

Exercise, Dialysis, and Environment: A Narrative Review in an Ecological Perspective

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Keywords

Exercise · Dialysis · Kidney disease · Environmental research

Abstract

Background: Patient empowerment and environmental sustainability may contribute to creating efficient and resilient healthcare models. Chronic kidney diseases call for a sustainable approach aimed at improving physical function and mental health of patients and possibly contributing to the slowing down of the evolution toward the end stage of renal disease (ESRD) with a reduction of the environmental and economic impact. **Summary:** Multidisciplinary interventions should be implemented particularly, at the final stages when patients are exposed to sedentariness, reduced health-related quality of life (HR-QoL), high cardiovascular morbidity and mortality, and the healthcare services to high costs, and participation in environmental pollution. Ecological strategies based on specific nutritional approaches, exercise, and environment should be designed and tested. In particular, the introduction to physical exercise represents a useful replacement therapy to counteract the hazards derived from the sedentary behavior of ESRD patients, with

low physical function associated with poor clinical outcomes. A more active and healthy lifestyle, particularly in the natural environment, could impact HR-QoL, mental and physical well-being but also on socialization, with lower anxiety and fatigue stress levels. Otherwise, combining sustainable exercise models into the patient's daily routine can be enhanced by the biophilic design called to reproduce a natural environment in the dialysis center. Finally, the involvement of the personnel and the health professionals in properly managing the exercise interventions and the related factors (location, modality, dose, intensity, and duration) might improve the patients' participation. In particular, ecological programs should be broadly inclusive and aimed to target the lowest performing populations through minimal feasible doses of exercise. **Key Messages:** Moving toward an ecological framework of lifestyle change in the very advanced stages of kidney disease, the potential synergies between environment, diet, and exercise may improve the physical and mental health of the patients and reduce the impact of dialysis.

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Introduction

The World Health Organization (WHO) defines sustainable healthcare (SH) as a system that improves, maintains, or restores health while minimizing negative impacts on the environment and leveraging opportunities to restore and improve it to the benefit of the health and well-being of current and future generations [1, 2]. Unfortunately, there is clear evidence suggesting that the activities of any healthcare system significantly impact and pressurize the environment [3, 4] by generating hazardous and conventional garbage or causing significant energy and water consumption and greenhouse gas emissions. Fortunately, technological advances in healthcare have shown the potential to provide health benefits while safeguarding the environment [5]. Effective, efficient, and resilient healthcare models should be designed according to environmental sustainability and patient involvement as well as transversally adaptable for treating of chronic and noncommunicable diseases. Among these, chronic kidney disease (CKD) requires sustainable approaches. In particular, for patients in the final stage, when dialysis treatment is life-saving while waiting, whenever possible, for kidney transplantation. However, critical aspects have been highlighted [6, 7], including high cardiovascular morbidity and mortality, reduced health-related quality of life (HR-QoL), costs related to management and transport to dialysis centers, and overall global disparities due to increasing demand and insufficient availability of treatment itself. Moreover, the serious environmental impact of hemodialytic treatment has also been reported and recently extensively reviewed [8, 9]. Therefore, specific strategies should be implemented for CKD patients and their families. Considering the overall scenario, this narrative review aims to describe the connections among exercise, recognized as a useful tool to counteract the hazards derived from the sedentary behavior of CKD patients [10–16], environment, and diet to make the former a policy priority, to improve the physical and mental health of CKD patients, and to reduce the impact of dialysis.

