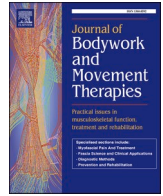














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## “Sit-to-stand test to assess muscle strength after intradialytic exercises in chronic kidney disease patients: A systematic review with meta-analysis”

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## ABSTRACT

**Introduction:** Chronic kidney patients undergoing hemodialysis (HD) experience a decline in muscle strength and functionality, as musculoskeletal disorders affect both strength and functional capacity. This study aims to evaluate the influence of intradialytic (ID) exercise on the strength and functionality of chronic kidney patients, as assessed by sit-to-stand test, and to identify the most commonly used sit-to-stand protocol.

**Methods:** A search was conducted across eight databases to identify relevant studies published before March 29, 2024. Clinical trials investigating intradialytic exercises and utilizing the sit-to-stand test as an assessment tool were eligible. The risk of bias in individual studies was assessed using the Physiotherapy Evidence Database (PEDro) scale. Mean differences (MD) and 95 % confidence intervals were calculated and pooled in meta-analyses. The quality of meta-analyses was assessed using the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) approach.

**Results:** A total of 6717 studies were initially identified. After screening, 17 articles involving 870 participants, met the inclusion criteria demonstrating acceptable methodological quality, with a mean PEDro scale of 5,23 ( $\pm 1,56$ ). Despite the lack of robust evidence, this review suggests that the ID exercise improves strength and functionality. Among the various sit-to-stand test subtypes, the 10-repetition sit-to-stand test was found to be the most effective.

**Conclusion:** Despite the low quality of studies, the 10-repetition sit-to-stand test (10-STs) seems to be the most effective for evaluating muscle strength of lower limbs and functionality. ID exercise seems to positively impact muscle strength and, consequently, the functionality of chronic kidney disease patients undergoing HD.

### 1. Introduction

In 2020, the number of patients with end-stage kidney disease who started hemodialysis (HD) in specialized treatment centers in the United States decreased by around 7.5 % (Johansen et al., 2023), while in Brazil there was an increase of 3.7 % in 2022 (Nerbass et al., 2022). It is believed that by 2030 the number of HD patients in the world will double compared to today (Chan et al., 2019). People who undergo

chronic kidney disease (CKD) treatment often present some type of vulnerability in their cardiorespiratory system, musculoskeletal system, and quality of life (Pender et al., 2023). These changes can have an impact on the patient's physical and functional performance (Fassbinder et al., 2015; Wilkinson et al., 2016). In this context, there are still gaps regarding which type of physical exercise should be adopted in these patients during HD, to mitigate or even prevent the loss of muscle strength and functional capacity from having a major impact on the

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quality of life of chronic kidney disease patients (McKenna et al., 2019).

Physical exercise stands out regarding quality of life, as it reveals positive results in pain relief and improvements in the physical function of kidney patients (Rossi et al., 2014; Westcott, 2012). Furthermore, the effects of physical training enhance movement control, functional independence, physical performance, glycemic control, body composition, improved muscle strength, walking ability, and better quality of life (Hellsten and Nyberg, 2015; Lima et al., 2013; Lopes et al., 2019; Wu et al., 2020). Studies show that the combination of resistance and aerobic exercise programs effectively improves kidney patients' functionality on HD (Orcey et al., 2012; Watson et al., 2018).

Physical aspects, such as the manifestation of strength and other functional aspects, can be assessed by the sit-to-stand test (SST), commonly used as it requires few resources and reduced physical space, making it a great test to apply in healthcare (Alcazar et al., 2018; Clarkson et al., 2019; MacRae et al., 2023). This test is safe, cheap, and reliable for use with patients with end-stage kidney disease. It is known several protocols for its use, such as those based on the time to perform a certain number of movements (5 and 10 repetitions) and others based on the number of movements performed in a predetermined time (30 and 60 s). Both are frequently used to evaluate muscular performance, physical function, and exercise tolerance in patients and their results can be associated with the degree of functionality and independence (Figueiredo et al., 2021; Lionardo de Paula et al., 2023; Norman-Gerum and McPhee, 2020).

To answer how intradialytic (ID) physical exercise interferes with the strength and functionality of chronic kidney disease patients, assessed by the sit-to-stand test when compared with patients who did not perform this type of exercise, a systematic review was designed to identify studies that aimed to evaluate the effectiveness of ID physical exercise on muscle strength of lower extremity and functionality in chronic kidney disease patients using the sit-to-stand test as an assessment tool and to identify which sit-to-stand test protocol is most used.

## 2. Methods

This systematic review of randomized controlled trials was developed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). and was previously registered on the PROSPERO website (CRD42022304123). It was not necessary to submit the project for approval by the Research Ethics Committee (REC), according to the Resolution of the Brazilian National Health Council (NHC) 466/2012.

### 2.1. Data sources, search strategy and eligibility criteria

The search was carried out in the ScienceDirect, *Biblioteca Virtual em Saúde* -BVS (Lilacs), Cochrane, PubMed (Medline), Pedro, Cinahl, Web of Science e Scielo databases to identify articles on the topic of this study. The first search phase was carried out on March 20th, 2022, and updated on March 29th, 2024, with no language or date restrictions. The keywords and/or terms used to search the databases were selected, using MeSH tools from the United States National Library of Medicine, in the Pubmed and DeCS databases, descriptors in health sciences from the BVS, and combined using the Boolean operators, “AND”, “OR” E “NOT”.

The manuscripts were found through keyword lines and the use of database resources. Some database automation features such as the “Clinical Trial”, “Randomized Controlled Trial”, “Humans”, “Medline” and “adult:+19 years” command buttons from the PubMed database; “Research articles” from the Science Direct database; “Ensaio clínico controlado” and “Lilacs” from the BVS database; “Trials” and “Embase” in the Cochrane database; “Clinical Trial” from the PEDro database; “Health Sciences” and “Article” from the Scielo bank were used immediately. The search strategies are available in Supplementary Appendix I.

The inclusion criteria adopted sought to select clinical trials and randomized clinical trials published until March 29th, 2024, that

reported aerobic and resistance exercises as an intervention during HD, and the functional sit-to-stand test to evaluate muscle strength and functionality in chronic kidney disease patients undergoing HD treatment, with patients over 18. Studies with any intervention other than physical exercise or with animal models were excluded.

### 2.2. Screening

The first stage of screening the trials was based on titles and abstracts of the exported citations, considering inclusion and exclusion criteria. After the first screening, the remaining trials had their files downloaded and included in the *EndNote*® program to undergo a second screening based on the full reading of the content. In these stages, the trials were selected independently by two investigators (KSA and BNL). Any disagreement regarding the study inclusion, a third investigator (LDC) opinion was requested.

### 2.3. Data Extraction

From the selected trials, nine characteristics and outcome data were extracted: author, year of publication, title, objectives, participants characteristics, therapeutic strategy, tests used for evaluation, results obtained, and main conclusions of each study. Methodological information was extracted by two independent reviewers and checked by a third one. For missing data or lack/insufficient information, the authors were contacted through email. Pre-intervention and post-intervention sit-to-stand test values were used to determine the average effect size in the cluster across studies. The effect size was extracted using *Review Manager Software* Version 5.4. *Cochrane Collaboration*.

