Narrative review

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What is the safety of an exercise program, as an intervention, during hemodialysis for the patient with chronic kidney disease?

¿Cuál es la seguridad de un programa de ejercicio, como intervención, durante la hemodiálisis para el paciente con enfermedad renal crónica?

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Abstract Chronic kidney disease is a high-cost pathology; it has a negative impact on the quality of life, especially in those who underwent hemodialysis. Consequently, it is important to develop strategies to decrease the clinical and economic impact. Intradialytic exercise is a complementary intervention that has shown a decrease in mortality and improvement in the quality of life in these patients. This paper aimed to review the available literature and determine the security of intradialytic exercise, look for population characteristics, training characteristics and the occurrence of adverse effects and their severity. This document is a topic review with a systematic search on Pubmed, OVID, VHL, Clinical Key and LILACS. 8 articles appeared after a keyword search with 15 additional papers discovered by manual research by the authors, the population included adults between 19 and 88 years of age with only 1 paper including a younger population from 9 to 24 years of age. Sex distribution was similar between male and female. Endurance training with a pedal system was the most frequent intervention. The frequency of intervention was 2 to 3 times per week at least for 2 months, and the intensity was low to mild. Some trials mentioned no adverse effect. Those with adverse effects reported cardiovascular alterations (hypotensive/hypertensive episodes), muscular injuries, but none of the adverse effects were considered severe or frequent. With the available information, the authors conclude that intradialytic exercise will be a secure intervention.
Key words: exercise therapy – renal dialysis – safety.

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Resumen La enfermedad renal crónica es una patología de alto costo, disminuye la calidad de vida, especialmente, la de los pacientes en hemodiálisis, es importante implementar estrategias para reducir su impacto clínico y económico. El ejercicio intradiálisis ha mostrado la reducción en la mortalidad por cualquier causa y mejoría en la calidad de vida. Por medio de esta revisión de la literatura disponible en las bases de datos Pubmed, OVID, VHL, Clinical Key y LILACS, se busca determinar la seguridad del ejercicio intradiálisis, se han revisado las características de la población intervenida, los tipos de intervención y los eventos adversos. Se incluyeron 8 artículos de la búsqueda sistemática y 15 más por búsqueda manual. Se encontró que la población era en su mayoría adulta (con edades entre los 19 a 88 años) y solo un estudio reportó una población más joven (edades entre los 9,1 a 24,2 años); la proporción entre géneros fue similar. Se encontró que la intervención más frecuente fue el ejercicio cardiovascular realizado con sistemas de pedales, de intensidades bajas a moderadas, con una frecuencia de 2 a 3 sesiones semanales durante mínimo 2 meses. Algunos estudios no reportaron efectos adversos, pero los que sí, mencionan complicaciones en el sistema cardiovascular (hipotensión/hipertensión) y en otras se manifiesta lesiones músculo esqueléticas (poco frecuentes), pero ninguna considerada severa o frecuente. Con la información disponible se concluyó que el ejercicio intrahemodiálisis parece ser una intervención segura.
Palabras clave: terapia por ejercicio, diálisis renal, seguridad.

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Introduction

Chronic kidney disease (CKD) is a non-communicable pathology that has a poor clinical prognosis and due to its chronicity leads to a high rate of disability with a great economic impact. In Colombia, for more than 20 years, the High Cost Account (CAC, by its acronym in Spanish) classifies it as a "high cost" pathology, however, these reports only included dialysis therapy, as an intervention for the management of this population; recently they are including a series of recommendations and interventions aimed at improving the health-related quality of life, with emphasis on maintaining an adequate weight and increasing functional capacity through exercise, as indicated in the guidelines of the Kidney Disease Outcomes Quality Initiative (K-DOQI)[1-3].

In a descriptive study of patients on hemodialysis (HD), with Colombian population, it was found that 97.5% had a sedentary lifestyle, Results similar to those reported by Paneye and collaborators in their study, where they found that 94% of the target population had low levels of physical activity, 73.2% had a body mass index (BMI) within normal parameters, but when the body composition was observed, they showed a low percentage of muscle mass and a high percentage of fat mass, data that allow to infer the importance of an intervention with exercise in this population[4].

