outcomes are needed. There is also a need to transition away from using exercise/PA as a stand-alone intervention. Instead, exercise should be included as a component of a multifactorial lifestyle modification strategy adhering to the principles of "lifestyle medicine."⁷⁶ There remains a need for closer collaboration and shared decision making between patients, general practitioners, nephrologists, and kidney physiotherapists/exercise physiologists, as exercise prescription requires teamwork. Working together is crucial to preventing exercise in nephrology from becoming an empty narrative, a niche interest without any translation to clinical practice and with no benefit to the health of our patients.

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