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Research Article

The Impact of Aerobic Exercise on Haematological and Cardiopulmonary Variables in Individuals with Renal Disease

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ABSTRACT

Background and objectives
Maintaining a healthy lifestyle is still a key component of managing CKD despite the conflicting evidence of efficacy from major trials on the potential of aerobic exercise to reduce CKD progression. This is because aerobic exercise has undeniable advantages for cardiovascular health, blood pressure control, and survival.

Methods: In this narrative review, we look at the research that has been done on how aerobic exercise affects the course of CKD and how well it works for patients' haemoglobin and cardiopulmonary indices.

Result: There is ample data to demonstrate that adopting excellent living habits and engaging in low-intensity aerobic exercise gives obvious benefits for survival.

Discussion: Despite this, as there is no evidence of harm from exercise intervention on kidney function, and considering the many other potential benefits of increased physical activity, exercise should be increasingly recommended and prescribed by health professionals. Many of the existing studies are restricted by the length of follow-up and small sample numbers. It was tough to undertake meta-analyses as there were few articles and various definitions of behaviours, referent groups, and CKD development. Therefore, additional study is required to provide practical ways to measure how effectively aerobic exercise impacts haematological and cardiovascular health in persons with renal illness.

Keywords: Chronic Kidney Disease; CKD; aerobic exercise; physical activity; haematological; cardiovascular; pulmonary

INTRODUCTION

Chronic kidney diseases (CKD) are the leading cause of morbidity and death in underdeveloped nations. The burden of CKD in India has yet to be quantified accurately. CKD is an epidemic condition in India. It is now estimated that over 850 million people worldwide suffer from renal illnesses [1]. The prevalence of chronic kidney disease (CKD) is believed to be over **13% (11–15%) and** rising up to 12% in many Western nations **[2-3]**. Consequently, chronic kidney disease (CKD) is one of the leading causes of mortality worldwide and is expected to rise to the fifth rank by 2040 [4]. The rising prevalence of diabetes, hypertension, obesity, and ageing are the key factors contributing to the global rise in CKD. The Global Burden of Disease (GBD) studies have revealed that chronic kidney disease (CKD) is currently the main cause of morbidity and mortality globally [5]. High morbidity and mortality rates, negative effects on health-related quality of life (HRQoL), large diagnostic and therapeutic costs, and the social impact of immunological diseases are all indicators of a significant health issue [6]. The decline in HRQoL may be caused by a variety of conditions, including worsening cardiovascular health, anaemia, malnutrition, declining cognitive function, poor sleep, increased depression rates, and various metabolic interferences that are more prevalent in CKD patients [7-8]. In general, sedentary behaviour is linked to higher rates of mortality. Whether engaging in low- or light-intensity exercises instead of sedentary behaviour improves survival in both the general population and the CKD populations. Living a healthy lifestyle is one of the safest and most cost-effective ways to improve one's quality of life and prevent and/or manage chronic disease [9]. Since lifestyle variables including diet, exercise, weight management, alcohol use, and cigarette use have mostly been studied in connection to decreasing CVD events and mortality risk, little is known about avoiding CKD development in the CKD population [4-6]. Numerous risk factors for CKD, including some that cannot be avoided, such as age, gender, and family history, have traits in common with those for cardiovascular disease. To reduce the risk of developing end-stage renal disease (ESRD), death, and other CKD complications, patients with CKD and their clinicians are seeking ways to change the course of their condition. It's crucial to implement prevention measures for CKD development and progression. Primary prevention of CKD is linked to lifestyle-related factors like boosting vegetable intake, upping physical activity, lowering salt intake, making dietary adjustments and limiting alcohol usage [10-11]. Cardiorespiratory fitness refers to the capacity of the respiratory and cardiovascular systems to provide oxygen to the body's working muscles while engaging in physical exercise. Early all-cause and cardiovascular-related deaths have a substantial correlation with impaired cardiorespiratory fitness [12-13]. Individuals with chronic kidney disease (CKD) have a reduced level of cardiorespiratory fitness compared to the general population. This reduction is shown early in the disease process and is exacerbated by a decrease in renal function. Additionally, CKD is linked to worse left ventricular function, greater aortic stiffness, and an increased risk of cardiovascular events [13-15]. Numerous conditions, such as anomalies in the morphology and function of skeletal muscles, endothelial dysfunction, arterial stiffness, dysautonomia of the nervous system, anaemia, depression, and other conditions, might affect these individuals' capacity for exercise. The aforementioned factors contribute to these patients' inactivity, reduced functional ability, weariness, social exclusion, and ultimately, an inadequate level of life [16-17]. In recent years international research has been done to support that low-intensity exercises are beneficial for renal patients which is a relatively novel idea in renal rehabilitation [8]. Patients with chronic kidney disease (CKD) are at high risk of developing cardiovascular (CV) disease, for which exercise training is an effective preventive therapy [18]. In this systematic review, we focus on historical and recent data on the role of aerobic exercise in the course of the progression of CKD, with a special emphasis on how effectively aerobic exercise impacts haematological and cardiovascular in persons with renal illness and may improve conditions of individuals and slow the onset of ESRD. However, exercise prescriptions for patients with chronic kidney disease (CKD) should be grounded in exercise training principles, such as individualization, specificity, adaptation, recovery, reversibility, and overload. Exercise load, which is the sum of exercise frequency, intensity, and duration, needs to be taken into account for any prescription.