### 2.4. Methodological quality assessment

The methodological quality of the selected articles was assessed using the PEDro scale described in the *Physiotherapy Evidence Database* (<http://pedro.org.au/>). This scale presents a total of 11 items that assess the methodological quality regarding the internal and external validity of clinical trials in physiotherapy being 10 as its maximum score. The following classification was considered to final score: 0–4: low quality; 4–5: reasonable/acceptable quality; 6–8: good quality; and 9–10: excellent methodological quality (Maher et al., 2003). The first assessment item of the PEDro scale is not used to calculate the total score. Studies that were not evaluated by the PEDro database were analyzed by two investigators (MMS and AFMPN). Disagreements were decided by a third investigator (LDC). Comparison between studies was carried out through critical analysis of their content.

The Grades of Research, Assessment, Development and Evaluation (GRADE) approach was used to assess the quality of evidence from the meta-analyses performed (Atkins et al., 2004). This approach specifies that a body of evidence can be downgraded from high-quality evidence, based on four criteria: (1) risk of bias across studies (downgrade if average PEDro score was <6 for studies included in the meta-analysis); (2) inconsistency of results (downgrade if I<sup>2</sup> >50 % indicating high statistical heterogeneity between the studies); (3) indirectness of results (downgrade if indirect comparisons between interventions or outcomes); (4) imprecision of results (down-grade if large confidence intervals, defined as > 0.8 for standardised mean differences (SMD) or mean differences (MD)).

### 2.5. Data analysis

The results related to the study population were presented through descriptive analysis. The intervention effect size (Z) was calculated for each study included, presented mean difference (MD) or standardized mean difference and 95 % confidence interval (95 %CI). When there was low heterogeneity in the data, a fixed-effects meta-analysis was performed to estimate the influence of ID physical exercise on the response

to the sit-to-stand test in patients with chronic kidney disease. If there was high heterogeneity, we used a random effects model. The absence of publication bias was certified using a funnel plot. A statistical significance level of 5 % was considered. The meta-analysis was performed using the *Review Manager Software* Version 5.4. *Cochrane Collaboration*.

### 3. Results

This review identified a total of 6717 records. After the second screening stage, 46 trials were selected for analysis, ending in 17 selected trials. The data, from all screening processes, are presented in a

flowchart (Fig. 1).

The main trials characteristics (author, year of publication, title, objective, and conclusions) are presented in [Tables 1](#), and [Table 2](#) reports the results obtained in each selected study.

Among the selected trials, four subtypes of the sit to stand test were identified. The STS-5, cited in four trials ([Huang et al., 2020](#); [Koufaki et al., 2002](#); [Martinez-Olmos et al., 2022](#); [Segura-Orti et al., 2019](#)); STS-10, cited in 10 trials ([Bogataj et al., 2020](#); [Martinez-Olmos et al., 2022](#); [Michou et al., 2023](#); [Ortega-Pérez de Villar et al., 2020](#); [Peréz-Dominguez et al., 2021](#); [Segura-Orti et al., 2009](#); [Segura-Orti et al., 2019](#); [Valenzuela et al., 2018](#); [Yeh et al., 2020](#); [Zhang et al., 2020](#));

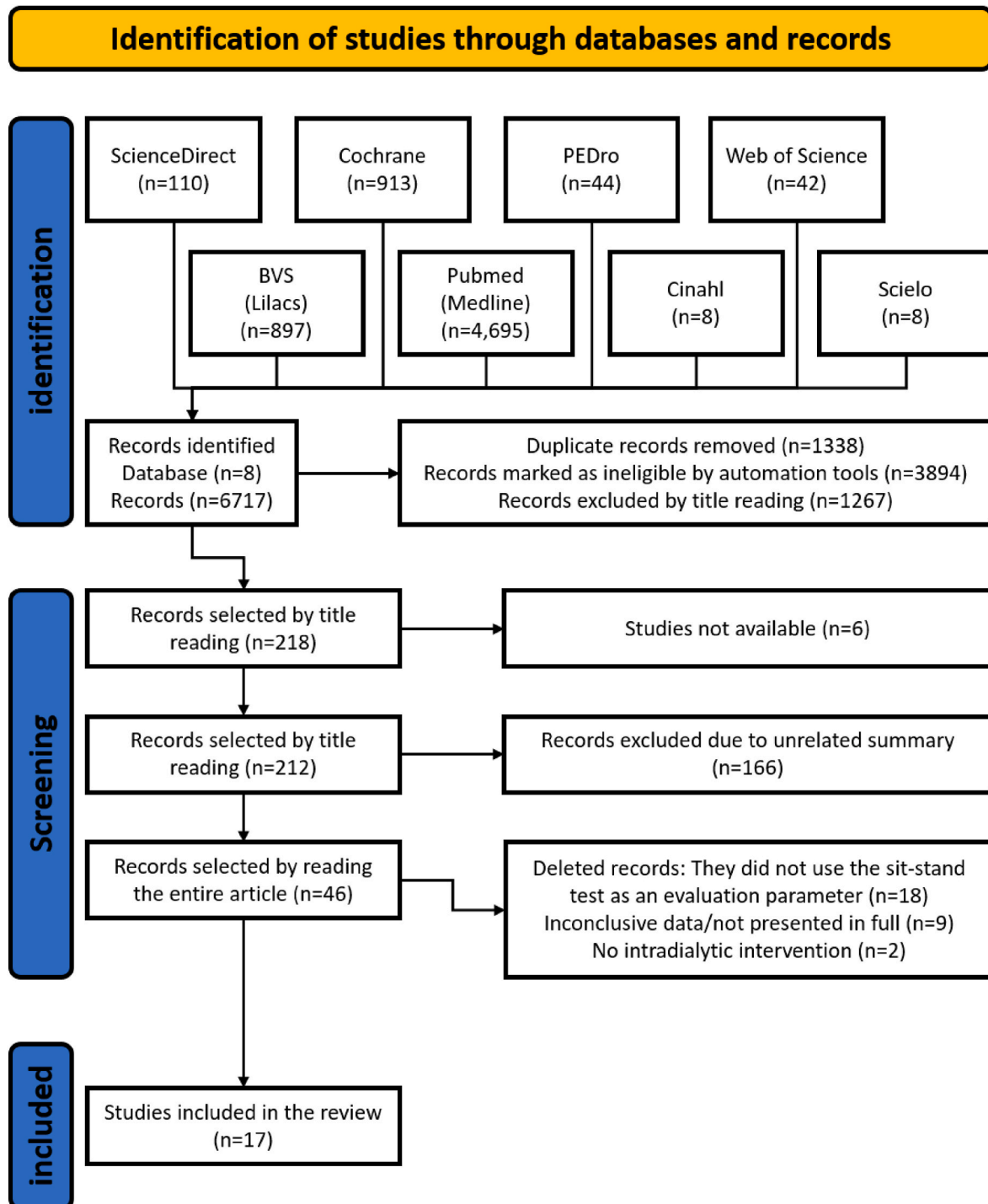


Fig. 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses flow diagram of the conducted search.