The prevalence of CKD has progressively increased worldwide; for our country in the last report of the CAC (2017) it was reported that in the last year, 38,869 people required some renal replacement therapy (RRT), which corresponds to a prevalence of 78.9 per 100,000 inhabitants, with an economically productive and relatively young population and an average age of 55.7 years[1,2]. The foregoing calls for proposals of strategies to reduce the clinical and economic impact of this chronic renal disease.

In the literature there are studies with different interventions and among these, physical exercise is included. It is important to highlight that with these interventions they talk about the reduction of mortality and decrease in the hospitalization rate, associated with the improvement in physical performance (both in cardiovascular endurance and in muscle strength) and how it affects the health-related quality of life in this population with CKD[3,5]. In turn, they expose numerous barriers to the implementation of these programs, such as the lack of promotion of exercise, funding, lack of time to do it, and doubts associated with the safety of this intervention (possible risks related to the practice of exercise), as well as the lack of expertise in the prescription of exercise in this type of patients with increased risk due to their underlying pathology and associated comorbidities[3].

In a population that regularly follows an exercise plan, the most common risk is musculoskeletal injury; however, the most serious are those of cardiovascular origin in any presentation, such as: arrhythmias, coronary heart disease and even associated sudden death. It should be taken into account that this risk increases with several factors such as age, previous health status, antecedents of cardiovascular risk, and even the intensity at which the exercise is performed (the greater the intensity, the greater the risk, and if the exercise is considered maximum is much more risky than if it is of submaximal intensity) among many others[6].

The strength workouts at adequate intensities and well controlled, increase strength and muscle functionality, reducing the risk of falls and promoting bone mineralization, which represents a benefit for patients with CKD. It is known that the population of chronic renal patients has a high prevalence of risk factors for cardiovascular disease, which in many cases is already established, however, the risk with an intervention that involves exercise in its management, probably is not significantly higher than the risk of other populations undergoing diagnostic tests for cardiovascular disease (for example, the stress test),[6] or of users of cardiac rehabilitation services, where they are widely managed, even with intense physical workloads.

This review aims to determine the safety profile of exercise programs in hemodialysis patients, the associated adverse events and the severity when they occur.

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Methods

This document is a topic review. The databases where the search was carried out were: Pubmed, OVID, VHL, Clinical key and LILACS. The terms of the strategy in Spanish were: *ejercicio terapéutico, diálisis renal, seguridad* and in English: exercise therapy, renal dialysis, safety. We included clinical trials, pilot studies, narrative and systematic reviews/meta-analyses, in which patients with chronic kidney disease were subjected to an intervention with exercise of cardiovascular endurance and/or strength, during the hemodialysis, and which also assessed as an outcome the safety of the intervention with these exercises and also the adverse effects (if any) of the intradialytic intervention. The search was restricted to English, Spanish and Portuguese languages. Articles that combined exercise with medications to lose weight or to improve functional capacity were excluded, as well as surveys of perception of physical activity where no intervention was carried out.

Data on outcomes such as the types of intervention and the characteristics of the population were also extracted. The articles were initially selected by title, later with a reading of the abstract and the full text. Articles that provide relevant information on the outcomes that are the subject of this review were also included by manual search. Finally, 23 articles were included. (Figure 1)

Results

Description of the articles included in the review

Of the 23 articles included, 9 are randomized clinical trials, 4 are non-randomized clinical trials, 3 are clinical studies before and after the intervention, 3 are narrative reviews, 1 is a pilot factorial 2x2 study; 2 are systematic reviews and meta-analyses and 1 is a prospective interventional study. Table 1 describes the design and some important characteristics of each article.

