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FISIOTERAPIA – OPÇÃO DE TERAPIA MANUAL ORTOPÉDICA

Effects of implementing exercise programs on patients diagnosed with gonarthrosis prior to total knee arthroplasty – a systematic review.

Silvana Fonseca Ferreira

09/**2021**

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Effects of implementing exercise programs on patients diagnosed with gonarthrosis prior to total knee arthroplasty – a systematic review.

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Dissertação apresentada para cumprimento dos requisitos necessários à obtenção do grau de Mestre em **Fisioterapia – Opção de Terapia Manual Ortopédica** pela Escola Superior de Saúde do Instituto Politécnico do Porto.

Agradecimentos

Gostaria de expressar o meu obrigada a todas as pessoas que, direta ou indiretamente, me auxiliaram ao longo desta jornada e sem as quais eu não teria conseguido completar este trabalho.

A Rafael Soares e Paulo de Carvalho, cuja orientação e apoio foram vitais, estou imensamente grata.

A Carlos Crasto e Pedro Maciel Barbosa, agradeço a atenção disponibilizada e os conselhos que comigo partilharam.

Aos meus colegas, com quem comparti este caminho.

À minha família e aos meus amigos, um especial obrigada pelo incentivo e pela paciência.

Resumo

Enquadramento: A osteoartrite é a condição mais comum a acometer a articulação do joelho, considerando-se uma das principais causas de incapacidade. Quando o tratamento conservador não tem sucesso, a cirurgia é recomendada. Sendo o exercício uma importante ferramenta utilizada nesta condição e após artroplastia total do joelho (ATJ), pensa-se que a sua implementação em contexto pré-cirúrgico permita uma otimização dos resultados.

Objetivos: Determinar se a implementação de um programa de exercício em pacientes com gonartrose previamente a ATJ é benéfica na melhoria da dor, funcionalidade e/ou qualidade de vida.

Métodos: Pesquisa de estudos clínicos randomizados controlados, publicados entre 2015 e 2020, conduzida em quatro bases de dados com aplicação de critérios de elegibilidade. Cada estudo foi sujeito a uma avaliação do risco de viés e a implementação das escalas PEDro e OCEBM.

Resultados: Oito estudos foram incluídos. Os seus grupos de controlo foram comparados com exercício em pré-operatório (n=5), exercício em pré-operatório combinado com educação (n=2) e exercício em pré-operatório em ambiente hospitalar *versus* domiciliar (n=1). Os estudos recolheram informação utilizando medidas auto-relatadas e medidas baseadas na *performance*.

Conclusão: Embora não tenha sido encontrada uma resposta conclusiva, foi observada uma tendência favorável (ainda que não significativa) do exercício enquanto estratégia de intervenção segura e com boa relação custo-benefício.

Palavras-chave: Artroplastia; joelho; fisioterapia; pré-operatório; exercício.

Abstract

Background: Osteoarthritis is the most common condition that affects the knee joint, and it is considered a leading cause of disability. When conservative treatment fails, surgery may be recommended. Exercise programs are an important tool in the management of knee osteoarthritis (OA) and in total knee arthroplasty (TKA) rehabilitation and, when implemented in a preoperative context, are thought to optimize postoperative outcomes.

Objectives: To determinate the effects of implementing exercise programs on patients diagnosed with gonarthrosis prior to TKA on pain, function and/or quality of life (QoL).

Methods: A literature search of Randomized Controlled Trials (RCTs), published from 2015 until 2020, was conducted across four databases. Eligibility criteria were applied. Individual studies were evaluated using PEDro and OCEBM scales. Risk of bias assessment was also performed.

Results: Eight studies were included. RCTs compared control groups with preoperative exercise (n=5), combined preoperative exercise and education (n=2) and preoperative exercise in hospital versus at home (n=1). The studies collected data regarding self-reported outcomes and performance-based outcomes.

Conclusion: A conclusive answer could not be given although it was seen a not significant general favor of this intervention as a safe and cost-effective option.

Keywords: Arthroplasty; knee; physiotherapy; preoperative; exercise.

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1. Introduction

Osteoarthritis (OA) is the most common condition that affects the knee joint and it is considered a leading cause of disability (Chesham & Shanmugam, 2017; Dennis et al., 2020; Moyer et al., 2017). Its overall impact depends on the severity of pain and the magnitude of loss of functionality, which negatively impacts an individual's quality of life (QoL) (Chesham & Shanmugam, 2017). It is described as a progressive multifactorial inflammatory disease of the entire synovial joint comprising mechanical degeneration of articular cartilage and osteophyte formation (Cui et al., 2020; Kan et al., 2019; Robinson et al., 2018). The diagnosis of knee OA consists of history and clinical examination and can be radiographically confirmed (Hussain et al., 2016). It is important to highlight that there is no correlation between radiological stages and symptoms, which tend to comprise pain, stiffness, reduced range of motion (ROM), crepitus and swelling (Hussain et al., 2016).