**Table 1**  
Characteristics of 17 included studies.

Author and Year	Title	Sample Characteristics	Objective(s)	Intervention	Tests and Assessments tools
Koufaki et al. (2002)	Effects of exercise training on aerobic and functional capacity of end-stage renal disease patients	<ul style="list-style-type: none"> <li>•Total: (n = 33)</li> <li>•Exercise group (n = 18)</li> <li>•Control group (n = 15)</li> </ul>	To evaluate the effects of physical training on the aerobic and functional capacity of patients with end-stage renal disease (ECKD).	Randomized study with incremental exercise test on a friction cycle ergometer with brake. Participants in the control group were instructed to maintain their usual level of physical activity and those in the experimental group were instructed not to engage in any other physical activity, only the ID exercise protocol.	<ul style="list-style-type: none"> <li>•STS-5</li> <li>•STS-60</li> <li>•VO2 peak</li> <li>•Biochemical data</li> <li>•NSRI walk test</li> <li>•7-day RQ</li> <li>•CLIMB</li> <li>•DESCENT</li> </ul>
Segura-Ortí et al. (2009)	Effect of resistance exercise during hemodialysis on physical function and quality of life: randomized controlled trial	<ul style="list-style-type: none"> <li>•Total: (n = 25)</li> <li>•Resistance exercise group (n = 17)</li> <li>•Aerobic exercise group (n = 8)</li> </ul>	To evaluate the effects of an ID resistance exercise program on exercise capacity, muscle strength, functional capacity, and health-related quality of life.	Randomized clinical trial in which the effects of an ID resistance training program with low-intensity ID aerobic training on functional capacity were compared. exercise, strength, and quality of life in HD patients.	<ul style="list-style-type: none"> <li>•STS-10</li> <li>•STS-60</li> <li>•6MWT (m)</li> <li>•Dynamometry (knee extensors)</li> <li>•Graded exercise test (GXT)</li> <li>•SF-36</li> </ul>
Bohm et al. (2014)	Effects of intradialytic cycling compared with pedometry on physical function in chronic outpatient hemodialysis: a perspective randomized trial	<ul style="list-style-type: none"> <li>•Total: (n = 43)</li> <li>•Exercise group (n = 20)</li> <li>•Control group (n = 23)</li> </ul>	To compare the effects of an intradialysis cycling exercise program with the use of a pedometer to encourage physical activity on the aerobic capacity, physical function, and quality of life of patients undergoing HD.	Randomized study that used an ID cycling exercise program (experimental group) and the use of a pedometer to encourage physical activity (control group), in addition to usual care. Patients were recruited from four outpatient HD units in Winnipeg, Manitoba, Canada.	<ul style="list-style-type: none"> <li>•STS-30</li> <li>•VO2 peak</li> <li>•6MWT (m)</li> <li>•Sit-and-reach</li> <li>•SF-36</li> <li>•Accelerometry</li> </ul>
Liu et al. (2015)	Effects of Aerobic Exercise During Hemodialysis on Physical Functional Performance and Depression	<ul style="list-style-type: none"> <li>•Total: (n = 20)</li> <li>•Exercise group (n = 10)</li> <li>•Control group (n = 10)</li> </ul>	To evaluate the effects of ID aerobic exercise on functional physical performance and depression in HD patients.	Clinical trial in which HD patients at a hospital in Taiwan were non-randomly allocated to an ID aerobic exercise group and a control group in which they received only usual care.	<ul style="list-style-type: none"> <li>•STS-60</li> <li>•6MWT (m)</li> <li>•Biochemical data</li> <li>•Beck Depression</li> <li>•Inventory II</li> </ul>
Valenzuela et al. (2018)	Intradialytic Exercise: One Size Doesn't Fit All	<ul style="list-style-type: none"> <li>•Total: (n = 59)</li> <li>•Exercise group (n = 23)</li> <li>•Control group (n = 36)</li> </ul>	To analyze the effects of a 14-week ID combined exercise program on the mental and health status of patients.	Clinical trial in which a 14-week ID exercise program was used to analyze the physical, mental and health status of chronic kidney disease patients. The control group performed only usual care, without interventions on days without dialysis.	<ul style="list-style-type: none"> <li>•STS-10</li> <li>•6MWT (m)</li> <li>•Hand grip strength</li> <li>•Beck's depression inventory and State-Trait Anxiety Inventory</li> <li>•SF-12</li> </ul>
Rosa et al. (2018)	Effect of continuous progressive resistance training during hemodialysis on body composition, physical function, and quality of life in end-stage renal disease patients: a randomized controlled trial	<ul style="list-style-type: none"> <li>•Total (n = 52)</li> <li>•Progressive Resisted exercise group (n = 28)</li> <li>•Control group (n = 24)</li> </ul>	Determine whether continuous progressive resistance training could improve body composition, physical function, and quality of life in patients undergoing HD.	Randomized clinical trial that sought to compare the effects of resistance exercises performed during HD, prescribed in two series of 15–20 repetitions, three times a week, for 12 weeks with a control group that received exercise without load and progression (active mobilization of the arms and legs, circumduction of the shoulder and neck girdle and unloaded breathing exercise in two sets of three to five repetitions, without stretching exercises.	<ul style="list-style-type: none"> <li>•STS-30</li> <li>•Anthropometric Profile</li> <li>•6MWT (m)</li> <li>•and grip strength</li> <li>•Sit-and-reach test</li> <li>•QoL physical (score)</li> <li>•QoL mental (score)</li> </ul>
Segura-Ortí et al. (2019)	Virtual reality exercise intradialysis to improve physical function: a feasibility randomized trial	<ul style="list-style-type: none"> <li>•Total: (n = 18)</li> <li>•Exercise group + virtual reality (n = 9)</li> <li>•Exercise group + control (n = 9)</li> </ul>	Assess the feasibility and impact of virtual reality exercise on physical function.	Randomized feasibility study of a 16-week exercise program plus 4 weeks of exercise in virtual reality to evaluate physical function in HD patients. The control group performed combined ID exercise (aerobic and resistance) and the experimental group maintained the control group intervention plus virtual reality (adding 30' of exercise in virtual reality in the last 4 weeks).	<ul style="list-style-type: none"> <li>•STS-5</li> <li>•STS-10</li> <li>•STS-60</li> <li>•6MWT (m)</li> <li>•Gait Speed (m/s)</li> <li>•OLHR</li> </ul>
Huang et al. (2020)	The effect of intradialytic combined exercise on hemodialysis efficiency in end-	<ul style="list-style-type: none"> <li>•Total (n = 32)</li> <li>•Exercise group (n = 16)</li> </ul>	To Compare the Effect of 24 Weeks of Combined Exercise and Usual Care on HD Efficiency,	Randomized and controlled study in which patients were randomized when they started HD into two groups. The experimental	<ul style="list-style-type: none"> <li>•STS 30</li> <li>•STS-5</li> <li>•Sp Kt/V</li> <li>•BP</li> </ul>

(continued on next page)

Table 1 (continued)