Characteristics of the population

In some of the articles reviewed, the population who participate in the studies must meet clear inclusion criteria, such as being over 18 years of age, being on hemodialysis (HD) for more than

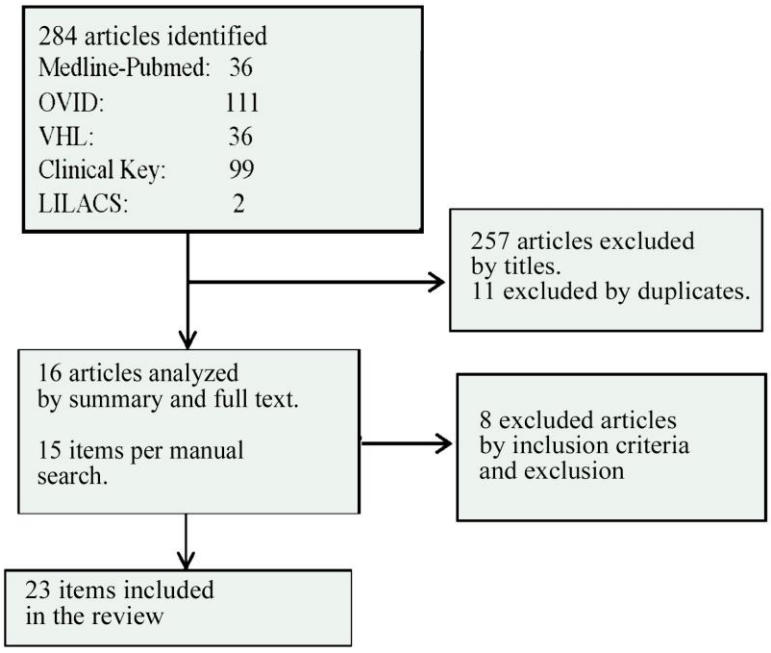

Figure 1. Flow chart of the search of articles for the review.

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Table 1. Description of the articles included in the review.

Author. Year (Reference)	Study design	Language	Extracted from database or manual
Thompson, et al[7]	Randomized pilot factorial study 2x2		PUBMED
Sheng, et al[8]	Systematic review and meta-analysis Included 24 studies	English	PUBMED
Paglialonga, et al[9]	Non-randomized clinical trial	English	PUBMED
Oh Park, et al[11]	Non-randomized clinical trial	English	PUBMED
Spinola Najas, et al[12]	Narrative review Included 6 intradialysis and 6 extradialysis studies	Portuguese	VHL (SciELO)
Bohm, et al[13]	Literature review Included 14 experimental studies	Portuguese	Manual
Segura-Orti[14]	Systematic review and meta-analysis Included 14 studies	Spanish	Manual
V. Esteve Simo, et al., 2015[15]	Prospective, non-randomized unicentric study	Spanish	Manual
Olvera Soto, et al., 2015[16]	Randomized clinical trial	English	Clinical Key
Parsons y King Val Vlack[17]	Narrative review Included 18 publications intradialysis and 16 extradialysis	English	Clinical Key
Mustata, et al[18]	Randomized controlled clinical trial	English	Manual
Konstantinidou, et al[19]	Randomized controlled clinical trial	English	Manual
Leaf, et al[20]	Non-randomized controlled clinical trial	English	Manual
Headley, et al[21]	Randomized controlled clinical trial	English	Manual
Kouidi, et al[22]	Non-randomized controlled clinical trial	English	Manual
Kouidi, et al[23]	Randomized controlled clinical trial	English	Manual
Storer, et al[24]	Clinical trial, before and after	English	Manual
Kong, et al[25]	Randomized controlled clinical trial	English	Manual
Painter, et al[26]	Randomized controlled clinical trial	English	Manual
Macdonald, et al[27]	Clinical trial, before and after	English	Manual
Cheema, et al., 2007[28]	Randomized controlled clinical trial	English	Manual
DePaul, et al., 2002[29]	Randomized controlled clinical trial	English	Manual
Koufaki, et al,[30]	Randomized controlled clinical trial	English	Manual