According to a recently developed national study, in Portugal there is a knee OA prevalence of 12.4%, with greater impact on the female gender (similar to general global data) (Branco et al., 2016; Cui et al., 2020). Treatment of knee OA includes pharmacological and non-pharmacological interventions, such as education, self-management, exercise and weight reduction (Kan et al., 2019; L. Snell et al., 2018). If conservative treatment fails, it may be recommended an operative management (Chesham & Shanmugam, 2017; Dennis et al., 2020; Kwok et al., 2015; Robinson et al., 2018).

Total knee arthroplasty (TKA) involves the resection and replacement of the distal femoral and proximal tibial joint surfaces and is considered an effective treatment at an advanced stage of knee OA allowing to reduce pain and improve functionality and QoL (Chesham & Shanmugam, 2017; Cui et al., 2020; Jette et al., 2020; Kan et al., 2019; Mistry et al., 2016; Moyer et al., 2017; Quinn et al., 2018; Robinson et al., 2018). TKA success depends not only on surgical technique and implant longevity, but also on an adequate rehabilitation (Chesham & Shanmugam, 2017; Mistry et al., 2016). The chances of developing major complications are small but possible (with an overall rate of 5% following primary TKA) and can lead to a need for revision surgery (with an increased complication rate of up to 26%) (Hussain et al., 2016; Quinn et al., 2018). Contraindications and individual risk factors must be assessed between patient and physician since certain preoperative characteristics have been shown to influence outcomes postoperatively (e.g., pain, physical function, body mass index, general mental health status) (Chesham & Shanmugam, 2017; Dennis et al., 2020; Jette et al., 2020; Kwok et al., 2015; Moyer et al., 2017; Quinn et al., 2018; Robinson et al., 2018).

For that reason, preoperative physiotherapy, often known as prehabilitation ("the process of enhancing functional capacity in a patient in order to allow him or her to withstand the stressor of inactivity associated with an orthopaedic procedure" (Kwok et al., 2015, p.1)), is thought to optimize postoperative outcomes with the greatest gains of functional recovery to take place within the first 12 months following knee replacement (Kwok et al., 2015; L. Snell et al., 2018; Moyer et al., 2017).

Despite the success of surgery, functional impairments can remain postoperatively, and differences can be found when these patients are compared to age-matched and gender-matched peers with no history of knee pathology (Kwok et al., 2015). It has been demonstrated that function and QoL after TKA may also be impacted by preoperative patient expectations (Moyer et al., 2017). This dissatisfaction added to a reduced functional capacity are a common and disabling problem after TKA (Robinson et al., 2018).

To fully capture functional recovery after TKA, performance-based and patient-reported outcome measures are recommended but currently there is no gold standard to assess people with knee OA (Berliner et al., 2017; Bourne, 2008; Dobson et al., 2013; Gabr et al., 2015; McAuley et al., 2014; Mizner et al., 2011; Wang et al., 2021). These are seen as complementary rather than competing approaches as they explore different aspects of the physical functioning (Bourne, 2008; Dobson et al., 2013).

Performance-based tests provide objective information about a person's functioning at a particular time and their ability to complete directly observed tasks (Gabr et al., 2015; McAuley et al., 2014; Mizner et al., 2011). These tests assess the patient's true performance rather than their perception of it (Bourne, 2008; Gabr et al., 2015) .

Patient-reported measures reflect the patient's perceptions of their abilities and physical function (McAuley et al., 2014; Mizner et al., 2011). These can be categorized into generic health status or disease-specific questionnaires, being the latter considered more responsive to change within the context of a specific condition (Berliner et al., 2017; Gabr et al., 2015; Giesinger et al., 2014). Lately, the focus has been shifting to a more patient centered approach, which rationalize the use of these tools (Berliner et al., 2017). However, they are described to fail to capture the actual change in functional performance after TKA, being difficult to discriminate pain from their ability to perform tasks (Mizner et al., 2011).

Recent evidence suggests that patient's preoperative health status has a strong relationship with postoperative progression (Chesham & Shanmugam, 2017; Dennis et al., 2020). Pain and functional status during the presurgical period has been demonstrated to be strongly associated with chronic postsurgical pain and functional ability (Berliner et al., 2017; Dennis et al., 2020).

Moreover, quadriceps muscular strength before and after TKA has also been significantly related to functional performance and limb avoidance loading patterns acutely after surgery (Chesham & Shanmugam, 2017; Mizner et al., 2011).

Although presurgical interventions general aim is to prepare the patient for the procedure and hospital stay and to facilitate early mobilization and recovery, it may be relevant to understand how a preoperative physiotherapy program implementation can impact postoperative outcomes (Dennis et al., 2020).

Clinical guidelines highlight exercise programs as an important tool in the management of knee OA and in TKA rehabilitation (Jette et al., 2020). Their potential benefits in a preoperative context consist of decreased pain, improved balance, increased isometric strength and ROM, reduced length of hospital stay and enhanced QoL, with no reported harms associated (Jette et al., 2020). Even so, there is a need to specify exercise regimens for type, frequency, duration and progression (Jette et al., 2020).