Author and Year	Title	Sample Characteristics	Objective(s)	Intervention	Tests and Assessments tools
	stage renal disease patients: a randomized-controlled trial	•Control group (n = 16)	Physical Function, and QL of ESKD Patients on HD.	group performed progressive ID combined cycling exercise (20-min aerobic exercises and 10-min resistance exercises) for 24 weeks, which continued during the first 2 h of HD. Patients in the control group received usual care and were advised to do activities such as extending their legs and arms for about 15 min during the first 2 h of HD.	•6MWT (m) •SF-12
Bogataj et al. (2020)	Kinesiologist-guided functional exercise in addition to intradialytic cycling program in end-stage kidney disease patients: a randomized controlled trial	•Total (n = 34) •Exercise group (n = 16) •Control group (n = 18)	Determine the effects of supervised functional training and counseling added to the basic ID cycling program on the physical performance of HD patients.	Prospective, randomized study that compared two exercise prescription strategies in patients undergoing HD. The effects of functional training added to ID cycling (experimental group) were evaluated. Functional training consisted of different full body exercises that train flexibility, strength, balance, coordination, power and endurance. The control group performed only ID cycling.	•STS-10 •6MWT (m) •Hand grip strength •Sit-and-reach test •Stork test (In value) •Back scratch test
Yeh et al. (2020)	Twelve-week intradialytic cycling exercise improves physical functional performance with gain in muscle strength and endurance: a randomized controlled trial	•Total (n = 62) •Exercise group (n = 30) •Control group (n = 32)	To evaluate the effect of a 12-week ID cycling exercise on physical functional performance with gains in muscle strength and endurance in end-stage renal patients on HD.	Randomized clinical trial conducted in a HD center in Taiwan for 12 weeks. The experimental group performed moderate ID cycling exercises with progressively increasing resistance during the sessions, plus usual care. The control group performed only usual care.	•STS-10 •STS-60 •6MWT (m)
Ortega -Perez de Villar et al. (2020)	Comparison of intradialytic versus home-based exercise programs on physical functioning, physical activity level, adherence, and health-related quality of life: pilot study	•Total (n = 23) •ID exercise group (n = 11) •HB exercise group (n = 12)	To compare the effects of ID exercise programs versus HB on the level of physical activity of patients undergoing maintenance HD. Secondary objectives were (I) to compare the effects of ID exercise versus hb on physical function, (II) HRQOL, (III) depression symptoms and (IV) adherence.	Randomized controlled clinical trial in which eligible participants were randomly assigned to two exercise groups (G = ID or G = HB). The ID group performed combined (aerobic and resistance) ID exercise. And the HB group performed home exercises, receiving guidance from a physiotherapist in the first 4 weeks during HD and then in weeks 7 and 16.	•STS-10 •STS-60 •SPPB •OLST •TUG •Hand grip strength •OLHR •6MWT(m)
Zhang et al. (2020)	Effect of intradialytic progressive resistance exercise on physical fitness and quality of life in maintenance hemodialysis patients	•Total (n = 87) •Resistance exercise group (n = 43) •Control group (n = 44)	To determine whether an intervention with ID progressive resistance exercise could improve physical fitness and quality of life in patients on maintenance HD.	Randomized clinical trial with patients from a HD clinic in China, randomly allocated between groups. The experimental group performed ID resistance exercise for 12 weeks and the control group performed only usual care, without exercise interventions, the evaluator was blinded.	•STS-10 •6MWT(m) •Hand grip strength •SF-12
Sovatzidis et al. (2020)	Intradialytic Cardiovascular Exercise Training Alters Redox Status, Reduces Inflammation, and Improves Physical Performance in Patients with Chronic Kidney Disease	•Total (n = 20) •Exercise group (n = 10) •Control group (n = 10)	Investigate changes in redox status, inflammatory indicators, physical performance, and general quality of life of patients with end-stage renal failure, after 6 months of intervention with ID aerobic training.	Randomized clinical trial involving patients from an outpatient HD unit. Participants were randomized into two groups: (A) Intradialysis training group and (B) Control group, which performed only usual care, without exercise intervention.	•STS-60 •Anthropometric Profile •VO2 peak •Hand grip strength •SF-36 •NSRI walk test •Biochemical data
Perez-Dominguez et al. (2021)	Effects of exercise programs on physical function and activity levels in patients undergoing hemodialysis: a randomized controlled trial	•Total (n = 57) •ID exercise group (n = 30) •HB exercise group (n = 27)	To compare the effect of combined ID exercise interventions (aerobic and resistance) and home exercise on functional capacity, level of physical activity and quality of life in chronic kidney disease patients.	Randomized clinical trial of 16 weeks of intervention, with outcome assessment and blinded data analysis. Participants were randomly allocated into two groups: (A) ID exercise and (B) Home exercise. Group B received an exercise guide, with photos and instructions, in addition to a weekly meeting with the physiotherapist, 15 min before HD.	•STS-10 •STS-60 •SPPB •Gait Speed (m/s) •6MWT(m) •OLHR •OLST •TUG •PASE •SF-36
Greenwood et al. (2021)	Exercise programmed to improve quality of life for patients with	•Total (n = 243) •Exercise group	To compare the effect of usual care and usual care plus	Randomized, multicenter controlled clinical trial involving	•STS-60 •KDQOL

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Table 1 (continued)

Author and Year	Title	Sample Characteristics	Objective(s)	Intervention	Tests and Assessments tools
	end-stage kidney disease receiving hemodialysis: the PEDAL RCT	(n = 116) ●Control group (n = 127)	intradialysis training for 6 months on quality of life, physical function, and clinical measures such as hemodynamic and biochemical data in chronic kidney disease patients on HD.	chronic kidney disease patients on HD at 5 centers, randomly allocated into two groups: Group (A) ID aerobic training on a cycle ergometer and Group (B) only usual care, without exercise.	●EQ-5D-5L ●VO2 peak ●Anthropometric Profile ●Duke Activity Status Index ●Arterial stiffness via PWV (msec) ●IPAQ ●10mTUG ●Tinetti Falls Efficacy Scale ●Biochemical data
Martinez-Olmos et al. (2022)	An intradialytic non-immersive virtual reality exercise programme: a crossover randomized controlled trial	●Total (n = 33) ●Exercise group + virtual reality (n = 15) ●Control group (n = 18)	To evaluate whether a 12-week period of ID exercise with virtual reality improves gait speed in patients receiving HD. The secondary objective was to evaluate the impact of the VR program on other functional measures, as well as adherence to the intervention.	Randomized, crossover, controlled trial involving ID exercise with virtual reality-VR. Group A - ID exercise with virtual reality, performed ID exercise with a maximum duration of 40 min using a non-immersive VR adapted video game called 'Treasure Hunt', in which the participant must try to catch targets and avoid obstacles by moving the lower limbs (flexion, hip abduction and adduction, and knee flexion and extension). Group B - control, performed only usual care, without exercise interventions and after 12 weeks performed exercises with VR (crossover trial).	●STS-5 ●STS-10 ●STS-60 ●SPPB ●OLST ●Gait Speed (m/s) ●6MWT(m)
Michou et al. (2023)	Effects of a combined intradialytic exercise training program on functional capacity and body composition in kidney transplant candidates	●Total (n = 29) ●Exercise group (n = 15) ●Control group (n = 14)	To evaluate the effects of a 4-month combined ID physical training on functional capacity and body composition indices in kidney transplant candidates.	12-week randomized controlled clinical trial, where Group A- Exercise, which performed a 4-month ID aerobic training program with static bike and strength with TheraBands and dumbbells and Group B- Control, performed only usual care, without interventions with exercise.	●STS-10 ●6MWT(m) ●Hand grip strength ●Bioelectrical impedance analysis