three consecutive months, attending three or more times per week to HD, having good mobility, or not having alterations that impair normal mobility[7,9,16] or age equal to or older than 80 years,[15] and others are clear when listing the exclusion criteria for these studies, such as the presence of an acute pathology that prevents participation in an exercise program,[7] acute coronary event, physical or mental impossibility, contraindications to perform a stress test, according to the American Association of Cardiology (AHA), also including individuals with DM, with high risk for retinal detachment,[11] or presence of severe hypotension considered as a blood pressure lower than 90/70 mm Hg during the sessions,[15] they also talk of transplant patients, or with loss of vision, which are also exclusion criteria[16]. The study by Konstantinidou,[19] is more selective and includes as exclusion criteria people with unstable or poorly controlled hypertension, heart failure in advanced stages, ventricular arrhythmias Lown 3, persistent hyperkalemia after HD, diabetes mellitus, liver, bone or peripheral vascular diseases. On the other hand, the population is mostly adult, ranging from 19 to 88 years of age (except for the study by Paglialonga, et al.,[9] which included the youngest population in a range between 9.1 and 24.2 years of age). The participation of women had similar proportions with a slight predominance of the masculine gender, and in some studies it is mentioned that they included black and Caucasian patients. In the studies of Thompson, Oh Park, Segura-Orti, and Simo, et al., is mentioned that the most frequent etiologic causes of CKD were arterial hypertension, polycystic kidney disease and glomerular disease. In addition, Olvera, et al., report that 83 % of the population had some degree of malnutrition of poor nutrition[7-14]. (Table 2). Some studies took into account laboratory parameters

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Table 2. Characteristics of the interventions performned in the reviewed clinical trials.

Estudio	Intervention	Frequency	Duration
Thompson, et al[7]	Aerobic exercise: each session included 5 minutes of warm-up and cool-down on the cycle ergometer at intensity between 9 and 11 on the Borg scale.	Not described	12 weeks
Paglialonga, et al[9]	The protocol was constant pedaling for 15 minutes with progression of 2.5 minutes each week. The resistance was adjusted to achieve the target intensity of 12 to 14 on the Borg scale.	Two to three sessions per week	3 months
Smart y Steele[10]	Intradialysis exercise sessions of 30 minutes using the cycle ergometer	Not described	Not described
Oh Park, et al[11]	Studies in population on regular hemodialysis, intervention with exercise vs. no exercise or comparing different types of exercise.	2-3 times per week	3 months
Bohm, et al[13]	Cycle ergometer exercise and strengthening of the extensors of the knee	2-3 times per week	6-40 weeks
Segura-Orti[14]	Cycle ergometer exercise during dialysis (14 randomized controlled clinical trials) during the first hour to the first 90 minutes. Intensity between 40% and 60% of the peak V02 or between 50% and 85% of the maximum heart rate.	3 times per week	Between 2 months and 4 years (90% of the studies with a duration between 3 and 6 months)
V. Esteve Simo, et al[15]	14 studies were reviewed, with interventions mainly of cardiovascular exercise and in some studies combined aerobic and strength exercises. The exercise intensity varied between 50 and 80% of the peak V02 or the maximum heart rate mainly.	Not described	12 weeks
Olvera Soto, et al[16]	Physical exercise adapted by medicine balls, weights, elastic bands and cycle ergometer in the first 2 hours of hemodialysis.	2 times per week	12 weeks
Parsons and King Val Ylack[17]	Strength exercise during the hemodialysis sessions with ankle weights and bands.	2-3 times per week	6, 8 and 12 weeks
Mustata, et al[18]	Exercise of low and moderate intensity, measured by % of V02 peak, maximum heart rate and Borg. Most cardiovascular exercise in bicycle, some programs combined with strength.	2 times per week	3 months
Konstantinidou, et al[19]	Mustata, et al., Intradialytic exercise with bicycle (11 patients)	3 times per week	Not described
Leaf, et al[20]	Konstantinidou, et al., 3 rehabilitation programs: interdialytic, intradialytic and unsupervised home-based plan with 1 hour of duration (7 patients).	Not described	6 weeks
Headley, et al[21]	Leaf, et al., Physical training of the forearm with isometric arm contraction (5 patients).	Not described	12 weeks
Kouidi, et al[22]	Headley, et al., Strength training for upper limbs with circuits with machines (10 patients).	3 times per week	4 years
Kouidi, et al[23]	Kouidi, et al., (2004), interdialytic and intradialytic aerobic exercise (48 patients).	3 times per week	6 months
Storer, et al[24]	Kouidi, et al., (1998), aerobic training, swimming or ball games	3 times per week	9 weeks
Painter, et al[26]	Storer resistance training (20 patients).	3-4 times per week	Not described
Macdonald, et al[27]	Painter, et al., walking, flexibility and strength at home without supervision and cycle ergometer exercise during dialysis (286 patients).	Not described	3 months