Several systematic reviews were previously conducted on the efficacy of preoperative exercise programs but the evidence has so far been weak or inconclusive (Kwok et al., 2015). Besides, they frequently study knee and hip arthroplasty surgery, with only few analyzing its effect on TKA in isolation (Chesham & Shanmugam, 2017; Kwok et al., 2015).

A concern regarding the implementation of preoperative exercise programs has been growing due to the higher number of individuals suffering from knee OA and the higher demand of TKA, as well as its associated socioeconomic burden (Chesham & Shanmugam, 2017; Kloppenburg & Berenbaum, 2020; Moyer et al., 2017). For that reason, additional research was required (Jette et al., 2020).

Thus, the purpose of this study was to determinate the effects of implementing exercise programs on patients diagnosed with gonarthrosis prior to TKA on pain, function and/or QoL.

2. Methods

A systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guideline. (Page et al., 2021) It was also prospectively registered with the PROSPERO database with the registration number CRD42020213126.

The search was conducted on multiple databases, including PubMed, PEDro, Virtual Health Library and CENTRAL, applying restrictions such as study design (RCT), language (English) and publication period (from 2015 until the 18th of October 2020, the date when the last search was carried out). The search terms were identified after preliminary searches of the literature. Unpublished studies were not sought. Eligibility criteria were defined and detailed in Table 1 and the structure of the electronic search strategy for each database used are described in the Appendix 1.

Table 1: Eligibility criteria for the included studies.

Eligibility Criteria		
	Inclusion	**Exclusion**
Population	▪ Aged 18 or over ▪ Male or female ▪ Radiographically and/or clinically diagnosed with knee OA ▪ Scheduled primary TKA ▪ Primary and unilateral surgical intervention ▪ Ability to understand and undergo an exercise program	▪ Age under 18 ▪ Absence of conclusive diagnosis of knee OA ▪ Bilateral surgical intervention ▪ Revision surgery ▪ Cognitive/psicological impairment, limitations of comunication ▪ Comorbilities as cardiac, neuromuscular or neurodegenerative conditions, or others that may affect physical activity tolerance
Intervention	▪ Exercise-based preoperative physiotherapy (as primary intervention or co-intervention) ▪ Implemented by physiotehrapists	▪ Not exercise-based approach ▪ Postoperative intervention ▪ Implemented by other professionals
Comparison	▪ Comparison between exercise-based intervention groups and control groups (submitted to other physical therapy interventions or to non-intervention) ▪ Follow-up of up to 12 months after TKA	▪ Follow-up of more than 12 months after TKA
Outcome	▪ Primary outcomes: pain, function and/or QoL ▪ Secondary outcomes: ROM, balance	
Study Design	▪ RCT	▪ Other study designs
Other characteristics	▪ English language publication ▪ Published in the last 5 years	▪ Publication in other languages ▪ Published over 5 years ago

The study selection followed the predefined eligibility criteria. It was conducted by one of the authors whose decisions were confirmed with another team member. A third element was consulted in case of doubt or disagreement. After search filters were applied, the studies titles and abstracts were screened and then their full texts were assessed for potential eligibility. Cochranes's "Data Collection Form for Intervention Reviews – RCT only" was used as a guide to elaborate a data extraction form of the included studies. In the event of missing data, the authors of the paper in question were contacted. Reviewers were not blinded to the information retrieved.

The risk of bias assessment was done by one of the reviewers and confirmed with the team using the Cochrane Risk of Bias Tool version 2.0 (RoB 2) for all five domains (randomization process, deviations from intended interventions, missing outcome data, outcome measurement, selection of the reported result).

3. Results

The literature search yielded 240 articles and, after removing duplicate studies and applying the eligibility criteria by reading title, abstract and full-text, 8 articles remained and were determined as the included studies, as observed in the flow diagram displayed in Figure 1.