Exercise and CKD

The promotion of physical activity in patients with CKD represents both an ecological strategy and a necessary “replacement therapy” since spontaneous activity measured or reported in these people is markedly reduced in comparison with the elderly population and age-matched peers [17–19]. This sedentary behavior is associated with progressive deconditioning, skeletal muscle atrophy, dysfunction, and chronic fatigue, leading to a

progressive reduction in exercise capacity, frailty, and disability [20–22]. In the course of this unfavorable progression, an inadequate lifestyle is associated with poor control of risk factors (e.g., blood pressure), low HR-QoL, psychological discomfort, depression, and lack of motivation [23]. Moreover, reduced physical activity and impaired mobility, as well as low physical function, are associated with poor clinical outcomes among the CKD population in general [24], with higher cardiovascular morbidity and all-cause mortality, particularly among patients on hemodialysis (HD) [25, 26]. When kidney disease progresses to its final stage and requires dialytic treatment, physical functioning frequently worsens [27]. After the initiation of dialysis therapy, particularly HD, the patients’ physical activity level decreases to approximately 25% of that recorded in age-matched sedentary healthy individuals, and one out of three HD patients is unable to perform activities of daily living without assistance [22]. This triggers a vicious and potentially dangerous cycle for the health of patients, with an increased risk of morbidity and mortality [22]. Physical activity represents an effective tool to break this vicious cycle, with reported beneficial effects on physical fitness, walking capacity, health-related QoL, and other parameters [10, 11] at all stages of the disease [11, 28]. Exercise has a positive impact on the cardiovascular system, walking capacity, and aerobic fitness, as well as on HR-QoL and mood [11, 28], and even minimal weekly doses of exercise have been reported to be associated with better clinical outcomes [27, 29, 30].

For the abovementioned reasons, the National Kidney Foundation KDOQI Clinical Practice Guidelines for Cardiovascular Disease in Dialysis Patients report that patients should be counseled and encouraged to increase their level of physical activity [31]. However, exercise is still not prescribed regularly as part of usual care [15, 22] due to several barriers related to patients’ and staff’s attitudes, including a reported poor proactivity in encouraging patients to participate in exercise programs [32]. A behavioral change in patients’ attitudes toward a more active and healthy lifestyle could represent an ecological intervention for its impact on physical, mental, and emotional well-being [28]. These interconnected aspects, potentially improvable through physical exercise [28], are perceived by patients [33–35] beyond the currently available scientific evidence [17]. Indeed, patients request effective interventions to prevent cardiovascular diseases, improve mobility, and slow physical decline after dialysis treatment to improve debilitating physical (fatigue, insomnia, and cramps) and mood symptoms (depression, anxiety, and frustration) [6, 36]. Patients also

aim to preserve a good HR-QoL with the possibility to travel [37, 38], maintain mobility and the ability to work, have dialysis-free time, and reduce the impact of dialysis on family and/or friends [6, 39–41]. Most of these aspects still need to be addressed, or the scientific literature struggles to find wide-ranging solutions not limited to specific effective interventions (e.g., a clinical trial). The everyday reality and routine nature of renal care address the limited availability of effective programs offering physical function assessment and/or exercise training, which positively influence the trajectory of renal care [17, 42, 43], or crushes on the reported patients' and nephrologists' barriers in understanding the importance of exercise interventions [15].

Exercise and Dietary Interventions

To favor an ecological strategy aimed at counteracting the negative effects of sedentariness and lack of exercise in patients with CKD, various key elements should be considered [16, 20]. At first, the importance of diet in protecting against the unfavorable progression of renal disease [44, 45] and the management of dialysis treatment [44] through a comprehensive nutritional approach based on natural foods and low protein, phosphate, or salt, red meat [46–50] and adequate fluid management [17, 50] is well known. The nutritional approach, on the one hand, may provide a synergistic effect with exercise, improving patients' well-being; on the other hand, the effects of nutritional interventions [51] could favor the physical performance of CKD patients [52] through targeted nutritional strategies (e.g., protein supplementation) associated with different types of exercise. However, based on the trials available in the literature, the results of the combination of exercise and supplementation are partly conflicting (Table 1), without clear evidence of its benefit. Finally, malnutrition should also be avoided and possibly prevented with simple screening tools [53].

