Chapter

Effect of Exercise on Health-Related Quality of Life in Patients with End-Stage Renal Disease

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Abstract

Chronic kidney disease (CKD) is becoming more common around the world. Chronic kidney disease (CKD) is linked to a wide range of other health problems, such as diabetes, hypertension, stroke, and pulmonary illness. Patients with CKD tend to lead sedentary lives for a variety of reasons. Dialysis patients, on the other hand, are much less active than the general population. All of these factors raise the likelihood of future morbidity and mortality, while also lowering the overall quality of life for people who are ill (HRQoL). Regular physical activity (PE) has been shown to increase overall well-being and HRQoL. Here, we discuss several PEs and their effects on CKD patients' physical fitness, function, and HRQoL, as well as the significance of haematocrit normalisation and the influence on their serum phosphorus levels. We have discussed the advantages of PE for this particular population of individuals as well as the side effects of intradialytic PE. There have also been discussions on factors that contribute to impaired physical function in CKD patients and the impact of PEs on different bodily systems.

Keywords: chronic kidney disease, end-stage renal disease, health-related quality of life, physical exercise, quality of life

1. Introduction

Health and QoL (quality of life) have different meanings to different people. Despite the fact that health has an impact on life happiness, health is simply a minor factor. As a result, health is seen as a component of QoL [1]. Perceived QoL refers to how people view and evaluate their quality of life. Subjective quantification refers to measuring how satisfied and happy you are with many aspects of your life, such as your health [2]. It is a notion that advocates quantifying your own life experience subjectively.

Health-related QoL (HRQoL) is a subgroup of QoL that is most affected by health or treatment [1]. Furthermore, either disease-specific or generic tools estimate it. It collects data on patients' knowledge about specific areas of health, such as HIV-QL31 or EORTC QLQ-C30, that are affected by a specific disease, whereas the latter measures general well-being that is applicable to all health states, including healthy individuals such as the 36-Item Short-Form (SF-36®) Survey or the EuroQoL 5 Domain (EQ-5D) tool.

Chronic diseases have become more common during the previous few decades. This is because the population is getting older, medical technology is improving, and infectious diseases are being better prevented and managed. Consequently, a higher proportion of people suffer from long-term disorders that impair their HRQoL. Chronically ill adults, such as those with hypertension, diabetes, coronary heart disease, congestive heart failure, chronic obstructive pulmonary disease, and arthritis, have lower HRQoL than healthy adults. Co-existing diseases reduce HRQoL even further [3].

Chronic diseases affect a range of HRQoL indicators, such as pain, general health, mental health, social function, and sleep, and a lower HRQoL may be the result. The primary care services supplied may have an impact on these other industries (e.g. mental health counselling, pain medication, and self-management education to aid in performing routine functions). HRQoL estimates, including complicated processes such as intervention dose–response relationships, might therefore play an important role in evaluating primary care services. An assessment of HRQoL in individuals with chronic conditions may also help raise awareness of the significance of providing high-quality care to all patients. HRQoL considerations are an important part of providing patient-centred comprehensive care, and this approach can help patients by improving their self-management skills. HRQoL. HRQoL estimates can be used for a variety of purposes, including patient-physician contact, programme design, and support services. A simple HRQoL assessment can make a big difference in a patient's quality of life [3].

Chronic kidney disease is defined as renal failure that lasts more than 90 days (CKD). It is quite common, affecting between 2.5 and 11.2% of adults in Asia, Australia, Europe, and the United States. If untreated, albuminuria can proceed to end-stage renal disease (eGFR 15 mL/min/1.73 m^2 and urine albumin >300 mg/g), necessitating a kidney transplant or the usage of MHD/PD (RT). The annual healthcare cost for persons with end-stage renal disease (ESRD) exceeds $1 trillion, indicating a considerable financial burden [4]. In India, HD is expected to cost INR 29,852 per month while peritoneal dialysis will cost INR 28,763 per month [5]. According to another study, sustaining individuals with ESRD costs INR 2,13,144 per year [6].

HRQoL deteriorates as CKD progresses in patients with ESRD, and is usually harmed as a result of lifestyle and dietary constraints, disease-related complications, multiple comorbidities, polypharmacy, dialysis-related side effects, rapid ageing, and a uraemic milieu [7]. Poor HRQoL has been associated with an increased risk of hospitalisation and mortality [7, 8], and therefore, attempts to enhance it are necessary for more than just obtaining a good HRQoL target.

Patients with CKD who do not require dialysis or HD are urged to participate in physical activity (PE), which should include 30 minutes of aerobic exercise (AE) on most days of the week [9, 10]. Despite these recommendations, physical activity levels, activity-related energy expenditure, and daily step count in CKD patients on MHD were all shown to be comparable to those of a sedentary lifestyle. In people with CKD and RT, a growing body of evidence demonstrates that regular PE improves HRQoL, the cardiovascular (CV) system, aerobic fitness, and walking capacity.