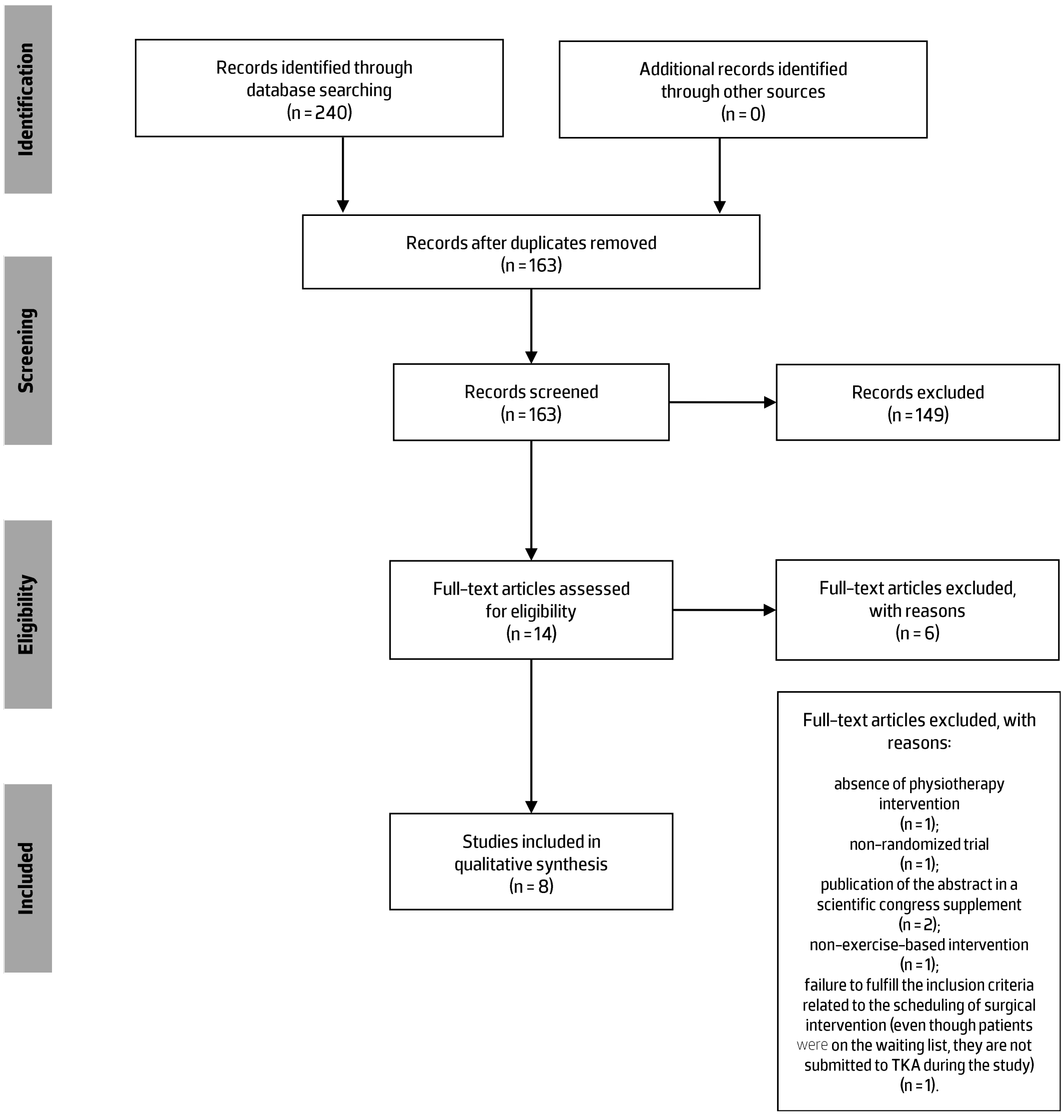

Figure 1: Flow diagram of study selection.

For each study, general characteristics such as authors and publication date, participants description, intervention and follow-up periods were sought and presented in Table 2. It also shows information regarding the PEDro scale assessment as well as the OCEBM level of evidence and

Table 2: General characteristics of the included studies.

Authors (Year)	Title	Participants Characterization		Intervention Period (Pre-TKA)	Follow-up (Post-TKA)	PEDro Scale	LoE (OCEBM)	SoR (OCEBM)
		Sample Size (M,F)	Age (mean ± SD)					
Huber et al. (2015)	Effect of preoperative neuromuscular training (NEMEX-TJR) on functional outcome after total knee replacement: an assessor-blinded randomized controlled trial.	IG: 22 (11,11) CG: 23 (13,10)	IG: 68.8 ± 8.0 CG: 71.9 ± 8.1	4-12 weeks	12 months	8/10*	II	B
Mat Eil-Ismail et al. (2016)	Preoperative physiotherapy and short-term functional outcomes of primary total knee arthroplasty.	IG: 24 (2,22) CG: 26 (5,21)	IG: 62.4 CG: 64.3	6 weeks	3 months	4/10*	II	B
Skoffer et al. (2016)	Efficacy of Preoperative Progressive Resistance Training on Postoperative Outcomes in Patients Undergoing Total Knee Arthroplasty.	IG: 30 (11,19) CG:29 (12,17)	IG: 70.7 ± 7.3 CG: 70.1 ± 6.4	4 weeks	12 weeks	8/10*	II	B
Calatayud et al. (2017)	High-intensity preoperative training improves physical and functional recovery in the early post-operative periods after total knee arthroplasty: a randomized controlled trial.	IG: 22 (4,18) CG: 22 (3,19)	IG: 66.8 ± 4.8 CG: 66.7 ± 3.1	8 weeks	3 months	7/10*	II	B
Fernandes et al. (2017)	Supervised neuromuscular exercise prior to hip and knee replacement: 12-month clinical effect and cost-utility analysis alongside a randomised controlled trial.	IG: 84 (37,47) CG: 81 (36,45)	IG: 67.9 ± 8.6 CG: 66.9 ± 8.3	8 weeks	1 year	6/10*	II	B
Casaña et al. (2019)	Preoperative high-intensity strength training improves postural control after TKA: randomized-controlled trial.	IG: 22 (4,18) CG: 22 (3,19)	IG: 66.8 ± 4.8 CG: 66.7 ± 3.1	8 weeks	3 months	7/10*	II	B
Dominguez-Navarro et al. (2020)	A randomized controlled trial assessing the effects of preoperative strengthening plus balance training on balance and functional outcome up to 1 year following total knee. replacement.	STG: 24 (10,14) ST+BG: 20 (7,13) CG: 21 (7,14)	STG: 70.8 ± 5.4 ST+BG: 70.4 ± 6.4 CG: 70.2 ± 5.6	4 weeks	52 weeks	5/10	II	B
Blasco et al. (2020)	The effects of preoperative balance training on balance and functional outcome after total knee replacement: a randomized controlled trial.	HomG: 26 (7,19) HosG: 25 (6,19) CG: 26 (11,15)	HomG: 72.3 ± 4.5 HosG: 70.2 ± 7.2 CG: 70.9 ± 9.5	4 weeks	6 weeks	6/10*	II	B