Connection between Exercise, Dialysis, and the Environment

In addition to nutrition, the synergy between exercise and the natural environment can also be exploited. According to Lewy et al. [59], "patients are less likely to exhibit signs of depression, especially where access to natural light and opportunities for physical exercise are present." Indeed, it is believed that spending time in nature can promote and encourage physical activity. A natural environment combined with exercise may improve mood, functioning, social cohesion, and positive social relations between people [60–72]. The connection between exercise and the environment has been exten-

sively reviewed, with a significant favorable effect of exercise in the natural environment on mobility, quality of life, and other biomarkers (Table 2).

Encouraging an active lifestyle and the ability to move freely outdoors is a goal for CKD patients [14], as is improving this aspect at the care site. Indeed, the positive effects of the natural environment should be particularly pursued in HD patients, where the ecological model acquires a double meaning, considering that the Greek word "oikos" means "home," or "place to live." Considering that HD therapy involves a prolonged daily presence in the place of care, the creation of a favorable ecosystem (e.g., by rethinking the care environment itself) could foster a model of psychological and social interactions, with benefits not only for patients but also for healthcare professionals. In this sense, the exploitation of the research in the fields of therapeutic and environmental design the so-called evidence-based design or the biophilic design [82–84], with the inclusion of nature or natural elements, may also be considered in the dialysis center. The importance of a friendly, healthy, and, when possible, colorful and stimulating hospital setting has been demonstrated in geriatric medicine, pediatrics, and psychiatric wards. In this broader sense, attention to a green environment should merge with attention to a healthier, friendly setting of care [7]. It is well known that the humanization process of healthcare spaces with natural elements can empower patients due to the reported positive changes in cognitive, physical, and social functions by reducing stress and pain and improving emotional well-being [83]. Indeed, the attempt to use architectural projects to reconnect humans with nature to improve psychological and physical well-being has led to radical transformations over the past decades in hospitals and healthcare centers [83]. The aims were to turn these places, characterized by pressure and stressors, into therapeutic environments, supportive of family involvement, efficient for staff performance, and restorative for workers under stress [64, 83–85]. In patients, exposure to different "kinds" of nature (including natural landscapes, direct contact, natural shapes, natural lights, and materials) results in a shorter length of hospital stay, lower use of analgesics, lessened perception of pain, greater quality of life in terminally ill patients, lower stress and anxiety levels, more positive thoughts and increased coping ability [64, 67, 83–95]. In addition, considerable literature links natural exposure to improved physiological health markers, such as increased expression of anticancer proteins, a reduction in hypertension, and favorable changes in heart rate variability [85, 95–100]. Nonetheless, these biophilic design choices also boost the

Table 1. Summary of paper that couples a nutritional and exercise intervention in CKD patients

Author	Journal	Year	Study design	Sample size	Age, years	Intervention	Outcomes	Results
Martin-Alemañy et al. [54]	J Ren Nutr	2019	Parallel controlled clinical trial	<i>n</i> = 45 (<i>F</i> = 24)	29±9	AE + ONS (<i>n</i> = 15) RE + ONS (<i>n</i> = 15) ONS (<i>n</i> = 15)	Physiological Psychological	Exercise and ONS had larger effects on PF than ONS alone
Gamboa et al. [55]	Am J Physiol Renal Physiol	2020	Prospective, randomized, open-label, parallel-arm clinical trial	<i>n</i> = 12 (<i>F</i> = 2)	41 (30–50)	RE + ONS (<i>n</i> = 6) ONS (<i>n</i> = 6)	Neurochemical	IPS increases protein balance, fat cross-sectional area of the thigh, and markers of mitochondrial content
Majchrzak et al. [56]	Nephrol Dial Transplant	2008	Randomized, prospective, crossover study	<i>n</i> = 8 (<i>F</i> = 2)	38±11	RE + ONS	Neurochemical	RE improves protein anabolic effects of intradialytic ONS
Dong et al. [57]	J Ren Nutr	2011	Randomized controlled trial	<i>n</i> = 32 (<i>F</i> = 11)	43±13	RE + ONS	Physiological	The addition of RE to ONS did not show any extra effects on muscle protein accretion
Martin-Alemañy et al. [58]	Nephrol Dial Transplant	2016	Randomized clinical trial	<i>n</i> = 36	44 (24–43)	RE + ONS (<i>n</i> = 22) ONS (<i>n</i> = 22)	Psychological; neurochemical	ONS during HD improves NS. The addition of RE did not show better effects