Physical activity benefits patients with CKD, especially those with end-stage renal illness, according to these data (ESRD).

2. Definitions

Quality of life (QoL): This is a phrase used to describe how well a person feels about their position in life as it relates to the culture and value frameworks in which they live, as well as their personal goals, standards, expectations, and concerns.

Furthermore, QoL refers to an all-encompassing sense of well-being that includes both objective and individual-level weighted metrics of well-being in terms of emotions, physical health, social well-being, and material well-being [1].

HRQoL relates to how well a person functions and perceives their well-being in connection to their physical, psychological, and social health, and includes well-being traits that are linked to or influenced by the presence of sickness or treatment [1, 2].

Physical activity (PA) is any movement of the body that needs the expenditure of energy and is caused by the activation of skeletal muscles [11]. Because it encompasses all motor behaviour, including both routine and recreational activities, it is an essential lifestyle aspect for overall health and well-being [12].

Physical exercise (PE) is a subcategory of PA that includes motions that are pre-planned, structured, and repeated. One or more aspects of physical fitness are improved or maintained as a final or transitional goal [11]. Aerobic and anaerobic activities with a set frequency, duration, and intensity constitute one type of PE.

3. Types of physical exercises

Patients with CKD who have PE had better outcomes overall, as previously mentioned. These individuals were indicated for a wide range of PEs, including the ones listed below:

3.1 Aerobic exercise (AE)

Aerobic energy production efficiency improves and cardiorespiratory fitness improves after taking AEs. Walking, running, cycling, rowing, and swimming are all examples of low-impact exercise. There are numerous health benefits to doing this, including higher insulin sensitivity (IS), greater mitochondrial density, increased levels of antioxidant enzymes in the body, improved lung and immune system performance, and increased cardiac output [13]. Patients with chronic diseases benefit from AEs because they lower their blood pressure (BP) and increase their maximum oxygen intake. Aside from improving physical function and aerobic capacity, these treatments may also provide other benefits for the patients. CKD patients on haemodialysis who engage in regular aerobic physical activity see some improvement in their diminished functional capacity [14]. AE may improve renal function and quality of life in CKD patients [15]. In-between-session AEs have shown encouraging benefits [16–18].

3.2 Resistance exercise (RE)

All main muscle groups are used in RE, which uses weight or resistance to make the body's skeletal muscles contract. In addition to lowering glycated haemoglobin levels, it has been linked to improvements in CV, body mass, physical function, glycaemic control, insulin sensitivity, blood pressure, and lipid profiles. Comparatively, it has a lower risk of hypoglycaemia and blood glucose fluctuations [13]. In order to help patients achieve functional independence, the RE is designed to include activities and context-oriented practice in areas that are important to each patient. It targets the antigravity muscles in particular and aims for the greatest possible carryover into daily activities. Body weight, gravity, resistance bands, free weights, and a weight vest can all act as resistance [19].

3.3 Combined exercise (CE)

It incorporates elements of AE and RE in one module. With CE, health and general cardiovascular benefits can be optimised while minimising risk factors associated with sedentary lifestyles. Because of this, it leads to better blood pressure regulation as well as lower insulin and glucose levels, glycated haemoglobin, visceral adipose tissue, and microalbuminuria [13].

3.4 Flexibility and balance exercises

Individuals benefit from it because it stretches muscles and improves balance and postural stability, allowing them to move more freely during other workouts and in daily life. It is possible for these to be static (e.g. not bending the knees) or dynamic (e.g. high knees). Exercises that improve balance and save you from falling include balance training. If you want to walk backwards or heel-toe in a straight line, you can do so [13].

Patients with severe renal impairment benefit equally from resistance and balance exercises, which both increase physical activity and improve renal function. Thus, to enhance the therapy effects of exercise in dialysis patients, it is better to combine these components in a balanced fashion or to change them individually [20].

4. Physical exercise in chronic illness

4.1 General impact

An important risk factor for many chronic diseases is physical inactivity, which can be prevented and treated. Chronic physical inactivity has been linked to an increased incidence of adverse CV events and a greater death rate in patients with peripheral arterial disease and dialysis. Simple frequent physical activity can serve as a springboard for healthy living and deliver substantial health benefits [21].

Daily PA and PE, according to current studies, can help avoid chronic diseases (such as cardiovascular disease, type 2 diabetes, obesity, and cancer) and mortality, as well as serve as a primary disease prevention strategy. Patients with high blood pressure and known cardiovascular diseases can potentially benefit metabolically and cardiovascularly from moderate-intensity activities [22–24]. A reduction in mortality risk may also result from improved and sustained physical fitness over time [10]. When a chronic illness is diagnosed, including PA and PE in the disease management strategy, improves the patient's overall health. PA and regular PE improve QoL and lengthen life when used in disease prevention or treatment [25].