Legend: SD – standard deviation; M – male; F – female; TKA – total knee arthroplasty; PEDro – Physiotherapy Evidence Database; LoE – Level of Evidence; SoR – Strength of Recommendation; IG – intervention group; CG – control group; STG – strengthening group; ST+BG – strengthening + balance and proprioception group; HomG – home group; HosG – hospital group; " * " – this score has been confirmed by PEDro and the classification is available at https://pedro.org.au/.

strength of recommendation, complemented by the Appendix 2. The data collection forms of the included studies are attached in the Appendix 3.

The risk of bias assessment in individual studies was summarized using the ROBINS-I tool (Figure 2). Regarding the assessment of risk of bias that may affect the cumulative evidence (risk of bias across studies) it is known that studies written in English language are more easily published, (as well as studies with larger sample sizes or that obtained positive results). (Boutron et al., 2019) The authors of the selected studies declared to have no conflict of interest except Fernandes et al. (2017) that mentioned potential competing interests due to participation of its authors in other companies or initiatives.

	D1	D2	D3	D4	D5	Overall
Huber et al. (2015)	+	!	+	+	+	!
Mat Eil Ismail et al. (2016)	!	!	+	!	!	!
Skoffer et al. (2016)	+	!	+	+	!	!
Calatayud et al. (2017)	+	!	+	+	!	!
Fernandes et al. (2017)	!	+	+	!	!	!
Casaña et al. (2019)	+	+	+	+	+	+
Dominguez-Navarro et al. (2020)	+	–	+	+	–	–
Blasco et al. (2020)	–	–	+	+	+	–

Low risk	+	Some concerns	!	High risk	–

Figure 2: Risk of bias of the included studies.

Legend: D1 – Randomization process; D2 – Deviations from the intended interventions; D3 – Missing outcome data; D4 – Measurement of the outcome; D5 – Selection of the reported result.

The intervention programs implemented were consulted and the comprised exercises were retracted and presented by categories (Table 3). The same method was done with the outcomes assessed by each study (Table 4).

Table 3: Exercises generally included in the intervention programs of the included studies.

	Huber et al. (2015)	Mat Eil-Ismail et al. (2016)	Skoffer et al. (2016)	Calatayud et al. (2017)	Fernandes at al. (2017)	Casaña et al. (2019)	Dominguez-Navarroet al. (2020)	Blasco et al. (2020)
Warm-up	▪	▪	▪	▪	▪	▪	▪	▪
Stationary bike	▪	▪	▪				▪	▪
Calf raises				▪		▪		
Ergometry cycling (hand or leg)				▪	▪	▪		
Ankle circulatory exercise (ankle pumps)		▪						
Step ups				▪		▪		
Strengthening	▪	▪	▪	▪	▪	▪	▪	▪
Isometric quadriceps		▪					▪	▪
Inner range quadriceps		▪						
Knee extension	▪		▪	▪	▪	▪	▪	▪
Knee flexion / Leg curl	▪		▪	▪	▪	▪		
Hip extension			▪					
Hip abduction	▪		▪	▪	▪	▪	▪	▪
Hip adduction	▪		▪		▪		▪	▪
Straight leg raise		▪					▪	▪
Heel slides		▪						
Leg press			▪	▪		▪		
Pelvic lift	▪				▪			
Sit-ups	▪				▪			
Chair Stands	▪				▪			
Stair climbing	▪				▪			
Balance	▪			▪	▪	▪	▪	▪

Table 3 *(continued)*

Slide exercise forward-backwards	▪				▪			
Slide exercise sideways	▪				▪			
Forward lunge	▪				▪			
Sideway lunge	▪				▪			
Double leg stance				▪		▪		
Single leg stance				▪		▪	▪	▪
Multiple direction changes							▪	▪
Foam standing balance							▪	▪
Bohler standing balance							▪	▪
Roller board							▪	▪
Dynamometric platform exercises							▪	▪
Side walk							▪	▪
Treadmill walk							▪	▪
Crosswalk							▪	▪
Tandem walk							▪	▪
Cool-down	▪	▪	▪	▪	▪	▪	▪	▪
Forward and backward walking	▪				▪			
Lower extremities mobility	▪				▪			
Stretching	▪	▪	▪	▪	▪	▪	▪	▪
Knee extensors			▪	▪		▪	▪	▪
Knee flexores/hamstrings		▪	▪	▪		▪	▪	▪
Hip abductors				▪		▪		
Ankle dorsiflexors			▪					
Ankle plantar flexors				▪		▪		

A summary of the obtained results is observed in Table 5 and 6. It presents the comparison between the intervention groups and the control groups for each outcome assessed. To facilitate this process, only three evaluation moments were presented: 6 weeks, 3 months and 1 year. This allowed to create uniformity of the assessment endpoints and a better comparison of results across studies. However, the full information regarding the measurement time points can be found in the Appendix 4.