CKD = Chronic Kidney Disease; ID = Intradialytic; HB = Home Based; HD = Hemodialysis; CLIMB = stair climb time in seconds; DESCENT = Stair descent time in seconds; 7-day RQ = 7-day Physical Activity Recall Interview Questionnaire; HRQoL = Health-Related Quality Of Life; SF-12 = Short Form 12, a short version of SF-36; SF-36 = Medical Outcomes Survey Short Form 36; OLHR = One-Leg Heel-Rise; OLST = One-leg standing test; ECKD = End-stage chronic kidney disease; STS-30 = sit-to-stand test in 30 s; STS-60 = sit-to-stand test in 60 s; STS-5 = sit-to-stand test in 5 movements; STS-10 = sit-to-stand test in 10 movements; 6MWT(m) = 6-min walk test; VO2 = Oxygen consumption rate; ESKD = End Stage Kidney Disease; QL = Quality of life; RCT = Randomized Controlled Trial; BP = Blood pressure; KDQOL = Kidney Foundation Disease Outcomes Quality Initiative; Sp Kt/V = Single-pool dialysis quality; NSRI = North Staffordshire Royal Infirmary; SPPB = Short physical performance battery; TUG = Timed-up and go test; PASE = physical activity scale for the elderly; IPAQ = International Physical Activity Questionnaire; 10mTUG = 10-m Timed; EQ-5D-5L = European Quality of Life Questionnaire - 5 levels.

STS-30, cited in three trials (Bohm et al., 2014; Huang et al., 2020; Rosa et al., 2018) and STS-60, cited in 10 trials (Greenwood et al., 2021; Koufaki et al., 2002; Liu et al., 2015; Martinez-Olmos et al., 2022; Ortega-Pérez de Villar et al., 2020; Perez-Dominguez et al., 2021; Segura-Orti et al., 2009; Segura-Orti et al., 2019; Sovatzidis et al., 2020; Yeh et al., 2020). Furthermore, other tests were reported such as the 6-min walk test cited in 14 articles (Bogataj et al., 2020; Bohm et al., 2014; Huang et al., 2020; Liu et al., 2015; Martinez-Olmos et al., 2022; Michou et al., 2023; Ortega-Pérez de Villar et al., 2020; Perez-Dominguez et al., 2021; Rosa et al., 2018; Segura-Orti et al., 2009; Segura-Orti et al., 2019; Valenzuela et al., 2018; Yeh et al., 2020; Zhang et al., 2020), handgrip strength cited in seven articles (Bogataj et al., 2020; Michou et al., 2023; Ortega-Pérez de Villar et al., 2020; Rosa et al., 2018; Sovatzidis et al., 2020; Valenzuela et al., 2018; Zhang et al., 2020), sit-and-reach test cited in three articles (Bogataj et al., 2020; Bohm et al., 2014; Rosa et al., 2018) gait speed cited in three articles (Martinez-Olmos et al., 2022; Perez-Dominguez et al., 2021; Segura-Orti et al., 2019), NSRI, walk test cited in two articles (Koufaki et al., 2002; Sovatzidis et al., 2020), OLHR, One-Leg Heel-Rise cited in two articles

(Ortega-Pérez de Villar et al., 2020; Perez-Dominguez et al., 2021), TUG = Timed-up and go test cited in two articles (Ortega-Pérez de Villar et al., 2020; Perez-Dominguez et al., 2021) and 10mTUG cited in one article (Greenwood et al., 2021).

The 10 items of PEDro scale reporting the methodological quality are in Table 3 and the summary of the quality of evidence from the meta-analyses (GRADE) is in Table 4.

The forest graphs below refer to studies that used intradialytic exercise and the sit-to-stand test in four subtypes (Fig. 2) in 12; 14; 16; 20 and 24 weeks of follow-up.

#### 4. Discussion

This systematic review with meta-analysis sought studies that used the sit-to-stand test to measure muscle strength and/or functionality compared to other assessment methods, such as dynamometer (Lionardo de Paula et al., 2023) and walking tests (Amatachaya et al., 2023; Bloem et al., 2018). From the analysis of the integral studies, which involved 870 chronic kidney disease hemodialysis patients, it is noted that

**Table 2**  
Results obtained in 17 selected articles.

Author/year	Assessment tool	Baseline		Time of intervention (weeks)	Follow up		p
		Control Group	Exercise Group		Control Group	Exercise Group	
		Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Koufaki et al. (2002)	STS-5	12.8 (±4.4)	14.7 (±6.2)	12	12.7 (±4.8)	11.0 (±3.3)	0.003*
	STS-60	23.7 (±6.8)	21.2 (±7.2)		24.1 (±7.2)	26.9 (±6.2)	0.006*
Segura-Ortí et al. (2009)	STS-10	20.4 (±3.3)	24.2 (±13.2)	24	19.1 (±2.7)	18.8 (±7.9)	0.30
	STS-60	27.6 (±8.1)	28.8 (±11.2)		28.2 (±7.6)	33.9 (±12.6)	0.11
Bohm et al. (2014)	STS-30	10.1 (±3.3)	10.2 (±3.6)	24	12.2 (±3.5)	11.4 (±2.6)	0.51
Liu et al. (2015)	STS-60	16.5 (±7.3)	17.9 (±6.4)	12	14.8 (±6.9)	20.8 (±5.1)	0.007*
Valenzuela et al. (2018)	STS-10	32.0 (±11)	26.0 (±10)	14	34.0 (±12)	21.0 (±8)	<0.001*
Rosa et al. (2018)	STS-30	10.88 (±3.04)	11.79 (±3.47)	12	11.79 (±2.93)	15.18 (±6.07)	0.015*
Segura-Ortí et al. (2019)	STS-5	12.4 (±2.8)	14.4 (±7.5)	20	9.7 (±2.7)	11.6 (±9.3)	<0.01*
	STS-10	27.6 (±9)	29.5 (±15)		19.5 (±5.5)	22.8 (±17.2)	<0.01*
	STS-60	22.0 (±7.7)	23.9 (±13.3)		29.0 (±10.2)	28.8 (±11.8)	<0.05*
Huang et al. (2020)	STS-5	13.67 (±2.39)	11.91 (±4.46)	24	13.34 (±2.15)	10.33 (±2.45)	0.176
	STS-30	12.60 (±1.51)	12.94 (±2.14)		11.91 (±1.2)	15.19 (±3.52)	0.001*
Bogataj et al. (2020)	STS-10	29.90 (±8.8)	28.90 (±6.5)	16	25.7 (±9.1)	18.5 (±5.8)	0.037*
Yeh et al. (2020)	STS-10	27.11 (±9.51)	31.85 (±12.43)	12	30.31 (±11.73)	23.81 (±7.27)	0.001*
	STS-60	20.28 (±5.28)	19.23 (±6.91)		19.59 (±5.20)	24.67 (±7.27)	0.001*
Ortega-Pérez de Villar et al. (2020)	STS-10	25.0 (±10.7)	25.4 (±10.6)	16	23.6 (±8)	22.3 (±7.2)	0.027*
	STS-60	21.6 (±7.7)	19.7 (±7.4)		20.8 (±3.7)	23.6 (±8.2)	0.195
Zhang et al. (2020)	STS-10	25.8 (±2.06)	25.04 (±2)	12	26.4 (±2.59)	24.41 (±2.79)	<0.001*
Sovatzidis et al. (2020)	STS-60	33.0 (±7.6)	33.83 (±7.2)	16	32.25 (±7)	38.08 (±6.3)	<0.05*
Perez-Dominguez et al. (2021)	STS-10	26.2 (±8.1)	28.4 (±11.2)	16	24.7 (±8.3)	25.2 (±12.3)	0.007*
	STS-60	23.3 (±8.5)	21.1 (±9.7)		23.0 (±9)	24.1 (±10.4)	0.164
Greenwood et al. (2021)	STS-60	13.8 (±6.6)	15.8 (±7.1)	24	14.4 (±9.7)	17.1 (±8.1)	0.16
Martinez-Olmos et al. (2022)	STS-5	13.5 (±7.3)	13.9 (±5.3)	12	14.1 (±7.2)	11.5 (±4.7)	<0.01*
	STS-10	29.7 (±10.9)	30.5 (±11.7)		30.6 (±10.5)	24.8 (±9.5)	<0.001*
	STS-60	21.7 (±9.7)	20.5 (±8.5)		20.3 (±8.7)	25.7 (±9.4)	<0.001*
Michou et al. (2023)	STS-10	22.07 (±2.99)	22.4 (±5.5)	16	20.42 (±3.73)	24.8 (±6.33)	0.05