METHODS

In this narrative review, the impact of aerobic exercise on the progression of chronic kidney disease (CKD) is discussed. CKD is defined as a progressive decline in GFR, the emergence of ESKD, or an increase in proteinuria or albuminuria in individuals with established CKD who do not require dialysis or a kidney transplant. We looked for observational studies, systematic reviews, randomized controlled trials (RCTs), and meta-analyses that examined the connection between CKD progression and lifestyle choices using PubMed. The following phrases were included in the search: haematological, cardiovascular, pulmonary, obesity, body mass index, BMI, CKD progression, end-stage renal disease, ESRD, end-stage kidney disease, ESKD, glomerular filtration rate decrease, GFR decline, physical activity, exercise. The relationship between CKD progression and lifestyle behaviours and nutritional status in combination is not included in this review because we did not include studies that looked at the impact of numerous lifestyle behaviours and nutritional status. We were not able to evaluate all published results because, as a narrative review, we were not able to include all published studies evaluating the relationship between CKD progression, nutritional status, and lifestyle behaviours. Instead, we concentrated on including high-quality studies and excluded studies that reported very similar results. We searched the English-language literature using the electronic databases PubMed, MEDLINE, Embase, and Google. "Aerobic exercise" OR "CKD" OR "renal disease" OR "haematological" OR "cardiovascular" OR "pulmonary" were the search phrases used. The required papers were archived with help from the writers' expertise and topic knowledge. Only pieces that adhere to the following criteria are included in the reviews below: Studies that focus only on CKD, aerobic exercise, pulmonary, cardiovascular, and haematological conditions are taken into account. Included are studies that were completed in the last ten years and in English. The PRISMA-based research methodology is shown in Figure 1.