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and identified their variation after the exercise program. (Tables 3 and 4).

Intervention

Types of exercise and frequency

The type of intervention most frequently performed was cardiovascular exercise (predominantly aerobic) and the most used mode was the cycle ergometer, followed by the stationary bicycle or some pedal system. Walk was only used when the exercise was done in periods out of the dialysis, not being supervised, as described in the study by Painter, et al.,[3] in some studies the intervention performed was combined (with predominantly aerobic exercises and also of strength), and in others only with strength exercises (mainly with elastic bands and self-loading) as in the studies by Olvera-Soto and Thompson, et al., but in the study by Simo, et al.,[15] they also included free weight (with dumbbells) and in other studies such as that of Heatly, et al[7-17]. they used other machines. They are described in more detail in Table 3.

In those studies in which exercise was done during hemodialysis, the interventions were made for a minimum period of 6 to 8 weeks, although some of these interventions reached 21 and 40 weeks; being 12 weeks the most used duration and only one study (with the longest duration) was of 4 years, where interdialytic interventions were included (Kouidi, et al) [7,9,11-14,16].

The number of sessions in the majority of the studies was 2 to 3 sessions per week, and only the study by Painter mentions 3 to 4 weekly sessions[9,11-14,16]. Also in most studies, the exercises were done between the first and second hours of the renal replacement therapy, being few the studies that do not specify the time of intervention during the exercise program[7-17]. Table 3.

Intensity of the intervention and duration of the session

The intensity of the exercise during the sessions was rated as mild to moderate, measured with the subjective scale of effort «BORG» (in values from 8 to 17 on a scale from 6 to 20), also with percentages of maximum oxygen consumption (VO2Max) or maximum heart rate (max HR) from 40% to 85%[7,8,13]. Interventions of high intensity in exercise of aerobic predominance or loads of high intensity in strength workout are no reported[14,17] and the minimum duration of the sessions was 15 minutes, but durations of up to 60 minutes per session are reported in some cases[3,7,9].

Type of monitoring of the sessions

The form of monitoring of the sessions is not reported in several of the articles, and in those that report it, they indicate that such supervision during the session was carried out by qualified healthcare personnel and in the programs that additionally included exercises at home, they refer that remote contact was made with some regularity for this supervisión,[14] which also was a way to motivate the participants in such a way that they would stay active in the home-based exercise plan[13].

Safety and adverse effects

There are few articles which refer the presentation of adverse effects; others simply do not narrate them. The studies by Olvera-Soto, Paglialonga, Simo, et al., report “no adverse effect” in relation to the intervention[9,15,16]. Also in the systematic review of Segura-Ortíz they describe that in 4 studies no adverse effects were reported during the exercise program[14,16].

Other studies, such as the narrative review by Spinola Najas,[10,11,13,17] provide information about «Safety and efficacy of physical training in chronic kidney disease», but do not report its adverse effects, and they highlight the hemodynamic changes in patients with CKD, who undergo an intervention with physical exercise during dialysis, being similar to the hemodynamic changes of healthy people, stressing the importance of monitoring the hemodynamic stability[12].