Pre-dialysis patients with severe CKD suffer from decreased physical function and performance due to a variety of factors, including renal function decline, arteriosclerosis, and chronic inflammation [26]. Pre-dialysis CKD patients with improved physical performance and higher PA levels have lower overall mortality and CVD risk [27]. Patients with CKD benefit greatly from exercise training, which includes both aerobic and resistance activities, as well as increased muscle strength and lower blood pressure (BP) [26]. PE also benefits dialysis patients' physical health by improving CV function, blood pressure, muscle strength, and nutritional status, as well as improving dialysis quality [28]. For HD patients, PA in everyday life has a greater impact on QoL than it does in the general population [29].

4.2 Effect on physiological parameters

Muscle mass, strength, IS, mitochondrial content, and regeneration capacity can all be improved with PA. It is common to employ resistance training to build muscle and improve overall strength. As a result, your muscles get bigger and stronger, while your overall fitness increases. This includes considerable gains in myofibre and whole-muscle growth, strength, quality, and physical performance, or the prevention of these decreases.

Patients with cardiovascular disease benefit from regular PE because it lowers blood pressure, reduces resting heart rate, and raises atherogenic marker levels while also enhancing physiological cardiac hypertrophy. There are many benefits to losing weight, including decreased visceral adiposity, lowered cholesterol, HDL-C, and blood pressure (BP), as well as improved maximum oxygen consumption (VO2max) through either diet or exercise alone, or a combination of the two. Workout has been found to improve glucose homeostasis, endothelial function, blood pressure (BP), and HDL-C levels regardless of weight without affecting weight. Those who are overweight or have type 2 diabetes are at greater risk of cardiovascular disease, and regular exercise reduces that risk or severity [30, 31].

Regular physical activity and/or aerobic fitness are linked to better IS performance. Insulin resistance may usually be ameliorated and, in some cases, completely reversed, using PE interventions. Both acute and chronic effects of PA on IS have been documented in the literature. Acute effects can be seen during and/or for up to 72 hours after a single bout of physical activity and are directly linked to it. If these bouts are repeated on a regular basis, long-term chronic IS enhancement occurs, resulting in better glucose management than what is generally seen in people who are less active. There appears to be a dosage response with an increase in PA of 500 kcal/week, reducing the incidence of T2DM by about 9% [32]. Exercise's ability to improve IS and glucose absorption in the elderly is important [33]. Having a healthy lifestyle that includes moderate-intensity aerobic activity and/or PA on 3–5 days a week for at least 30 minutes has been linked to better IS and glycaemic management.

PE enhances the peroxisome proliferator-activated receptor co-activator 1 in cardiomyocytes after both endurance and resistance exercise (PGC-1) [33]. By improving mitochondrial fatty acid oxidation (the primary substrate used by healthy myocardium), PE also improves ATP synthesisation performance. Preventing CV dysfunctions in obese people, through PE-induced improvements in mitochondrial function, Is well documented. The reconfiguration of the mitochondrial network (fusion, fission, and autophagy) that occurs during exercise has also been found to improve mitochondrial function/efficiency [33].

4.3 Effect on general well-being

Recent research reveals that physical activity (PE) provides a number of benefits for people of all ages, and that it improves psychological well-being and quality of life (QoL). Physical education (PE) boosts self-efficacy, task orientation, and perceived competence in youngsters. Physical activity has been related to improved health outcomes in both children and adults, including a more positive self-image and a better mood. Last but not the least, for the elderly, physical activity promotes security, social connections, and mental health [34].

PE increases one's quality of life by interacting with biological and psychological systems. Higher cerebral blood flow improves oxygen delivery to brain tissue and allows for more oxygen consumption. Other biological causes include decreased muscular tension and increased endocannabinoid receptor numbers in the bloodstream, among others. The changing amounts of neurotransmitters caused by the phenomenon of neuroplasticity may also have an impact on one's overall well-being. When someone has a traumatic brain injury, their levels of neurotransmitters such as serotonin and endorphins rise. By emphasising the sense of control, self-efficacy, and competency, PE boosts students' self-esteem and self-concept while also creating a positive social synergy [34].

The benefits of regular and moderate physical activity extend beyond improved general health to lowered coronary heart disease (CHD) risk. T2DM patients who have PE experience a drop in their blood sugar and systolic blood pressure, which reduces their risk of developing DM-related complications, dying from the disease, or suffering from a heart attack. Because it reduces weight, PE lowers the risk factors for developing type 2 diabetes. Physical inactivity is linked to obesity and diabetes mellitus (DM), as well as a higher incidence and mortality from cancer (e.g. breast, endometrial). So PA and PE are linked to improved well-being and lowered mortality risk [35].

4.4 Improving physical fitness and function

Exercise therapy improves fitness and reduces the risk of illness consequences in people with chronic diseases [36]. Regular PA has been shown in these cases to enhance the human physique, lipid profiles (e.g. by decreasing the levels of total cholesterol, raising HDL-C levels, and diminishing the low-density lipoprotein [LDL]-to-HDL ratios), glucose homeostasis, autonomic tone, IS, coronary blood flow and endothelial function; improve cardiac function; and reduce BP, systemic inflammation, and blood coagulation. Chronic inflammation is a prominent cause in the majority of chronic illnesses, according to high levels of inflammatory markers such as C-reactive protein, and PE has been found to help avoid them [37].