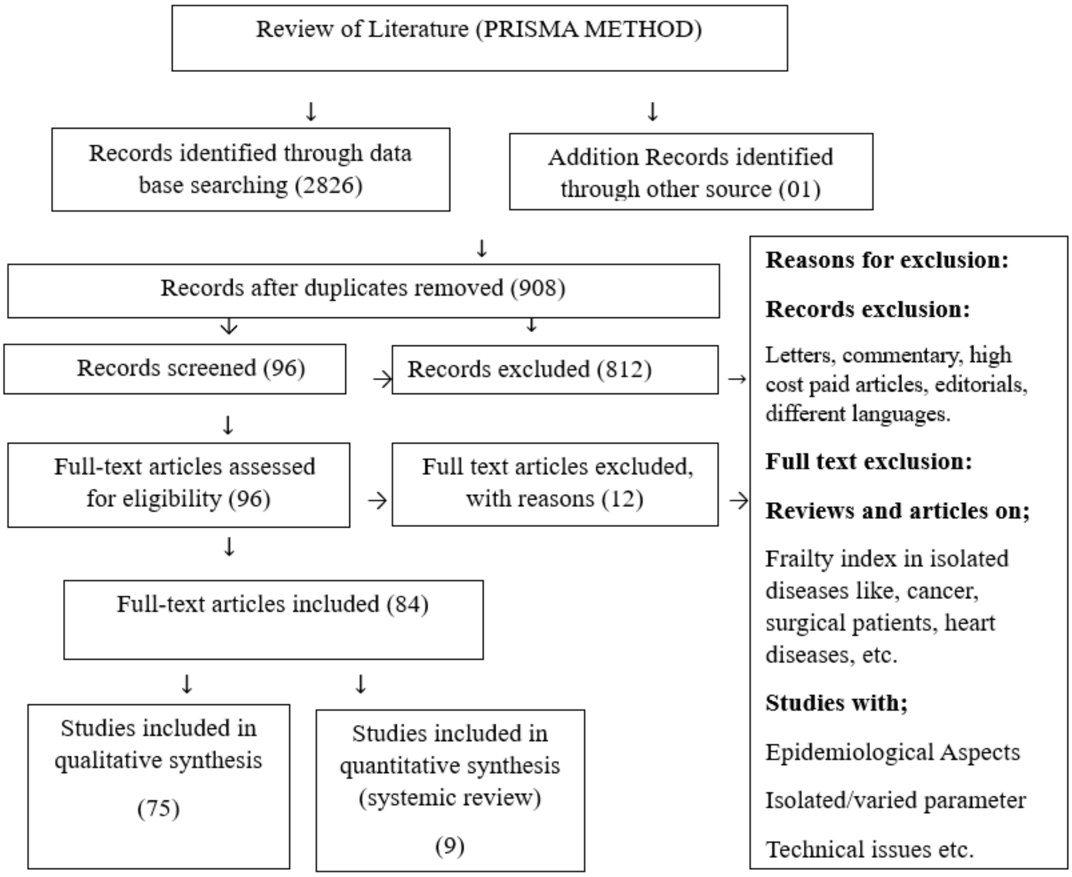

Figure-1: depicts the research technique using the PRISMA method.

HEMATOLOGICAL RESPONSES TO AEROBIC EXERCISE ON CKD

Aerobic training has a slight positive impact on exercise tolerance and estimated glomerular filtration rate in patients with CKD stages 3–4. The aggregated findings were assessed as being of low to intermediate quality, despite having limited data. A total of 362 participants from 11 randomized controlled trials were chosen. In comparison to standard care, the estimated glomerular filtration rate and exercise tolerance improved after an average of 35 weeks of aerobic training (+2.16 ml/min per 1.73m2) following an aerobic training program [19].

Acute exercise may provide clinically significant information to enhance renal health and filtration in individuals with chronic kidney disease. Twenty CKD patients participated in a trial where they completed 30 minutes of moderate and high-intensity interval training each. Blood and urine samples were collected before, after, and 24 hours after exercise, and the results were compared. The results of the study indicate that there was an increase in average renal filtration in both eGFR-CKD-EPI (8.6 2.3 ml/min/1.73 m2) and eGFR-MDRD (7.2 2.0 ml/min/1.73 m2) one hour after exercise (P =.007 and P =.009). (Forsse et al., 2023) [20].

The two most recent meta-analyses that examined the effect of RCTs testing physical activity and exercise interventions on the progression of CKD in people with CKD found no differences between the intervention and control groups in terms of estimated glomerular filtration rate (eGFR), serum creatinine, or proteinuria. Nevertheless, the RCTs considered in the aforementioned meta-analyses included small numbers of participants, were brief, and lacked adequate observational time to evaluate the influence of disease progression risk. Additionally, since serum creatinine is correlated with muscle mass, it can be challenging to interpret minor increases in creatinine levels during an exercise trial due to increased physical activity and muscle metabolism, which leads to an underestimate of eGFR and, consequently, kidney function (Sahu et al.,2022) [25-27].

A randomized control experiment was conducted to examine the short-term effects of intradialytic aerobic exercise on blood gases, oxidative stress, and solute clearance in patients with chronic kidney disease. Thirty people were permitted to perform aerobic exercise of the lower limbs on a cycle ergometer for 30 minutes at an intensity of 60–70% of the maximum heart rate. Blood samples were obtained before and immediately following the activity, or the corresponding time in the control group. The exercise raised the amounts of serum solutes, however only phosphorus was shown to be significantly elevated. In terms of solute removal and acid-base balance, there were no noticeable changes. Acute intradialytic aerobic exercise reduced total antioxidant capacity and reversed hypoxemia brought on by hemodialysis, but it did not affect the blood acid-base balance or the elimination of solutes. (Bohm et al, 2017).