Interventions such as that of the study by Thompson, et al.,[7] classify as serious adverse events any life-threatening event, such as sudden death, cardiac event, others that require hospitalization or

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Table 3. Interventions and report of adverse events.

Estudio	Objective	Sample size	Adverse events	Results
Thompson, et al[7]	To evaluate the feasibility of a main study that evaluates the effectiveness of cycling and strength exercise on QoL, each performed during hemodialysis treatment.	25 patients	Complication fistula (n=2) Hypotension (n= l) Hypertension (n=3) Trauma (n= l)	None of the adverse events presented was severe and the frequency of presentation was low.
Paglialonga, et al[9]	Intradialysis exercise can improve Kt 1 V, VO 2 peak, and quality of life, intradialysis exercise is safe for patients on HD. Therefore, we present a suggestion to update the clinical guidelines to inform clinicians about the benefits of intradialysis exercise in patients on HD.	10 individuals	None	30 minutes of intradialysis cycling exercises is feasible for the majority of pediatric patients in chronic HD and are well accepted and tolerated. This exercise program can lead to an improvement of the exercise capacity of this population.
Oh Par k, et al[11]	To investigate the safety and viability of aerobic and strength training during hemodialysis for patients with end-stage renal disease and to assess its impact on their cardiac condition, muscle strength and functional status.	22 individuals	Not reported	A well-designed exercise program during hemodialysis can be carried out safely with proper supervision and education of the patient, to improve muscle strength, mental and physical function and possibly cardiac fitness.
Bohm, et al[13]	To review the literature on the effects of exercise in patients on hemodialysis.	541 patients	Does not report adverse events	The evidence suggests that patients on hemodialysis should be included in a standardized exercise program.
Esteve Simo V., et al[15]	To analyze the effect of an adapted program of intra-dialysis physical exercise on muscle strength, functional capacity and health-related quality of life on our elderly patients (> 80 years) on hemodialysis.	22 patients	None	The adapted program of intradialysis physical exercise improved muscle strength, functional capacity and health-related quality of life of the elderly patients on HD.
Olvera, et al[16]	To evaluate the effect of strength exercise performed during hemodialysis sessions on the anthropometric indicators of muscle reserve and hand strength.	61 patients	None	In favor of the exercise program.
Parsons y King Val Vlack[17]	Review of the impact of intradialytic vs. extradialytic exercise.	573 patients	Not reported	Intradialysis exercise improves blood pressure and vascular function more than extradialysis exercise.
Mustata, et al[18]	Predialytic exercise with bicycle.	11 patients	Not reported	Reduction in arterial stiffness.

Continuación Table 3. Interventions and report of adverse events.

Estudio	Objective	Sample size	Adverse events	Results
Konstantinidou, et al[19]	Three rehabilitation programs: interdialytic, intradialytic and unsupervised home-based plan of 1 hour of duration.	48 patients	Not reported	The most favorable exercise was the interdialytic, but patients preferred the intradialytic; improvement in physical qualities in all training models.
Leaf, et al[20]	Physical training of upper limbs with isometric contraction of the arm.	5 patients	Not reported	Increase in the size of the cephalic vein.
Headley, et al[21]	Strength training for the upper limbs with circuits with machines.	10 patients	Not reported	Increase in peak V02, increase in distance in the 6-minute walk test, decrease in time in the sit-to-stand test, no significant effects on hypotension.
Kouidi, et al[22]	Aerobic training, swimming or ball games.	7 patients	Not reported	Increase in nerve conduction velocity of type II fibers, peak V02 and peak strength in lower limbs.
Kouidi, et al[23]	Interdialytic vs. intradialytic aerobic exercise	48 patients	Not reported	Increase of V02, improvement of quality of life.
Storer, et al[24]	Training in cycle ergometer	12 patients	Not reported	Increase in cardiopulmonary function, power and strength.
Kong, et al[25]	Single exercise session with a cycle ergometer for 60 minutes.	11 patients	Not reported	Increased dialytic efficiency (KtN) decrease in creatinine, potassium, urea rebound effect.
Painter, et al[26]	Exercise of cardiovascular endurance, 30 minutes, 4 times per week	167 patients	Not reported	Increase of the VO2 peak, strength and improvement of functionality.
Macdonald, et al[27]	High intensity interval training and strength exercise for muscle hypertrophy.	9 patients	Not reported	Increase in physical capacity without reversion of muscle atrophy.
Cheema et al[28]	Impact of strength training on muscle quality and volume.	49 patients	Headache, hypotension, cramps, difficulties with the fistula. Rotator cuff tear.	No statistically significant difference was found in terms of adverse events between the intervention group and the control group.
DePaul, et al[29]	Effect of a resistance exercise program plus progressive strengthening in patients on hemodialysis and erythropoietin management.	38 patients	Withdrawal due to fatigue, hypotension, abrasion with pedal. Pain in the extremities due to strengthening.	No statistical difference between the groups in the laboratory parameters measured, all adverse events were mild.
Koufaki, et al[30]	Effect of exercise on aerobic and functional capacity in patients with end-stage chronic kidney disease.	33 patients	Rupture of the knee ligament (not related to the protocol).	There were no complications related to the exercise protocol.