Premature death is reduced when one's physical fitness improves, whereas it is increased when one's fitness deteriorates. Even a little increase in physical fitness has been shown to lead to a considerable decrease in risk. The health status of previously inactive adults improved significantly when their physical fitness was modestly increased [37]. Regular physical exercise reduces weight gain, obesity, coronary artery disease, type 2 diabetes, and Alzheimer's disease over time [38].

Even in the absence of increases in aerobic fitness, an improvement in health status indices can be detected as PA levels rise. That is especially true in the elderly, where frequent PA can minimise the risk of chronic illness and impairment while having no discernible effect on conventional physiologic performance metrics such as oxidative potential and cardiac output. PA can improve musculoskeletal fitness as well as cardiovascular fitness. According to a growing body of evidence, improved musculoskeletal fitness is linked to greater overall health and a lower risk of chronic illness and disability.

Health-related quality of life and hospitalisation, surgical results, and death are all influenced by one's ability to execute fundamental physical duties. Patients on haemodialysis benefit from PA because it increases their bodily function and physical ability, which lowers their blood pressure and increases their oxygen intake to their maximum potential [39]. The number of 30-second sit-to-stand tests (STS) increased after exercise began, and the time it took to complete the 8-foot timed up-and-go tests decreased, with no evidence of exercise-related unpleasant sensations. Some patients underwent a low-intensity home walking programme, while others were assigned at random to a slower-moving control group [40]. As a result, PE helps people with CKD become more fit and functional.

4.5 Patients with CKD

According to a recent meta-analysis, exercise treatment improved eGFR while simultaneously lowering blood pressure, BMI, and systolic blood pressure in CKD patients who were not on dialysis. Short-term exercises have been shown to lower TG levels as well [41]. Another systematic review and meta-analysis on individuals with comparable conditions found that frequent exercise increased peak oxygen consumption more than standard treatment and improved physical and walking abilities [26].

The effectiveness of a systematic physical exercise programme in patients with HD was examined over the course of a long trial, which also looked at patient compliance and the study's clinical outcomes. Exercise ability, strength, and QoL improved significantly over the course of a year in individuals with high and moderate compliance [42]. Recent meta-analysis shows that exercise improves HRQoL and aerobic capacity in people with ESRD undergoing HD. Patients' physical conditions improved as a result of doing aerobic or combination exercises for eight to 52 weeks, three times each week, according to the authors [43].

5. Risks associated with physical inactivity in patients with CKD

5.1 Why to improve HRQoL in patients with ESRD?

Patients on dialysis, like those with cancer or heart failure, have lower HRQoL and quality of life than the general population [44]. Treatment for end-stage renal disease (ESRD) has advanced significantly, but mortality and morbidity remain high and the quality of life for those on dialysis is declining. A patient's well-being and survival chances are taken into account when a treatment plan's success is assessed. ESRD patients are more likely to die or be hospitalised if their quality of life (QoL) is low, according to new research [45].

Despite improvements in care outcomes such as dialysis adequacy (Kt/V), phosphorus management, and haemoglobin levels, HRQoL among dialysis patients has not changed much over the preceding 10 years. The quest for therapies to improve dialysis patients' HRQoL has been undertaken by a number of studies. Renal replacement therapy's primary goal is to improve HRQoL in dialysis patients by increasing patient satisfaction and by improving their overall prognosis [46].

Overall survival has been linked to a range of clinical outcomes, including HRQoL (health-related quality of life). HRQoL measures both mental and physical health. The prevalence of depression in dialysis patients (up to 30%) has been linked to hospitalisation and mortality [47, 48]. A better mental health status can be achieved with the appropriate management [49]. Identifying and assessing the mental health state of these people is so critical. Another reason for low HRQoL is a patient's worsening physical health. Patient's PA and physical function are typically impaired in dialysis patients. There is a link between reduced PA and physical performance on an on-going basis and symptoms of depression and anxiety, and dialysis patients with lower physical function have a lower chance of survival [50, 51]. Patients on haemodialysis who are in poor physical health 3 months after dialysis begins are more likely to die [52].

As a result of these findings, we feel that HRQoL in ESRD patients must be improved in order to boost functional ability, psychological status, and patient satisfaction, lower mortality and hospitalisation rates, and improve the overall prognosis of the patients.

5.2 Exercise in patients with ESRD

On the day of dialysis, dialysis patients are much less physically active than the general aged population, as they are sedentary throughout the process and suffer from post-dialysis weariness. On days when they are not receiving dialysis, dialysis patients are 17% less physically active than non-dialysis patients. With decreased physical activity comes several risks, such as catabolic disorders that can cause muscle loss and lead to sarcopenia, mitochondrial dysfunction, and other conditions such as anaemia, mineral disorders, protein energy loss, diabetes, neurological dysfunction, and cardiovascular dysfunction [20]. Dialysis patients may also be at risk for these conditions.