STS= Sit to stand test; SD = Standard Deviation; \*p < 0.05.

intradialytic exercise is effective in increasing muscle strength and functionality (Fig. 2). In addition, the studies showing non-robust evidence regarding the selection of the best subtype of the sit-to-stand test for evaluation in renal patients. The sit-to-stand test is widely used and reported in the literature, but we cannot establish which subtype is the best for carrying out the assessments. Of all the mentioned studies that used sit-to-stand test protocols, the one that proved to be most effective for measuring and evaluating muscle strength and functionality was the sit-to-stand test of 10-repetition (Bogataj et al., 2020; Segura-Orti et al., 2009, 2019; Valenzuela et al., 2018; Zhang et al., 2020).

In the selected studies, four different approaches to the sit-to-stand test were observed: STS-5 and STS-10, which analyze the time taken to perform 5 and 10 repetitions of the test; STS-30 and STS- 60 which involve the number of repetitions performed in 30 and 60 s. The STS-60 is widely used but showed up not very effective as an assessment tool after ID interventions with physical exercise, perhaps due to facts that can be considered as disadvantages, such as the execution time, which should evaluate endurance more than muscle strength itself and, considering that frailty and fatigue are often present in chronic kidney patients, especially those on hemodialysis, it is possible that longer tests do not accurately assess the patient’s real strength level (Koufaki et al., 2002; Segura-Orti et al., 2009, 2019; Yeh et al., 2020).

Other tests used to assess functionality were also identified in the studies, and the 6-min walking test is one of the most used (Bogataj et al., 2020; Bohm et al., 2014; Huang et al., 2020; Liu et al., 2015; Martinez-Olmos et al., 2022; Michou et al., 2023; Ortega-Pérez de Villar et al., 2020; Perez-Dominguez et al., 2021; Rosa et al., 2018; Segura-Orti et al., 2009; Segura-Orti et al., 2019; Valenzuela et al., 2018; Yeh et al., 2020; Zhang et al., 2020), along with the handgrip strength test (Bogataj et al., 2020; Michou et al., 2023; Ortega-Pérez de Villar et al., 2020; Rosa et al., 2018; Sovatzidis et al., 2020; Valenzuela et al., 2018; Zhang et al., 2020). It is important to emphasize that in the included studies in this review, variables such as gender, age, and nutritional aspects did not participate in the analyses carried out. Such variables are extremely relevant and could directly influence the observed results, constituting a

bias to be considered.

It is important to highlight that this review focused on the search and analysis of studies that used the sit-to-stand test as a measure to assess the strength and functionality of chronic kidney disease patients who performed ID exercises. The search strategies for studies that were part of this systematic review involved eight prominent global and national databases, ensuring great sensitivity in the selection. Moreover, the comparative analysis between the different sit-to-stand test protocols applied to chronic kidney disease patients on HD was not able to fill existing gaps concerning strategies for evaluating peripheral muscle strength and functionality in this population, not making it clear that the best test subtype to be used in clinical practice nor evaluation parameters, which is a relevant issue in this study (Anding et al., 2015; Norman-Gerum and McPhee, 2020).

Furthermore, it was also observed in most of the studies in this review, that intradialytic exercises seem to significantly improve the muscle strength and functionality of kidney patients in HD (Bennett et al., 2015) and the aerobic exercise is the most used during ID training (Bogataj et al., 2020; Bohm et al., 2014; Greenwood et al., 2021; Koufaki et al., 2002; Liu et al., 2015; Sovatzidis et al., 2020; Yeh et al., 2020), perhaps due to the ease of its application when compared to combined (Bogataj et al., 2020; Huang et al., 2020; Michou et al., 2023; Ortega-Pérez de Villar et al., 2020; Perez-Dominguez et al., 2021; Segura-Orti et al., 2019; Valenzuela et al., 2018) or concentrated interventions on resistance exercise (Rosa et al., 2018; Segura-Orti et al., 2009; Zhang et al., 2020).

As far as we know, this is the first study to sought studies that used the sit-to-stand test to measure muscle strength and/or functionality, which makes it difficult to compare with others. The differences observed in the results of the studies included, during the analysis, were due to different intervention times with ID exercise in addition to the variety of sit-stand test protocols to assess muscle strength and functionality (Lionardo de Paula et al., 2023). Many studies indicated an intervention time of more than 16 weeks. We know that ID physical exercise time can directly influence muscle strength and consequently

**Table 3**  
PEDro scale items and scores of included studies (n = 17) presented by author and year of publication.

	Koufaki et al. (2002)	Segura-Ortí et al. (2009)	Bohm et al. (2014)	Liu et al. (2015)	Valenzuela et al. (2018)	Rosa et al. (2018)	Segura-Ortí et al. (2019)	Huang et al. (2020)	Bogataj et al. (2020)	Yeh et al. (2020)	Ortega -Perez de Villar et al. (2020)	Zhang et al. (2020)	Sovatzidis et al. (2020)	Perez-Dominguez et al. (2021)	Greenwood et al. (2021)	Martínez-Olmos et al. (2022)	Michou. V et al. (2023)
Random allocation	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Blind allocation	0	0	1	0	0	1	1	1	1	1	1	0	0	1	0	1	0
Similar groups prognosis	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Participant blinding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blinding of therapists	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blinding of assessors	1	1	0	0	0	0	1	0	1	0	0	1	0	1	1	1	0
Measurements of at least one key outcome were obtained in more than 85 % of subjects	0	1	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0
Analysis by intention to treat	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Intergroup statistical comparisons for at least one key outcome	1	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1
Measures of central tendency and variability for at least one key outcome	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
<b>SCORE (0–10)</b>	<b>5</b>	<b>7</b>	<b>5</b>	<b>3</b>	<b>2</b>	<b>5</b>	<b>8</b>	<b>6</b>	<b>8</b>	<b>5</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>6</b>	<b>4</b>

**Legend:** 1 = yes 0 = no; Average score obtained was 5.23 ( $\pm 1.56$ ). The studies were of reasonable methodological quality.