An investigation into the impact of Hatha yoga practice on lipid markers in hemodialysis patients with ESRD was conducted in prospective, randomized research. In the Hatha yoga exercise group, 33 ESRD people were paired with 35 ESRD people in the control group. Serum triglycerides, total cholesterol, low-density lipoprotein (LDL) cholesterol, and high-density lipoprotein (HDL) cholesterol levels were assessed at baseline (0–17 months) and four months later. The total cholesterol, triglycerides, LDL cholesterol, and total cholesterol/HDL cholesterol ratio significantly decreased in the pre-hemodialysis Hatha yoga exercise group. (Gordon et al, 2012)

A randomized controlled experiment was to ascertain the impact of the intradialytic exercise program on serum electrolyte levels and haemoglobin. During the first two hours of dialysis, low-intensity aerobic exercise was administered three times per week for two months, lasting a total of 15 minutes. A total of 47 clinically stable hemodialysis patients (n = 25 for aerobic exercise and n = 23 for control) were divided into the two groups. Following the intervention, there were noticeable increases in serum potassium and phosphorus levels. The exercise group's serum calcium and haemoglobin levels did not significantly change. Therefore, a basic aerobic exercise regimen is safe and beneficial for dialysis patients with ESRD. (Makhlough et al, 2012)

A trial to test whether extended intradialytic exercise increases hemodialysis efficiency. Ten stable hemodialysis patients who agreed to take part in the trial were recruited. The study subjects underwent three hours of supine cycling at 40% of their maximum exercise capacity as well as no activity at all. In order to determine the effectiveness of hemodialysis, blood samples were taken prior to and following both situations. During the activity, there were no negative effects recorded. In comparison to the control group, the efficiency indices dramatically increased following the extended workout. Plasma potassium levels were decreased by 77.5%, and the ratios of urea to creatinine and creatinine to urea were also dramatically improved. Consequently, the extended low-intensity intradialytic exercise increases hemodialysis effectiveness. Therefore, it is important to urge HD sufferers to engage in regular exercise not only for the recognized long-term advantages to cardiovascular health but also for the immediate impact exercise has on HD adequacy. (Giannaki et al, 2011)

The meta-analysis included 12 RCTs with CKD patients and found that aerobic exercise on a regular basis greatly improved several outcomes, including estimated glomerular filtration rate (SMD = 0.65, 95% CI [0.30, 1.00]), serum creatinine (SMD = -0.63, 95% CI [-0.86, -0.40]), 24-hour urine protein volume (SMD = -0.41, 95% CI [-0.70, -0.11]), and serum urea nitrogen (SMD = -0.66, 95% CI [-1.20, -0.12]). The estimated glomerular filtration rate in individuals with chronic kidney disease was considerably improved after a single 30-minute exercise session ($p < 0.01$), and the exercise modalities of walking and running had a similar effect. The SCr levels of CKD patients were seen to be considerably improved when walking and running were chosen as exercise modalities ($p < 0.05$), while there was no significant change when cycling was chosen [24].

A total of 12 studies were conducted, including 745 patients. With CARE, the estimated glomerular filtration rate improved considerably in comparison to no exercise or usual care (mean difference = 5.01, 95% CI: 2.37 to 7.65; within-group analysis: MD = 3.01, 95% CI: 0.86 to 5.16). Significant improvement was also seen in the blood serum creatinine levels after receiving CARE (between-group analysis: MD = -8.57, 95% CI: -13.71 to -3.43; within-group analysis: MD = -6.33, 95% CI: -10.23 to -2.44). However, there were no appreciable changes in proteinuria, physical composition, cholesterol levels, or quality of life. In addition to seeing increases in high-density lipoprotein and a reduction in very low-density lipoprotein and triglyceride levels, patients with advanced chronic kidney disease (CKD) who trained in aerobic exercise saw these changes [26].

CARDIOVASCULAR RESPONSES TO AEROBIC EXERCISE ON CKD

Patients with CKD have a high burden of risk factors for cardiovascular disease (CVD) and experience high rates of CVD events. In practically all phases of CKD, CVD is the leading cause of death in patients. Maintaining a healthy lifestyle offers a cross-cutting approach to reduce the risk of CVD [9, 27]. Various positive effects of exercise on the cardiovascular system are widely known. Physical inactivity is a known independent risk factor for the development of coronary artery disease, and there has been a direct link discovered between it and cardiovascular mortality. Lower levels of physical activity are associated with an increased risk of cardiovascular disease death [28].

A randomized cross-over study with 15 people was carried out to assess the effects of exercise during hemodialysis. In addition to measuring blood pressure, this study also looked at neutrophil degranulation, systemic inflammation, and plasma indicators of heart damage. Immediately following the activity, blood pressure rose; however, an hour later, it had dropped to resting values. The result of the study found there were no variations in myoglobin or CKMB levels between the experimental and control groups. TNF-, interleukin-1, or interleukin-6 circulating concentrations were unaffected by exercise. Exercise was safe and well tolerated during intradialytic therapy; it had no adverse effects on immune response or systemic inflammation. (Dungey et al, 2015).