Better results are strongly linked to increased levels of physical activity and healthy exercise habits. In all DOPPS countries, independent of physical state or social circumstances, patients who regularly exercised more than once a week had superior outcomes, according to the Dialysis Outcomes and Practice Pattern Study (DOPPS) [53]. Patients on CKD and dialysis who receive PA had a decreased death rate [20]. In addition, dialysis patients who completed a median of around 4000 steps daily and had PA of more than 50 minutes per day had better outcomes [54]. A less sedentary lifestyle is related to the improved results even in CKD patients with various impairments [20].

5.3 Factors leading to poor physical function

Exercise is hindered by factors that prevent genuine clinical practice from following the evidence. A study conducted in the United Kingdom found some important characteristics linked to CKD patients' behavioural alterations. Their physical health (frailty, anaemia, and age-related problems) and mental health (fear of damage or worsening of their ailment) were hindering their ability to engage in regular physical activity. People with concurrent illnesses and CKD-related symptoms including weariness and joint discomfort rated this as the biggest challenge to doing enough exercise [55]. Fear of injury was one of the biggest psychological barriers to physical activity. Some patients' fears about exercise may stem from the fact that healthcare providers are not adequately informing them about the health benefits of physical activity [56]. Individuals wanted individualised guidance and support from their healthcare providers on safe and effective exercises for those with kidney disease.

Further research from Canada found that weariness, dyspnoea, and weakness were the most common barriers to PE in a patient-reported outcome study (PRO). Regardless of modality or age group, PE patients preferred to exercise at home (73%) using a combination of AE and RE (41%). Despite the fact that most research has shown good effects on biochemical indicators and the potential for reduced mortality, these PRO studies suggest that these hopeful results are less meaningful for dialysis patients and may not encourage them to adhere to an "exercise regimen." Instead, they are looking for ways to reduce exhaustion and regain energy so they can go about their regular activities normally. As a result, it is critical that we identify and address these challenges in order to ensure high levels of patient satisfaction. In other words, custom programmes must be approved in order to start and sustain regular PE adherence.

6. Exercise has an effect on patients with CKD

As stated previously, patients with CKD are less fit and functionally compromised. When compared to healthy persons, their aerobic capacity is about half as poor, and they have weak physical strength and mobility problems. They are more likely to suffer from many disorders. People often complain of back, hip, and leg discomfort, tiredness, and muscle weakness due to electrolyte imbalance and other reasons [57].

6.1 Muscle structure and function

After a six-month exercise programme in HD patients, histological testing revealed a 51% increase in type II fibres and a 29% increase in average fibre area. There was also an increase in capillary density and mitochondrial regeneration [58]. Cross-sectional fibre area increased by 46% after 6 months of AE treatment, although another study found a drop in the percentage of atrophic fibre types I, IIa, and x as a result (from 51, 58, and 62% to 15, 21, and 32%, respectively). The therapy also improved the capillary network in the muscles. After a 12-week intradialytic progressive RE, there was a rise in thigh muscle volume [59]. The increased mitochondrial number and greater rate of protein synthesis that come with strength PE may also result in an increase in aerobic capacity. PE A rise in calcium levels in the cell cytoplasm, a surge in ATP production, and the creation of reactive oxygen species are all associated with endurance training, according to research [60]. Changes in mitochondrial function can occur after a few weeks of physical exertion (PE), and the degree of change is inversely proportional to PE intensity.

When looking at the effects of PE on adult CKD patients, a systematic review found that it had a significant favourable impact on metrics such as walking capacity, CV dimensions, and physical fitness [14]. Studies on exercise's positive effects on cardiopulmonary function, muscle strength, and walking ability in people with CKD revealed a meta-analysis [61].

A recent systematic review and meta-analysis found that resistance training, rather than aerobic training, significantly increased leg mass. After undergoing RE, my grip and knee extension strength significantly increased. AE claims to have enhanced the STS short form, but there is not enough proof to back them up. The 6-minute walking test score and the median version of the STS test in the physical performance dimension were both improved by AE and RE [62]. High-intensity resistance (RE) training on dialysis patients may increase muscular growth and strength, especially in the trained muscles. If dialysis patients desire to improve their physical performance, they can use AE and RE.