Table 4: Outcome measures used by each study.

	Self-reported Outcomes									Performance-based Outcomes																		
	Questionnaires							Pain		Function								ROM	Muscle Strength		Physical Activity		Joint Effusion	Balance				
	KOOS	WOMAC	SF-36	EQ-5D	EQ-5D-3L	EQ-VAS	HRQL	NPRS	VAS	TUG	CST	30sCST	SCT	30sMKB	6minWT	10mWT	20mWT	Gonio.	HHD	ID	SWarm	NHANES III	Perim.	RT(eo)	RT(ec)	BBS	SLS/OLS	FRT
Huber et al. (2015)	▪		▪	▪		▪				▪	▪			▪			▪	▪	▪		▪	▪						
Mat Eil-Ismail et al. (2016)	▪																	▪										
Skoffer et al. (2016)	▪						▪	▪		▪		▪			▪	▪		▪		▪			▪					
Calatayud et al. (2017)		▪	▪						▪	▪			▪					▪	▪									
Fernandes et al. (2017)	▪				▪																							
Casaña et al. (2019)																								▪	▪			
Dominguez-Navarro et al. (2020)	▪									▪								▪	▪							▪	▪	▪
Blasco et al. (2020)	▪			▪						▪								▪	▪							▪	▪	▪

Legend:; KOOS – Knee Injury and Osteoarthritis Outcome Score; WOMAC – Western Ontario and McMaster Universities Arthritis Index; SF-36 – 36-Item Short Form Health Survey; EuroQol – European Quality of Life Scale; 5D – five dimensions; 5D-3L – five dimensions, three level; HRQL – Health-Related Quality of Life (0-100); NPRS – Numeric Pain Rating Scale; VAS – 10cm Visual Analog Scale; TUG – Timed Up and Go Test; CST – Chair Stand Test; 30sCST – 30 seconds Chair Stand Test; SCT – Stair Climbing Test; 30sMKB – maximal number of knee-bending in 30 seconds; 6minWT – 6 minutes Walk Test; 10mWT – 10 meters Walk Test; 20mWT – 20 meters Walk Test; Gonio. – Goniometry; HHD – Hand-held dynamometry; ID – Isokinetic dynamometry; SWarm – SenseWear armband; NHANES III – National Health and Nutrition Examination Survey; Perim. – Knee Joint Perimetry; RT(eo) – Romberg Test (eyes opened); RT(ec) – Romberg Test (eyes closed); BBS – Berg Balance Scale; SLS – Single Leg Stance; OLS – One Leg Standing Test; FRT – Functional Reach Tests.

Table 5: Summary of the obtained results – self-reported outcomes.

			Self-reported Outcomes														
			Questionnaires													Pain	
			KOOS					WOMAC									
Study	Data Assessment		Symptoms	Pain	ADL	Sports and Recreation	QoL	Pain	Stiffness	Functional	SF-36	EQ-5D	EQ-5D-3L	EQ-VAS	HRQL	NPRS	VAS
Huber et al. (2015)	6 weeks		↑	↓	↓	↑	↑				–	–		↑			
	3 months		↑	↓	↓	↑	↓				↓	–		↑			
	1 year																
Mat Eil-Ismail et al. (2016)	6 weeks		–	↑	↑	↑	↑										
	3 months		↑	↑	↑*	↑	↑										
	1 year																
Skoffer et al. (2016)	6 weeks		↑	↑	↑	↑*	–								↑	–	
	3 months		–	↓	↑	↑	↓								↑	–	
	1 year																
Calatayud et al. (2017)	6 weeks																
	3 months							↑*	↑*	↑*	↑*						↑*
	1 year																
Fernandes et al. (2017)	6 weeks																
	3 months																
	1 year		↑	↑	↑	↑	↑*						↑*				
Casaña et al. (2019)	6 weeks																
	3 months																
	1 year																
Dominguez-Navarro et al. (2020)	6 weeks	**ST**	↑	↑	↓	n.a.	↑										
		ST+B		↓	↑												
	3 months																
	1 year	**ST**	↑	↑	↑	n.a.	↑										
		ST+B															
Blasco et al. (2020)	6 weeks	**Home**	↑	↑	–	n.a.	↑										
		Hospital		↓	↓		↓										
	3 months																
	1 year																

Legend: KOOS – Knee Injury and Osteoarthritis Outcome Score; WOMAC – Western Ontario and McMaster Universities Arthritis Index; SF-36 – 36-Item Short Form Health Survey; EuroQol – European Quality of Life Scale; 5D – five dimensions; 5D-3L – five dimensions, three level; HRQL – Health-Related Quality of Life (0-100); NPRS – Numeric Pain Rating Scale; VAS – 10cm Visual Analog Scale; "↑" – intervention group outcome better than control group; "↓" – intervention group outcome worse than control group; " * " statistically significant; " – " – no differences between intervention and control group; n.a. – not assessed.