F, female; AE, aerobic exercise; ONS, oral nutritional supplementation; RE, resistance exercise; PF, physical function; IPS, intradialytic protein supplementation; HD, hemodialysis; NS, nutritional status.

activity of the parasympathetic nervous system, thereby decreasing stress levels and encouraging a general sense of well-being [83–85]. Favorable effects have also been reported in healthcare staff in terms of increased attention level and productivity, organizational capability, and increased job satisfaction [83, 101–105]. Moreover, staff stress and fatigue can be reduced through a healing and supportive environment, which may be achieved by applying evidence-based concepts such as places of respite in healthcare design [93]. Finally, caregivers and visitors who are perhaps equally benefited by an outdoor place of respite due to daily stressful conditions and long hours need positive distractions within the healthcare campus [83, 85].

Considering that biophilic design is based on the attempt to transfer the innate inclination of individuals toward natural systems and processes in urban projects, six biophilic design elements (environmental features; natural shape and forms; natural patterns and processes; light and space; place-based relationships; and evolved

human-nature relationships) are possible [102]. The modification of the healthcare environment is achievable not only through architectural solutions that encourage direct contact with the external natural environment but also through the insertion of green or biophilic elements within interior spaces. Biophilic design is not only about integrating plants into the built environment (e.g., green walls, green roofs, and plants in rooms) but also consists of a more complex experience founded on correctly understanding of the human-nature relationship [101, 102]. Finally, through real contact with nature, indirect experience of nature through contact with the image of nature, or perspective in interior spaces, an increasingly immersive nature experience can be provided [82–84]. The humanization process of healthcare spaces, being an adaptable and potentially effective tool, is an experience that could also be realized in the dialysis center, considering the long-term occupation of patients, and it could also be associated with intradialysis physical activity engagement.

Table 2. Summary of the literature reviews that investigated the psychophysical effects of exercise in natural environments

Author	Journal	Year	Studies included	Intervention	Outcomes	Results
Antonelli et al. [73]	Int J Biometeorol	2019	8	Forest walking	Psychological	Forest bathing can reduce stress levels
Brito et al. [74]	Environ Sci Technol	2022	24	Green exercise	Physiological Psychological	Green exercise is associated with greater benefits than indoor exercise
Hansen et al. [75]	Int J Environ Res Public Health	2017	64	Forest walking	Physiological Psychological	Forest walking reduces HR and BP, and increases relaxation
Ideno et al. [76]	BMC Complement Altern Med	2017	20	Forest walking	Physiological	Forest walking can significantly reduce BP
Yau et al. [77]	Environ Health Prev Med	2020	14	Forest walking	Physiological neurochemical Psychological	Forest walking has physiologically and psychologically relaxing effects on people with pre-HTN and HTN
Lahart et al. [78]	Int J Environ Res Public Health	2019	28	Green exercise	Physiological Psychological	Limited evidence that green exercise offers superior benefits than indoor exercise
Marini et al. [79]	Int J Environ Res Public Health	2022	6	Green exercise	Physiological Psychological	Green exercise can have positive impact on healthy population
Park et al. [80]	Int J Environ Res Public Health	2022	32	Forest walking, green exercise	Physiological Psychological	Forest walking can improve physiological and psychological outcomes
Piva et al. [72]	Rev Environ Health	2022	10	Forest walking	Physiological neurochemical psychological	Forest walking can improve physiological and neurochemical parameters and psychological wellbeing
Wicks et al. [81]	Appl Psychol Health Well-Being	2022	24	Green exercise	Psychological	Green exercise can improve psychological outcomes better than exercise performed in urban environments

SCL, salivary cortisol; HR, heart rate; BP, blood pressure; HTN, hypertension.