6.2 Nutrition

There is an imbalance between the increased protein requirement and the inadequate dietary food intake caused by HD, which results in skeletal muscle loss in CKD patients. Increased protein synthesis and anabolism from regular PE may help to slow the rate at which people lose lean body mass as they age. On non-HD days, however, As found in aged adults, and HD patients have a lower muscle protein synthesis response to diet. Furthermore, combining physical exercise with a high-protein diet has been shown to help decrease or even stop muscle loss. When used in conjunction with RE, intradialytic nutritional supplements improve both body composition and muscle mass. With PE, nutritional supplementation has significantly stronger protein anabolic effects when taken orally. Increased phosphorylation of mRNA translational signalling proteins due to RE and whey protein intake leads to enhanced protein synthesis in untrained individuals. In addition, ingestion of whey protein after RE activates the mTOR signalling pathway in a dose-dependent manner [63]. Supplementing PE with proper energy sources such as carbohydrates, protein, vitamins and iron will help keep muscle protein breakdown under control. Due to the energy loss and decreased digestive function associated with dialysis, patients are advised to consume more protein (1.2 times) than the average person.

6.3 Cardiovascular function

Systematic PE protects heart tissue in ESRD patients and slows the progression of coronary artery disease by reducing myocardial oxygen demand and facilitating better perfusion. Inflammatory indicators are reduced, and endothelial function is improved as a result. The NO levels can be raised and coronary arteries and other vessels dilated in as little as a few weeks of PE practice. Chronic AE lowers heart rate, systolic and mean blood pressure, and both at rest and during submaximal activity, decreasing myocardial oxygen demand in those with CHD. Submaximal PE improves arterial compliance, lowers peripheral vascular resistance, and boosts cardiac output in HD patients. As a result of reduced sympathetic tone, these beneficial adaptations may be due to increased parasympathetic activity, decreased catecholamine levels, and decreased endogenous cardiac output stimulation. PE, particularly the AE, raises resting vagal tone while lowering sympathetic tone in both healthy people and those with kidney disease [63].

There are only a few studies showing that PE can help patients with left ventricular dysfunction by increasing myocardial contractility, ejection fraction, stroke volume, and left ventricular mass. Improvements in skeletal muscle performance are another evidence of PE's beneficial effect on heart function [64]. The ejection fraction increased significantly after 30 minutes of intradialytic AE at 60–70% of maximum heart rate, according to the results of study. It was discovered that pre- and post-training left ventricular ejection fractions were associated with VO2peak [64]. HD patients who participated in an outpatient exercise training programme saw similar improvements in heart function [65]. Finally, long-term exercise helps hypertensive HD patients regulate their blood pressure and lowers their mortality rate [43, 66].

6.4 Glycaemic control and insulin resistance

With AE, you will have better IS and less IR. RE also lowered blood glucose levels, indicating that it could be a viable option for diabetic patients looking to improve their glycaemic control [13]. Muscle tissue insensitivity is the major source of IR, which is a common symptom of uraemia regardless of the kind of renal illness present. Regular physical activity enhances IS in healthy persons as well as those suffering from disorders linked to a sedentary lifestyle [67]. When establishing training programmes to enhance IR, total exercise length should be considered, with 3 hours of exercise per week being proven to be more effective than 2 hours [68]. Patients on HD may be more resistant to the effects of exercise on IR if they are in a uraemic setting. The results of a 12-month trial comprising 3 to 5 courses per week demonstrated that exercise has an impact on IR in this group.

A combination of CE and AE or RE is better at controlling blood sugar than either one alone. As a result of the CE increasing IS, adipose tissue loss, increased muscle mass, and decreased visceral and subcutaneous fat are all observed. When AE or RE is used alone, the glycated haemoglobin level improves. Patients who had CE, on the other hand, had better glycaemic control [13].

6.5 Renal function

Many studies have looked at how exercise affects CKD prognostic variables. Patients with CV illness and CKD demonstrated improved eGFR with exercise therapy, according to one study [69]. Another study [70] confirmed that patients with stage 3–4 CKD benefited from moderate-intensity exercise in terms of kidney function and BMI.

Meta-analysis of the impact of PE found that eGFR increased considerably in individuals with non-dialysis CKD, as did SBP, DBP, and BMI. PE had a rapid and considerable impact on TG levels (3 months). When it came to non-dialysis CKD patients, PE had no impact on SCr, TC, HDL-C, or LDL-C [41].

Kidney health benefits from exercise that includes both aerobic and resistance components. A meta-analysis of adult patients with CKD looked at renal function and discovered that combining exercise with medication significantly increased estimated glomerular filtration rate. The amount of creatinine in the blood was also reduced. These individuals' blood pressure has also reduced dramatically. There were no significant differences in proteinuria, cholesterol levels, physical composition, or quality of life between the groups.

6.6 HD efficiency

The inclusion of intradialytic AE significantly increased dialysis efficacy after the first month in a randomised controlled trial (RCT) and remained elevated throughout the programme [17]. Another RCT found that interdialytic mixed resistance and aerobic exercise enhanced physical performance in the sitting to standing, handgrip force task, time up and go, and 6-minute walk tests. Similarly, mini-nutritional assessment long-form scores increased considerably following the intervention period. The somatic and mental components of the QoL scale expanded significantly, but hospital anxiety and sadness decreased little. According to the results of the biological parameters, combined exercise reduced blood pressure while increasing HDL-C, LDL-C, and TGs levels throughout the body; however, there was no significant effect of intervention time on C-reactive protein, haemoglobin, albumin, or total cholesterol levels in the study participants' blood. In both the urea reduction ratio and the 6-minute walk test, aerobic and resistive training produced significant improvements. They dramatically increased dialysis efficiency and productivity [16].