Table 4. Characteristics of the intervened populations.

Article	Hb (g/dL) or Hct (%)	Albumin	LVEF %	Others	Characteristics of the intervened population
Leaf, et al[20]	33.7 ± 5.3 % N.R	N.R	N.R	Creatinine 3.8 ± 1.5 GFR = 33.7 ± 5.3 mL/min GFR = 30–59 mL/min per 1,73m2	n = 5, mean age 57 ± 9, average weight 80.0 ± 5.1 n = 46, mean age 58 ± 8, average weight 101.7 ± 24.9
Headley, et al[21]	30.9 ± 4.2 %	N.R	N.R	Creatinine 13.2 ± 4.0	n = 7, mean age 44.1 ± 17.2, average weight 67.0 ± 15.9
Kouidi, et al[22]	11.4 ± 1.4 g/dL	N.R	N.R	Creatinine 12.5 ± 3.5	n = 12, mean age 44 ± 9, average weight 76 ± 12
Storer, et al[24]	9.5 to 13.9 g/dL	N.R	N.R	Creatinine 0.57	n = 11, age 32 to 78
Kong, et al[25]	N.R	N.R	N.R	N.R	n = 56, age 39.7 ± 12.6
Painter, et al[26]	11.7 ± 0.4 g/dL	N.R	N.R	N.R	n = 9, mean age 48.4 ± 5.3, BMI = 24.8 ± 1.5
Macdonald, et al[27]	N.R	41,3 ± 1,8 g/L	N.R	Creatinine 940.9 ± 185.9 ų mol/L	n = 49, mean age 62.6 ± 14.2, average weight 75.7 ± 18.3
Cheema, et al., 2007[28]	11.6 ± 1.2 g/dL 35 ± 4 %	34.5 ± 3.1 g/L	N.R	Creatinine 814.9 ± 176.5ų mol/L	n = 20, mean age 55 ± 16
DePaul, et al., 2002[29]	12.1 ± 1.4 g/dL	N.R	N.R	N.R Creatinine 3.8 ± 1.5 GFR = 33.7 ± 5.3 mL/min	n = 18, mean age 57.3 ± 14.3, average weight 76.3 ± 13.6 n = 5, mean age 57 ± 9, average weight 80.0 ± 5.1
Koufaki, et al[30]	33.7 ± 5.3 %	39 ± 5,5 g/L	N.R	GFR = 30–59 mL/min per 1,73m2	n = 46, mean age 58 ± 8, average weight 101.7 ± 24.9

Hb= hemoglobin, Hct= hematocrit, N.R = Not registered, GFR= Glomerular filtration rate, n= number of participants in the intervention, BMI = Body mass index.

that cause a disability, and as mild adverse events, the skeletal muscle injury, hypoglycemia, hypotension, hypertensive emergency, altered state of consciousness or those that need some additional intervention by the renal unit staff other than ultrafiltration. They indicate the following Results of adverse events by groups: in the group of combined exercise (aerobic and strength), and in the group of aerobic exercise: two patients presented adverse effects. In the group of strength exercise, one patient presented an adverse event and finally, in the group of stretching they did not present adverse events. None of the adverse events presented was considered severe, which indicates that their presentation is very low (details of the adverse events in Table 3)[7].