Exercise and CKD Progression

Among the clinical outcomes related to the ecological approach to exercise in CKD patients, there is the possibility of positively interfering with renal function and renal disease progression through patients' physical empowerment. Slowing the disease progression process represents not only significant economic savings that can be reinvested in health interventions but also significant savings in the environment, and especially in the HR-QoL life of the person and family members [6, 7]. Stable values of kidney function parameters have been observed among physically active older subjects [106] com-

pared to inactive ones [107], as well as a slower rate of eGFR loss in patients with CKD, as well as in persons at a higher level of fitness [18, 43, 108–111] or a favorable or even small effect on eGFR after physical training, without effects of exercise on proteinuria [112–114].

The deceleration of CKD progression may be related to the favorable effects of physical activity and exercise on blood pressure control and vascular stiffness, although the results are controversial [115–117]. In CKD patients with concomitant peripheral artery disease and claudication, walking as a form of exercise rehabilitation may lead to a lower rate of peripheral revascularization [43,

Table 3. Summary of the literature reviews investigating the effects of intra- or extra-dialysis exercise training on different outcomes

Author	Journal	Year	Studies included	Intervention	Outcomes	Results
Cai et al. [122]	Ann Palliat Med	2022	7	AE, RE	Physiological Psychological Neurochemical	AE + RE can improve the urea clearance index, mental health, social functioning, and QoL
Bernier-Jean et al. [28]	CDSR	2022	89	AE, RE	Physiological Psychological Neurochemical	There is no certainty about the effects of AE or RE on the mental component of QoL
Hargrove et al. [123]	CJASN	2021	15	AE	Physiological Psychological	IDE and EDE can be therapeutic options for RLS, depression, muscle cramps, and fatigue
Hu et al. [124]	Qual Life Res	2022	33	AE, RE	Psychological	AE can improve QoL. IDE can enhance the PCS and PF but not the MCS and BP
Huang et al. [125]	Am J Nephrol	2019	20	AE, RE	Physiological Psychological Neurochemical	AE or AE + RE can be beneficial for exercise capacity, walking capacity, and QoL
Molsted et al. [126]	Dan Med J	2019	8	RE	Physiological Psychological	RE can improve self-reported physical function and the physical component of SF-36
Salhab et al. [127]	J Nephrol	2019	22	AE	Psychological	IDE has a positive effect on the physical and mental components of SF-36
Song et al. [128]	J Pain Symptoms Manag	2018	15	AE, RE	Physiological Psychological	AE and RE may reduce the severity of RLS, depression, and fatigue
Zhang et al. [129]	Nurs Open	2018	14	RE	Physiological Psychological	IDE may give benefits in physical function; however, there is no difference in the SF-36

AE, aerobic exercise; RE, resistance exercise; QoL, quality of life; IDE, intradialytic exercise; EDE, extradialytic exercise; RLS, rest-leg symptoms; PCS, physical component summary; PF, physical function; MCS, mental component summary; BP, bodily pain; SF-36, short-form health survey.

118], with a lower need for kidney-invasive diagnostics (e.g., angiographic procedures) employing contrast agents [119, 120]. However, the overall quality of the reported trials is generally low, and the potential ability of exercise to delay the initiation of dialysis treatment needs to be verified in prospective high-quality studies [109]. In dialyzed patients (both HD and PD), the effects of physical exercise on dialysis treatment efficiency have been reported [121], with benefits observed in terms of improved HD adequacy, exercise capacity, depression, and quality of life (Table 3).

An Ecological Model for Patients on Dialysis

The demonstrated wide range of clinical benefits and patients' requests indicate the need for effective exercise-based interventions, which have been pro-

posed and validated by researchers in the field [18]. However, despite the evidence in recent literature, it is difficult to believe that a single exercise-based intervention, even the most effective, can be widely disseminated and accepted by the majority of the scientific community [18, 42]. The creation of sustainable, feasible, and broadly inclusive models of exercise and the incorporation of these activities into patients' daily routines is a necessary objective to pursue despite its complexity.