Table 6: Summary of the obtained results – performance-based outcomes.

Study	Data Assessment	Function: TUG	Function: CST	Function: 30sCST	Function: SCT	Function: 30sMKB	Function: 6minWT	Function: 10mWT	Function: 20mWT	ROM: Gonio. Flex	ROM: Gonio. Ext.	Muscle Strength: HHD	Muscle Strength: ID	Physical Activity: SWarm	Physical Activity: NHANES III	Joint Effusion: Perim.	Balance: RT(eo) (COP area)	Balance: RT(ec) (COP area)	Balance: BBS	Balance: SLS/OLS	Balance: FRT
Huber et al. (2015)	6 weeks	n.a.	n.a.						n.a.	n.a.		n.a.			↑						
	3 months	↓	↓						–	↓	↑	↓			↑						
	1 year																				
Mat Eil-Ismail et al. (2016)	6 weeks									↑											
	3 months									↑											
	1 year																				
Skoffer et al. (2016)	6 weeks	↑*		↑*			↑	↑		↓			↑*			↓					
	3 months	↑*		↑*			↑	↑		↓			↑*			↓					
	1 year																				
Calatayud et al. (2017)	6 weeks																				
	3 months	↑*			↑*					↑*	↓*	↑*									
	1 year																				
Fernandes et al. (2017)	6 weeks																				
	3 months																				
	1 year																				
Casaña et al. (2019)	6 weeks																				
	3 months																↑*	↑*			
	1 year																				
Dominguez-Navarro et al. (2020)	6 weeks ST	↑								↑	↑	↑*							↑	↑	↑
	6 weeks ST+B									↑	↓										
	3 months																				
	1 year ST	↑								↑	↑	↑							↑	↑*	↑
	1 year ST+B																				
Blasco et al. (2020)	6 weeks Home	–								–		–							↑*		
	6 weeks Hospital																				
	3 months																				
	1 year																				

Legend: TUG – Timed Up and Go Test; CST – Chair Stand Test; 30sCST – 30 seconds Chair Stand Test; SCT – Stair Climbing Test; 30sMKB – maximal number of knee-bending in 30 seconds; 6minWT – 6 minutes Walk Test; 10mWT – 10 meters Walk Test; 20mWT – 20 meters Walk Test; Gonio. – Goniometry; HHD – Hand-held dynamometry; ID – Isokinetic dynamometry; SWarm – SenseWear armband; NHANES III – National Health and Nutrition Examination Survey; Perim. – Knee Joint Perimetry; RT(eo) – Romberg Test (eyes opened); RT(ec) – Romberg Test (eyes closed); BBS – Berg Balance Scale; SLS – Single Leg Stance; OLS – One Leg Standing Test; FRT – Functional Reach Tests; "↑" – intervention group outcome better than control group; "↓" – intervention group outcome worse than control group; " * " statistically significant; " – " – no differences between intervention and control group; n.a. – not assessed.

Even though several authors determined an improvement of the pain outcome, only Calatayud et al. (2017) found a statistically significant difference in favor of the intervention group at 3 months after TKA. A not significant improvement was noticed by Mat Eil-Ismail et al. (2016), Fernandes et al. (2017), Dominguez-Navarro et al. (2020) and Blasco et al. (2020) at 6 weeks after TKA, pointing to a tendency of an early post-operative effectiveness.

A significant improved functional performance was detected by Skoffer et al. (2016) (at 6 weeks and 3 months after TKA) and Calatayud et al. (2017) (at 3 months after TKA). Huber et al. (2015), Dominguez-Navarro et al. (2020) and Blasco et al. (2020) could not find important differences in comparison to conventional procedures or non-interventions.

For QoL measures, only Fernandes et al. (2017) identified a significant difference at 1 year after TKA. While Huber et al. (2015) and Skoffer et al. (2016) struggled to find progress in this self-reported outcome, Mat Eil-Ismail et al. (2016), Dominguez-Navarro et al. (2020) and Blasco et al. (2020) (in the domiciliary intervention group) observed an improvement comparatively to the control groups.

In relation to the ROM of the operated knee, a general improvement was noticed by Mat Eil-Ismail et al. (2016) and Dominguez-Navarro et al. (2020), while Blasco et al. (2020) observed no differences between the assessed groups.

Blasco et al. (2020) and Casaña et al. (2019) interventions were effective in significantly improving balance at 6 weeks and 3 months, respectively. Dominguez-Navarro et al. (2020) presented similar overall balance outcomes and only the SLS/OLS at 1 year after TKA suggested otherwise but the authors stated that this isolated result could not confirm this effect.