Individuals with stages 3-5 of chronic kidney disease may see an improvement in their CV risk profile due to the advantages of aerobic exercise training. This view is also supported by European recommendations [29, 17]. Nonetheless, after an aerobic exercise program, there were no appreciable improvements in blood pressure as compared to standard treatment [19].

Huang et al. studied exercise in hemodialysis patients by a systematic and meta-analytic approach. The duration of the interventions, which spanned from eight weeks to twelve months, comprised both weight training and aerobic exercise. Training sessions were typically conducted three days a week. There was a moderate level of exercise intensity, with a peak power of around 55–60%. Each session's exercise length (training volume) ranged from 15 to 90 minutes. Seven trials with a total of 137 patients in the experimental group and 123 patients in the control group had blood pressure checks. The study's conclusion, which conflicted with earlier findings, suggested that weight training may not be helpful for dialysis. The findings also showed that aerobic and combination exercise did not lower diastolic blood pressure [30].
There were 12 trials with 745 patients as compared to usual care or no exercise. Patients who completed CARE also indicated a drop in blood pressure in the within-group analysis (systolic blood pressure: MD = −5.24, 95% CI: −7.93 to −2.54; diastolic blood pressure: MD = −3.63, 95% CI: −5.35 to −1.91). [26]

PULMONARY RESPONSES TO AEROBIC EXERCISE ON CKD

RESPIRATORY RATE

In individuals with end-stage renal disease (ESRD), tachypnea is a regular occurrence that should almost be expected as the body attempts to adjust to a strained circulatory system. Additionally, rapid breathing expels excess carbon dioxide as a buffer mechanism for the increased acidity. In direct proportion to the intensity and metabolic demands of the working muscle, the respiratory rate rises and may remain elevated [31-32]
The most common problems experienced by patients with chronic kidney disease (CKD) are dyspnea, fast and deep breathing, or what is known as Kussmaul breathing. This may occur when the blood's pH lowers due to changes in electrolytes and the loss of bicarbonate. The body may retain excess fluid in the lungs. Breathlessness may occur from this accumulation and anaemia. (Furdaus and Wahyudi, 2016)

FORCED VITAL CAPACITY

Some data suggest a possible connection between chronic kidney disease (CKD) and lung function. Previous research indicates a correlation between increasing CKD and deterioration in lung function.
Park et al. studied the link between Forced Vital Capacity (FVC) and Chronic Kidney Disease (CKD) in middle-aged and older Korean men. They found that FVC was inversely and independently related to CKD. This study implies that in individuals with lower FVC, vigilant monitoring of renal function may be required to assess potential kidney failure [33].
In the study by Kim et al., 10030 participants were chosen from a community-based cohort. Over 14 years (from 2001 to 2014), people who took part in a community-based cohort were the subjects of longitudinal studies. Age, sex, BMI, and smoking status were among the clinical variables that differed between participants with and without CKD. There was no change in the initial clinical features after propensity score matching with those variables. We used the linear mixed model (LMN) to examine the relationship between chronic renal disease and the reduction in lung function as well as the interaction with the time effect. The forced vital capacity (FVC) values in the CKD group rapidly declined in comparison to the non-CKD group, as shown by the LMN model (overall p-value = 0.0012) with time interaction [34].

CONCLUSION

It is estimated that over two-thirds of CKD patients are sedentary. Treatments that extend the duration of light exercise while decreasing the length of sedentary behaviour may improve survival. When paired with safety precautions, aerobic, resistance, or mixed exercise seems to provide several advantages for CKD patients that is decreased cardiovascular risk factors, and enhance glomerular filtration. In nondialysis CKD patients without overt CVD, moderate to intense aerobic exercise was safe therefore in this patient group, aerobic exercise needs to be taken into consideration as an additional therapeutic approach for CVD prevention. Before recommending any fitness regimen, it is important to take the patient's health into account as well as the kind and stage of renal disease. Conversely, exercise prescriptions for patients with chronic kidney disease (CKD) should be grounded in exercise training principles, such as individualization, specificity, adaptation, recovery, reversibility, and overload. Exercise load, which is the sum of exercise frequency, intensity, and duration, needs to be taken into account for any prescription.

Statement of Ethics

Ethics clearance was not necessary for this paper since it is a literature review.

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Conflicts of interest

There are no conflicts of interest.

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