Moving toward an ecological framework of the patient's engagement in physical activity, the interaction between the subjective and the environmental factors that influence, positively or negatively, patients' behavior needs to be considered [130, 131]. According to Sallis and Owen [132], these interventions should

Table 4. Parameters that should be considered when designing an exercise program in population with renal failure

Absence of medical contraindication to exercise	
Evaluation of patients' exercise capacity	
Patients' preferences and attitude	
Training parameters (F.I.T.T.)	
Frequency	Times per day Times per week During dialysis Extra-dialysis
Intensity	Low Moderate Vigorous/high
Time	Interval training Continuous training Resting time
Type of exercise	Aerobic (e.g., walking overground/treadmill, cycling, and rowing) Strength (overweight, natural load, etc.) Combined Others (e.g., yoga and Tai-Chi)
Other parameters	
Setting	Indoor/outdoors Gym/natural environment Dialysis center
Economic	Allowance of patients Reimbursement
Availability of resources	Trainers and their experience Instruments/machine spaces
Supervision	At home Supervised At home with online supervision

operate on multiple levels and should be designed considering the four domains of physical activity, namely, active recreation, household activities, occupational activities, and active transportation, which contribute to defining “active living” [131–133]. For CKD patients, different models should be designed, paying particular attention to the most fragile subgroup of this population or those at the final stage of the disease. These four domains are mainly limited by the impact of the dialytic treatment, which occupies a significant part of the patient's day and causes him/her to experience fatigue and limited residual energy. In this scenario, various exercise-based interventions should be tested in real-life models, taking into account the complex characteristics of these patients, including skills, limitations, and preferences (Table 4).

An expert in exercise training may offer group-based or individualized training solutions by assessing the subject's domains [131] and acting as a connector between the person, the environment, the family, and the nephrology staff. Customization should consider several related aspects to be integrated into the ecological model, such as patient-related factors (family context, age, disability status, income), needs, and preferences about exercise execution [131, 134].

If we know “why exercise” is sufficient to design the model, it is important to clearly define where, when, and how much [18] exercise is recommended for patients. The expert should also properly manage the exercise intervention and its determining factors.

The location at which exercise training is performed is a crucial factor, according to the individual preferences of a single patient. This aspect, only partly investigated,

shows the preference of patients for home-based exercise [18, 33], including low-cost tele-rehabilitative therapies that are considered effective [6]. However, the choice of the home environment, or natural or outdoor environment, may be dependent on the patient's degree of fitness, age, knowledge, skills and abilities, neighborhood or environmental surroundings, and related safety (e.g., access to sidewalks) or autonomy of transport [70, 71]. Training activities at home can be facilitated by technology and controlled by wearable or remote systems. They can be carried out individually, organized (e.g., walking groups), or structured through precise home-based programs [18, 27, 134]. The choice of an extra home environment may consider supervised community-based programs, which are limited by the availability of fitness facilities, distances from patients' homes, the possibility of transportation, and the costs and affordability for patients.

As a final alternative, some patients may prefer the hospital environment or, more specifically, the dialysis unit [18, 33]. Here, it may be implemented with an exercise specialist or a multi-professional team to carry out different unstructured or structured training interventions [134, 135].

After the setting, a second crucial parameter is the exercise modality. The scientific literature offers various recommendations regarding the intensity, duration, and frequency of aerobic and/or resistance training [136]. Despite low functioning and high cardiovascular risk, no side effects related to exercise were reported, leading to a lack of evidence for exercise restrictions [10, 11, 137]. However, the main issue remains encouraging people with comorbidities and disabilities [15] to engage in physical activity and exercise; therefore, safe and inclusive approaches need to be fully considered.