**Table 4**  
Summary of meta-analyses.

Certainty assessment		N° of patients				Effect		Certainty		Importance		
N° of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	intradialytic physical exercise	usual care	Relative (95 % CI)	Absolute (95 % CI)		
4	randomised trials	serious <sup>b</sup> serious <sup>a, b, c, d, e</sup> serious <sup>b, c, d, e</sup>	serious <sup>b</sup>	not serious	serious <sup>c</sup>	none	61	55	-	SMD 0.49 SD lower (1.02 lower to 0.04 higher)	⊕○○○ Very low	IMPORTANT
10	randomised trials	serious <sup>a</sup>	serious <sup>d</sup>	not serious	not serious	none	212	215	-	SMD 0.37 SD lower (0.71 lower to 0.02 lower)	⊕⊕○○ Low	IMPORTANT
3	randomised trials	serious <sup>a</sup>	serious <sup>e</sup>	not serious	serious <sup>c</sup>	none	64	63	-	SMD 0.51 SD higher (0.34 lower to 1.35 higher)	⊕○○○ Very low	IMPORTANT
10	randomised trials	serious <sup>a</sup>	not serious	not serious	not serious	none	280	254	-	SMD 0.45 SD higher (0.28 higher to 0.62 higher)	⊕⊕⊕○ Moderate	IMPORTANT

CI: confidence interval; SMD: standardized mean difference.

GRADE = GRADE working group grades of evidence (see reasons for downgrade).

Reasons for downgrade.

<sup>a</sup> From the assessment of the risk of bias using the Pedro scale, it was observed that the values ranged between 2 and 8 points. The average score obtained was 5.23 (±1.56). The studies were of reasonable methodological quality.

<sup>b</sup> inconsistency of results (I<sup>2</sup> = 54 % indicating high statistical heterogeneity between the studies).

<sup>c</sup> Large confidence interval, >0.8 for standardized mean differences (SMD).

<sup>d</sup> inconsistency of results (I<sup>2</sup> = 68 % indicating high statistical heterogeneity between the studies).

<sup>e</sup> inconsistency of results (I<sup>2</sup> = 80 % indicating high statistical heterogeneity between the studies).

the response to the different STS protocols (Bogataj et al., 2020; Ortega-Pérez de Villar et al., 2020; Yeh et al., 2020).

There was difficulty in accessing some studies as they were not available on the search and research platforms and/or presented incomplete data. Contact with the respective authors was attempted, but without success therefore they were excluded. Other implications were the fact that some studies do not perform random allocation (Greenwood et al., 2021; Koufaki et al., 2002; Liu et al., 2015; Michou et al., 2023; Segura-Orti et al., 2009; Sovatzidis et al., 2020; Valenzuela et al., 2018; Zhang et al., 2020) blinding (Bohm et al., 2014; Huang et al., 2020; Liu et al., 2015; Michou et al., 2023; Ortega-Pérez de Villar et al., 2020; Rosa et al., 2018; Sovatzidis et al., 2020; Valenzuela et al., 2018; Yeh et al., 2020), and the absence of intention-to-treat analysis (Greenwood et al., 2021; Huang et al., 2020; Koufaki et al., 2002; Liu et al., 2015; Martinez-Olmos et al., 2022; Michou et al., 2023; Ortega-Pérez de Villar et al., 2020; Perez-Dominguez et al., 2021; Rosa et al., 2018; Sovatzidis et al., 2020; Valenzuela et al., 2018; Yeh et al., 2020; Zhang et al., 2020), which would increase the risk of bias (Table 3).

In the absence of a gold standard for assessing muscle strength (dynamometer), the STS-10 can be considered one of the best tests to ensure adequate assessment of muscle strength and functionality in chronic kidney disease patients undergoing HD, appears to be more effective, as the limited number of movements of this test highlights its indication for evaluating the patient's ability to generate strength, especially for those with muscle weakness, this issue is in accordance with our analyses. (Anding et al., 2015; Brodin et al., 2008; Norman-Gerum and McPhee, 2020; Segura-Orti and Martínez-Olmos, 2011). Other studies that consider the influence of variables such as gender, age, nutritional aspects, and intervention time with ID exercise are still necessary.

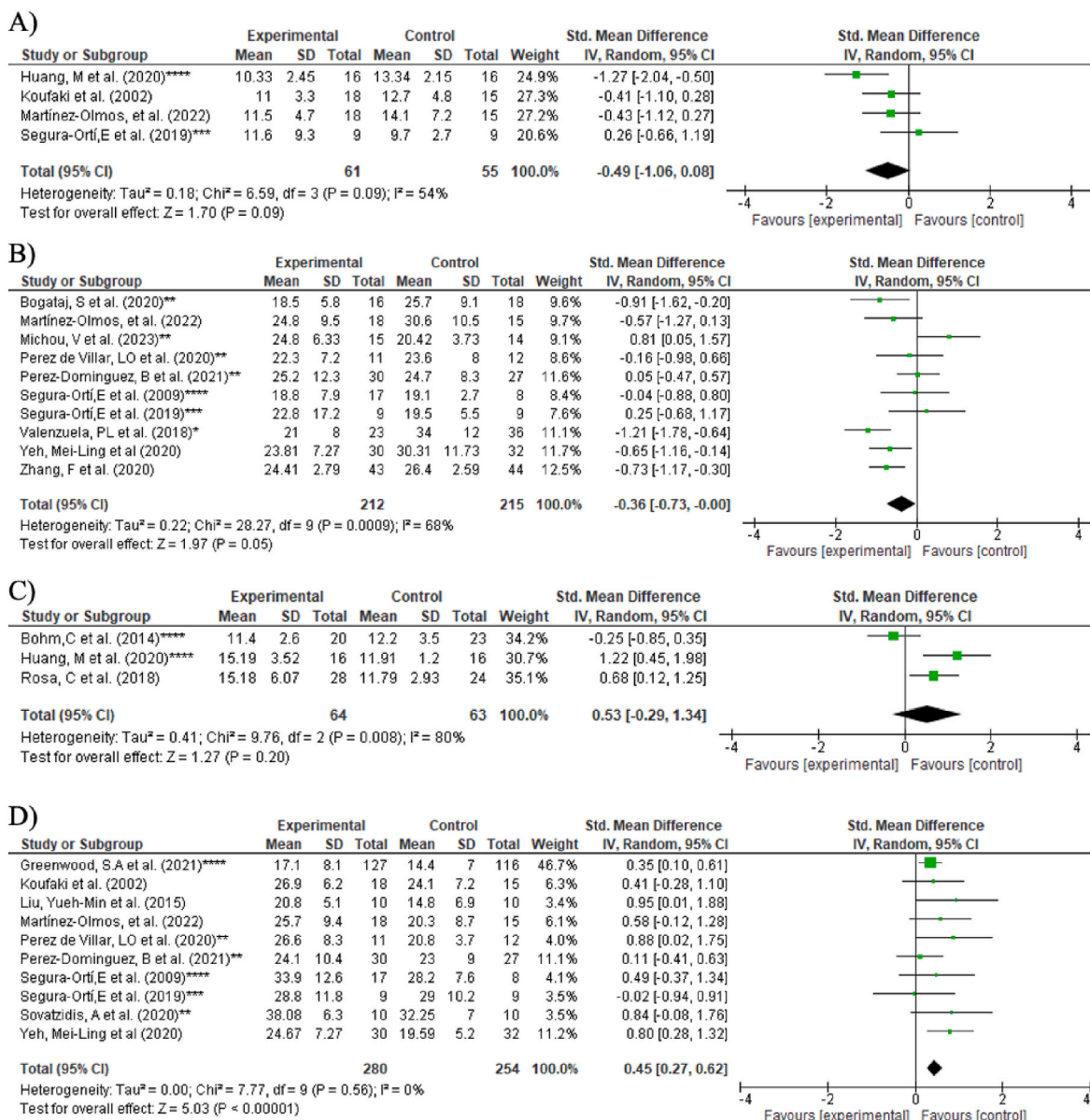
However, the present study will guide health professionals in the interdisciplinary approach to chronic kidney disease patients undergoing HD, as well as in the use of ID exercise and in the selection of functional assessment tests and assessing lower extremity muscle strength, such as the sit-stand test. It is important to highlight that the sit-to-stand test is also used to evaluate functional progress and lower limb muscle strength in HD patients. Studies seeking to identify which STS subtype is most effective for evaluating lower limb muscle strength and functionality in chronic kidney disease patients, especially those on hemodialysis, are important and necessary.