6.7 Physical function and QoL

Regular exercise has been shown in a number of trials to help prevent CKD-related pulmonary function losses by strengthening respiratory muscles and increasing pulmonary function [71, 72]. After a year of training at home, participants with pre-dialysis CKD showed only minor gains in hand grip and knee extension strength [71]. Study after study found that older adults who were given more supervision gained more strength than older adults who were left alone, but these increases were often minimal [73]. Studies show that working out increases peak VO2 by 41% at the ventilatory threshold and 36% at the peak of activity. Ventilatory efficiency, on the other hand, was same between the two groups. The training groups did not differ in terms of strength or body composition; however, the 6MWT and 1STS showed improvement.

People with CKD had poorer HRQL even when they participate in exercise programmes despite evidence to the contrary [14]. Recent meta-analyses [43] reveal that physical activity improves aerobic capacity, walking ability, and HRQoL. The SF-36 domains of physical functioning, role physical, and role emotional all increased over time as a result of exercise training, resulting in remarkable improvements in overall health. After the exercise intervention, all five dimensions of Kidney Disease Quality of Life improved [74]. The EXITE (Exercise Introduction to Enhance Dialysis Performance) experiment found that MHD patients' functional status improved after a simple, personalised six-month home-walking programme. When compared to the normal treatment group, the exercise group exhibited a significant improvement in social interaction and cognitive performance, but the other 17 categories showed no significant differences [40]. There were five studies out of the 21 included in a meta-analysis that showed an increase in the SF-36 physical component score after exercise training, with a mean increase of 10%. In spite of the fact that the overall SF-36 physical component score changed little, the exercise group's physical component score increased by 43% [74].

7. Benefits of exercise

Regular PE in patients with CKD is associated with a myriad of health benefits, including physiological, psychological, and functional benefits.

7.1 Physiological benefits

Regular PE reduces CV mortality, hypertensive medication use, inflammatory markers (C-reactive protein); prevents muscle wasting; improves toxin removal by dialysis, exercise capacity, blood pressure control, lipid profile (increased HDL-C and reduced TG), haematocrit (prior to erythropoietin therapy), glycaemic control, serum albumin, nutritional summarise.

7.2 Psychological benefits

There is a link between regular physical activity and a better psychological profile (lower stress/anxiety/hostility/depression and increased engagement in pleasurable activities), perception of general and mental health, physical functioning, and vitality. Subjective weariness symptoms are reduced, as is the impression of physical pain, all at the same time [75–77].

7.3 Functional benefits

Regular physical exercise improves muscle strength, 6-minute walk distance, gait speed, sit-to-stand time, balance (which reduces the chance of falling), independence, and HRQoL [75–77].

8. Aerobic fitness and haematocrit (Hct) normalisation

Due to an increase in cardiac output and an improvement in muscles' innate ability to receive and use oxygen from the blood, physical activity has inherent benefits [78]. According to a meta-analysis, both moderate and intensive exercise trainings improve cardiorespiratory fitness and cardiometabolic health [79].

Patients with ESRD have a significant loss of fitness and functional competence [80], increasing their risk of death and limiting their ability to carry out everyday tasks [81, 82]. Renal anaemia is one of the most important variables that contribute to poor physical fitness [14]. Anaemia lowers oxygen carrying capacity, posing a barrier to maximum oxygen intake, PE capacity, and time to fatigue, particularly in those with ESRD [83].

Oxygen absorption can be viewed as an avenue for oxygen to get from the lungs to functioning tissues *via* systemic blood released by the heart during PE (physical exercise). Instead of being forced to deal with renal anaemia, recombinant erythropoietin was developed. A popular treatment for anaemia is erythropoiesis-stimulating agents (ESAs), which enhance QoL and cognitive function [84, 85], reduce left ventricular hypertrophy [86], and slightly increase maximum oxygen uptake in relation to haematocrit rise when used to treat anaemia [87]. Intradialytic PE, on the other hand, increases maximal oxygen absorption [88, 89] and has a cardioprotective effect [90]. PE, like ESAs, does not restore exercise ability in CKD patients to that of healthy people [24, 91]. Both of these treatments have been proven to improve maximum oxygen uptake and physical fitness, but they do not restore patients' fitness levels to those seen in the majority of sedentary people with normal renal function. Despite the fact that raising the haematocrit increases the blood's oxygen carrying capacity, other parts of the oxygen pathway remain intact, preventing the normalised haematocrit from providing any further health advantages. The ability of regular PE to give its maximal benefit is, on the other hand, restricted by the existence of anaemia. In a third situation, some components of dialysis or ESRD obstruct the regular oxygen pathway, which may be unaffected by either Hct normalisation or regular PE [92].