Exercise protocols should be designed to require a few preparticipation visits for the selected patients at a proper intensity to be safe for people with different capabilities [15, 16] and to minimize exercise-limiting symptoms. For example, in patients with peripheral artery disease, who represent a significant percentage of CKD patients, claudication pain often represents a barrier to training [138]. Low pain levels during exercise or pain-free training may favor good adherence [27, 139, 140]. In elderly individuals, a modest increase in physical activity has been associated with improved renal function while keeping the patient in the sedentary range [114]. Low-intensity programs carried out for short periods (8–15 min per day) were associated with benefits in strength, HR-QoL, clinical outcomes,

and hospitalization in CKD and ESKD patients [27] and may reduce post-dialysis fatigue and symptoms such as restless legs and cramps, with a legacy effect [141]. According to the Dialysis Outcomes and Practice Patterns Study, an exercise frequency of more than weekly session was associated with a lower mortality risk [21]. Effective protocols should be based on simple exercises (walking, pedaling, lightweight, or bands), possibly structured [27]. Finally, the program should be well accepted and chosen from various options to involve persons in their care and even flexible [134, 142]. The guidelines for chronic diseases recommend performing at least 150 min of moderate-intensity aerobic physical activity a week or 75 min of vigorous-intensity activity [143]; however, even lower doses of exercise can provide documented benefits [144]. In terms of duration, training programs ranging from 4 to 6 months are generally reported for end stage of renal disease patients, and effective shorter repeatable cycles of exercise training may be designed to gain rapid benefits and favor training periodization over a foreseeable time, also considering the high-risk of morbidity and drop-outs.

Ecological exercise programs should aim to increase physical activity and favor socialization. However, in this direction, protocols should aim to be the least expensive possible (or free of charge) and the least expensive in terms of transportation, training tools, and resources (electricity, pollution, etc.). Moreover, they should have minimal training goals that may be reached to avoid frustration and possible abandonment. Finally, exercise interventions could also be combined with physical or psychological complementary activities or behavioral interventions such as laughter therapy [145], mindfulness treatments, narrative and storytelling, and relaxation (music and cinema) [146].

Therefore, it is necessary to define who can carry out this synthesis and provide the ideal exercise accompaniment for each subject, considering the reported positive effects of counseling [18]. An expert healthcare professional may represent a professional and human resource on the patient's side. Considering the several limitations of physical activity among nephrological nurses [147, 148], as well as the poor experience of nephrologists [147], the presence of health and fitness professionals may have a crucial role in creating multi-professional teams in dialysis units [149]. These figures may address organizational and logistic issues and patient counseling in terms of exercise, based on the experience progressively gained

[134]. Furthermore, this role is crucial considering the importance of integrating with personnel engaged in the patients' healthcare (doctors, nurses, etc.) to disseminate the possible benefits derived from exercise and increased physical activity, considering the reported low rates of exercise counseling among nephrologists [32].

Finally, changes in the individual ecological approach can occur according to local [131] or general availability of community facilities, rehabilitative services in the hospital, changes in exercise and physical activity policy barrier domains, and novel strategies in kidney care, which could facilitate health services to increase physical activity levels in CKD and ESKD patients [15]. Given the importance of these outcomes to patients and stakeholders, researchers in the field of nephrology are warranted to develop tools to enable valid and consistent measurement of these outcomes and identify interventions that could favorably modify them.

Conclusion

Researchers are currently attempting to hypothesize and test safe, sustainable, and effective interventions to improve patients' mobility and attitudes toward exercise in real-world environments. On this basis, feasible models that overcome as many barriers as possible with ease of application may be derived and implemented in nephrology centers in any country, aiming at including as many patients as possible and overcoming the selection criteria imposed by randomized trials. When possible, multidisciplinary interventions promoting

exercise training, dietary improvements, and behavioral and environmental modifications should be designed. Multidisciplinary models that are sufficiently effective and cost-efficient and based on simple concepts, if shared without preconceptions by stakeholders, could be welcomed by persons on HD, positively impacting patient-centered outcomes and with wide dissemination.

These steps could favor "global and local policy reform to address funding, service provision, legislation, regulations, guidelines, environmental aspects, and communication and marketing to maintain physical activity and a high quality of life of people with kidney disease" [15]. However, in addition to top-down interventions, bottom-up efforts from patients and researchers are necessary [7].

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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