In the systematic review and meta-analysis of Sheng, are mentioned 3 studies (Cheema,[28] De Paul[29] and Koufaki[30]), and in them there are case-controls, being documented adverse events with the intervention of exercise during dialysis, and compared with the control, it is shown that muscle-skeletal complications (reported in the 3 studies), and cardiovascular complications (all related to hypotension) are mild; in this last study (by Cheema)[28] a cardiovascular adverse effect also occurred in the control group. (Tables 3 and 4)

Conclusions

Reviewing the literature we found that the population in which the studies were conducted were mostly of adult people (older than 18 years and populations over 80 years), of both genders, whose cause of chronic kidney disease was mostly due to HTA, DM, polycystic kidney disease and glomerular disease, and whose exclusion criteria to participate in the studies were defined in their majority related to presenting or having recently had an acute disease (mostly of coronary origin) or presenting contraindications to perform a stress test according to the guidelines of the American Heart Association (AHA), where the risk of presenting an acute cardiac event is increased. The inclusion criteria generally refer to populations controlled in a HD program (for more than three consecutive months and with sessions of 3 or more times per week) without other considerations or biochemical variables that contraindicate the performance of directed

and controlled physical activity of moderate intensity. It is found that the intervention with exercise during hemodialysis is safe, and in those studies that report adverse events, these are mostly mild, and those that are reported as serious occurred both in the group of intervention with physical exercise and in the controls in a same proportion without representing a statistically significant difference, so we can conclude that with the available evidence, an intervention with intrahemodialysis physical exercise can be recommended as a safe therapeutic modality.

Discussion

We found that in many studies the incidence of adverse events associated with the exercise intervention during hemodialysis is not reported, either because they did not occur or because no reference was made to the complications or adverse effects related to the intervention, since simply those that were present are a common occurrence during dialysis. For these intradialytic exercise programs, in general, all types of population are included (excluding, according to some articles reviewed, populations with a high risk of presenting cardiac complications related to high-intensity exercise, such as during a cardiovascular stress test, but they do not contraindicate exercises of moderate or low intensity), with an age range where adults predominate, being few the interventions in children and adolescents. Regarding the exercise sessions, these are of low to moderate intensity, finding that there are no studies with high intensities or loads, both of cardiovascular and strength training exercises. In the studies that reported adverse effects, these were classified as non-severe and of low frequency in their presentation, which allows to intuit that it is a safe intervention for this population. This study included narrative reviews, but also systematic reviews and meta-analyses that provide data relevant to our objective, although there is not a large number of clinical studies that report adverse effects that can be related to this type of program; for this reason, it is very important to give relevance to the safety of these activities during a hemodialysis program, so that future studies can provide recommendations with a high power of evidence and a statistics that demonstrate the safety of intrahemodialytic physical exercise.

Contribution of the authors

Angélica Puentes and Andrés Hernández carried out the systematic search of articles; the three authors conducted the manual search of articles.

The three authors reviewed the articles selected. Oscar Sarmiento constructed the tables.

All the authors reviewed the final paper and gave their approval.

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Conflict of interest

The authors of this article declare they do not have any conflict of interest.

Declaration of funding of the project

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Ethical responsibilities

Protection of people and animals

The authors declare that no experiments were performed on human beings or animals for this research.

Data confidentiality

The authors declare that they have followed the protocols of their workplace on the publication of patient data.

Right to privacy and informed consent

The authors declare that patient data do not appear in this article.

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