When compared to the numbers in the untrained anaemic phase, PE, Hct normalisation, or their combination leads in significantly increased maximal power and VO2. PE boosts cardiac output, peak tissue-diffusing capacity, and citrate synthase activity, but Hct normalisation boosts maximum arterial oxygen and arteriovenous oxygen difference. The maximal arteriovenous oxygen difference did not increase even when arterial oxygen levels increased in the combined phase, and they were the same as in healthy sedentary people [93]. As a result, it can be inferred that exercise and Hct normalisation have good effects but do not result in normalisation of exercise capacity in HD patients, which could be due to skeletal muscle anomalies.

9. Intradialytic exercise (IDE)

In order to urge patients to be more physically active, doctors often prescribe IDE (intermittent daily encouragement). It reduces fatigue, improves sleep quality, increases exercise tolerance, raises QoL, and even improves psychological status when used correctly. Furthermore, it has been proposed that IDE can boost dialysis's efficiency, which in turn reduces inflammation and boosts bone mineral density.

Because they may combine both aerobic and anaerobic elements into a single training session, the sit-to-stand test and the 6-minute walk test have been found to increase fitness. The depressive state index dropped significantly. The results of the QoL survey, with the exception of physiological discomfort, did not demonstrate a substantial rise. There were no significant changes in dry weight, blood pressure, Kt/V, or metabolic variables except for intradialytic hypotension. According to a meta-analysis, IDE raises Kt/V and maximum oxygen consumption during physical activity, reduces depression, and enhances the physical component of quality of life (QoL). SBP and DBP could both be dramatically reduced with IDE. In the end, IDE had no effect on the mental component of QoL. The enhanced muscle blood flow and expanded capillary surface area caused by IDE, on the other hand, may help HD remove toxins more effectively. There was also less dropout and increased compliance with the IDE [94] in addition to better acceptance and adherence.

10. Analyses of intradialytic vs. non-clinical exercise programmes

Home-based exercise (HBE) was found to be as effective as centre-based training in CKD patients who were not on dialysis. After 12 and 24 weeks, all of the cardiopulmonary metrics, including VO2peak, improved significantly. This was also seen during follow-up with respect to functional ability assessments. QoL and sleep both improved significantly [95].

In other research, researchers have compared the effects of IDE and HBE on the symptoms of HD. Neither their 6-minute walk test distance nor their pulse wave velocity changed significantly during the course of the study's 6-month follow-up period (which included blood pressure readings from both the peripheral and central nervous systems as well as physical activity). The second trial found that both groups' levels of physical activity grew significantly over time. While the one-legged standing test had a significant group-time interaction, the Short Physical Performance Battery, the timed up-and-go test, the STS-10 right and left hand grab, and the one-heel left leg rise all had a significant time influence. There was no change in the HRQoL score. Physical activity levels and physical function changed similarly in response to both treatments [96]. As a result, the effectiveness of IDE and HBE is comparable, and both produce positive effects.

11. Serum phosphate levels in a group of haemodialysis patients

Hyperphosphatemia, one of the comorbidities commonly associated with increased cardiovascular risk, is caused by reduced renal excretion of phosphate in CKD patients. Reduced hyperphosphatemia reduces the risk of vascular calcification in patients on pre-dialysis and MHD therapy. Medical intervention (active vitamin D, phosphate chelators, and calcimimetics) and diet are crucial in the treatment of mineral bone disorder-CKD. PA affects phosphate absorption in the gut.

According to a study, active HD patients had the highest levels of serum phosphate, and the link between the two was determined to be direct. The levels of serum phosphate were shown to be closely linked to those of serum calcium and albumin. An unanticipated rise in serum phosphate levels should be minimised and overall results should be improved by tailoring nutritional advice for chronic HD patients according to their amount of physical activity [97].

Patients who were hyperphosphatemic at baseline, but not the general population, did not improve appreciably following a 12-month moderate-intensity aerobic IDE, according to the results of another trial. The malnourished inflammation score remained constant throughout the study. A small but statistically insignificant rise in the QoL visual analogue scale was associated with IDE. Patients with hyperphosphatemia benefited the most from 45 minutes of aerobic IDE, which was reported to be both safe and effective [98].

Cycling on stationary cycles while getting haemodialysis was found to be a safe and helpful therapeutic intervention for individuals with end-stage renal disease in a recent RCT (ESRD). After an 8-week intervention, serum phosphate and parathyroid hormone levels improved dramatically, whereas albumin and calcium levels remained stable [99].

12. Conclusion

Sedentary lifestyles and lack of regular physical activity are common among CKD patients. This way of living has a negative impact on HRQoL and raises the risk of disease and death. Physical activity enhances physiological, functional, quality of life (QoL), and psychological components when done on a regular basis. When used in conjunction with dialysis, it improves both efficiency and adherence. However, overcoming the obstacle to regular PE and prescribing personalised PPE to CKD patients should be prioritised.

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