## 5. Conclusion

Despite the low methodological quality of the studies included in this review, ID exercise protocols seem to have positive influence in the muscle strength and consequently the functionality of chronic kidney disease patients on HD. Exercises performed for periods longer than 16 weeks can be considered more significant in gaining strength and improving functionality, and the assessment of muscle strength in the lower limbs can be better measured using the 10 repetitions of sit-stand test (STS- 10).

## 6. Clinical relevance

- Functionality and lower extremity muscle strength can improve with intradialytic exercise.
- There is no standardization for the use of the sit-stand test, four subtypes have been identified and the STS-10 appears to be the best subtype for assessing functionality and lower extremity muscle strength.
- Further research is needed to establish the effect of the sit-stand test, given the low methodological quality of the studies included in this review.



Legend: 12-week follow-up; \*14-week follow-up; \*\*16-week follow-up; \*\*\*20-week follow-up; \*\*\*\*24-week follow-up.

Fig. 2. Forest Plot graphics referring to studies that used intradialytic exercise (ID) and four subtypes of the sit-to-stand test. SMD difference (CI = 95 %) effect of comparison between ID physical exercise and control group: A = 5-movement sit-to-stand test (STS-5), B = 10-movement sit-to-stand test (STS-10), C = 30-s sit-stand test (STS-30) and D = 60-s sit-stand test (STS-60).

**CRedit authorship contribution statement**

**Klebson da Silva Almeida:** Writing – original draft, Methodology, Formal analysis. **Natália Silva Costa:** Formal analysis. **Bráulio Nascimento Lima:** Writing – original draft, Formal analysis. **José Leonardo Dos Reis Neves:** Writing – original draft, Data curation. **Luiz Gustavo Pereira Barreto:** Writing – original draft, Data curation. **Luana de Jesus Freitas:** Writing – original draft, Data curation. **Monique Mesquita Silva:** Writing – review & editing. **Mariela de Santana Maneschy:** Writing – review & editing. **André Filipe Moraes Pinto Novo:** Writing – review & editing, Formal analysis. **Luciana Dias Chiavegato:** Writing – review & editing, Writing – original draft, Methodology,

Formal analysis.

**Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## APPENDIX I

Search lines were used to select articles for the Systematic Review on the use of intradialytic exercise and the sit-stand test in chronic kidney disease patients on HD.

Search terms, keywords, and databases.

Keywords per database
<p>PubMed; Scielo; Bvs; Cochrane            (((((((((((((kidney disease) OR (chronic renal Insufficiency)) OR (chronic kidney Insufficiency)) OR (renal insufficiency)) OR (chronic kidney disease) OR (chronic renal disease)) OR (chronic kidney failure)) OR (nephrotic syndromes)) OR (kidney syndrome)) OR (nephrological failure)) OR (kidney disorder)) OR (glomerulopathies)) AND            (((((((((((((((exercise) OR (physical exercise)) OR (physical activity)) OR (physical fitness)) OR (therapy exercise)) OR (aerobic exercise)) OR (aerobic training)) OR (aerobic activity)) OR (aerobic workout)) OR (cardiovascular training)) OR (cycloergometric exercise)) OR (resistance training)) OR (strength training)) OR (weight training)) OR (strengthening program)) OR (endurance training)) OR (isometric exercise)) OR (intradialytic exercise)) OR (physical fitness))) AND (((((kidney therapy) OR (extracorporeal dialyses)) OR (renal dialysis)) OR (hemodialyses)) OR (hemodiafiltration))) AND (((((((((((functionality) OR (functional)) OR (functional performance)) OR (functional physical performance)) OR (physical performance)) OR (functional performances)) OR (functional capacity)) OR (sit-to-stand)) OR (sit-to-stand test)) OR (sitting-rising test))</p>
<p>ScienceDirect            (“chronic renal Insufficiency” OR “chronic kidney disease”) AND (exercise OR “aerobic exercise” OR “resistance training”) AND (“renal dialysis”) AND (functionality OR “sit-to-stand test”)</p>
<p>PEDro            “kidney disease” exercise* functional*            “kidney disease” exercise* “functional capacity*”</p>
<p>Scielo; Bvs            (doença renal) OR (insuficiência renal crônica) OR (insuficiência renal) OR (doença renal crônica) OR (síndromes nefróticas) OR (síndrome do rim) OR (falha nefrológica) OR (distúrbio renal) OR (glomeropatia) AND ((exercício) OR (exercício físico) OR (atividade física) OR (aptidão física) OR (exercício Terapêutico)) AND ((exercício aeróbico) OR (treino aeróbico) OR (atividade aeróbica) OR (treino aeróbico) OR (treinamento cardiovascular) OR (exercício no cicloergômetro)) AND ((treinamento resistido) OR (treinamento de força) OR (musculação) OR (programa de fortalecimento) OR (exercício isométrico)) AND ((terapia renal) OR (diálise extracorpórea) OR (hemodiálise) OR (hemodiafiltração)) AND ((funcionalidade) OR (funcional) OR (desempenho funcional) OR (desempenho físico funcional) OR (performance física) OR (performances funcionais) OR (capacidade funcional) OR (sentar-se de pé) OR (teste sentar-se de pé) OR (teste sentar-levantar))</p>
<p>Web Of Science            ((kidney disease) OR (chronic kidney disease) AND (exercise) OR (physical activity) OR (training) OR (intradialytic exercise) OR (physical fitness) (All Fields) and (hemodiafiltration) OR (hemodialysis) (All Fields) and (functionality) OR (functional) OR (performance) (All Fields) and (sit-to-stand) OR (sit-to-stand test) OR (sitting-rising test) (All Fields))</p>
<p>Cinahl            ((kidney disease) OR (chronic kidney disease)) AND ((exercise) OR (physical activity) OR (training) OR (intradialytic exercise) OR (physical fitness)) AND ((hemodiafiltration) OR (hemodialysis)) AND ((functionality) OR (functional) OR (performance)) AND ((sit-to-stand) OR (sit-to-stand test) OR (sitting-rising test))</p>

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