4. Discussion

This systematic review summarized evidence from 8 RCT's regarding the effects of implementing exercise programs prior to TKA. Exercise interventions are known to be effective in reducing pain in knee OA prior to TKA but previous research could not assertively confirm their success in improving outcomes postoperatively (Huber et al., 2015; Moyer et al., 2017; Wallis & Taylor, 2011). This type of intervention was largely considered to be safe and to have a small clinical effect although statistical significance was not always achieved (Huber et al., 2015; Jette et al., 2020; Kan et al., 2019; Kwok et al., 2015; Moyer et al., 2017; Rice et al., 2019; Saueressig et al., 2021; Skoffer et al., 2016; Wallis & Taylor, 2011; L. Wang et al., 2016).

Our primary outcomes included pain, function and QoL. Our secondary outcomes included balance and ROM. It was often observed a discrepancy between the results of performance-based outcomes and self-reported outcomes both in the intervention group and in the control group, where a positive trajectory of self-rated functionality did not reflect a greater functional tasks performance over time (Calatayud et al., 2017; Huber et al., 2015; Skoffer et al., 2016). This is in accordance with previous studies indicating that patient-reported measures could not replicate the acute worsening of physical impairments and performance-based tasks, since they depend on the value that patients place on their activity and participation after TKA (Berliner et al., 2017; McAuley et al., 2014; Mizner et al., 2011). While performance-based measures provide a more objective view of participants' physical function and are associated with ROM, muscle strength or balance, self-rated measures may depend on treatment effect expectations or on comparisons with the functional performance before the intervention and are associated with pain and QoL (Bourne, 2008; Juhl et al., 2014; Kauppila et al., 2009; Skoffer et al., 2015, 2016).

Pain is a relevant outcome to consider hence change in pain may substantially influence patients' perception of change in functional ability (Mizner et al., 2011). Statistically significant difference in favor of the intervention group was only found by Calatayud et al. (2017) at 3 months after TKA. These results are explained with a positive relationship between pain and isometric knee extension and flexion strength, which significantly improved after the training program. However, the patients' consumption of medication was not measured throughout the study. A not significant improvement was noticed by Mat Eil-Ismail et al. (2016), Fernandes et al. (2017), Dominguez-Navarro et al. (2020) and Blasco et al. (2020) at 6 weeks after TKA, although Skoffer et al. (2016)

was the only one assessing prescribed and nonprescribed medication, founding no differences between groups.

A significant improved functional performance was detected by Skoffer et al. (2016) (at 6 weeks and 3 months after TKA) and Calatayud et al. (2017) (at 3 months after TKA). Authors of both studies acknowledged higher training intensity as a major strength of their work since it has an important role in the achievement of optimal gains. Huber et al. (2015) tried to explain their lack of significant improvements with the possible use of the contralateral leg as compensation to complete the functional task. Even so, Fernandes et al. (2017) suggested that functional limitations due to other diseases should be considered to optimize outcomes after surgery.

QoL is mainly measured through questionnaires, being an important self-reported outcome. Only Fernandes et al. (2017) and Calatayud et al. (2017) identified a significant difference at 1 year and 3 months, respectively, after TKA with the other authors failing to demonstrate the improvements achieved. Skoffer et al. (2016) stated poor responsiveness of the patient-reported scales and lack of power of these measures as possible explanations. Moreover, the way of answering questionnaires may depend on expectations about treatment effects and/or comparisons with the functional performance before the interventions (Berliner et al., 2017; McAuley et al., 2014; Mizner et al., 2011; Skoffer et al., 2016).

Regarding the ROM, Calatayud et al. (2017) detected significant differences at 3 months after TKA with an enhanced knee flexion and a decreased knee extension of the intervention group when compared to the control group. The authors classified these results as plausible because the extensor musculature is especially affected during this sort of surgery. Nonetheless, Huber et al. (2015) observed a not significant decreased knee flexion and improved knee extension. Mat Eil-Ismail et al. (2016) referred that, generally, there is a correlation between preoperative and postoperative knee flexion, i.e., knees with good preoperative flexion have better flexion postoperatively than those with poor preoperative results. Considering that, it should be noted that ROM is not only dependent on a single factor such as preoperative physiotherapy alone, but is also affected by the surgical features implemented, knee kinematics, associated perioperative complications and compliance to postoperative rehabilitation (Mat Eil-Ismail et al., 2016).

Blasco et al. (2020) and Casaña et al. (2019) interventions were effective in significantly improving balance and they established that muscle strengthening (including knee, hip and ankle joints) along with exercises challenging balance and proprioception may enhance postural stability and reduce risk of fall. Casaña et al. (2019) highlighted high-intensity strength program as a beneficial intervention that should be pursued. Even so, Blasco et al. (2020) and Dominguez-

Navarro et al. (2020) recognized that the effect of the balance training may not be measurable at an early stage after surgery since this sort of adaptations take time to occur.

It is important to notice the impact of the tools selected by each study to assess preoperative and postoperative outcomes. There is an absence of consensus about the best measures' combination, with authors highlighting different paths of evaluation. Some encourage the use of five performance-based tests as a core set (including 30s CST, 40m fast-paced walk test, SCT, TUG and 6MWT), while others recommend patient-reported measures as mandatory and performance-based measures as optional (Dobson et al., 2013; McAuley et al., 2014; Mizner et al., 2011). Besides, the minimum clinically important difference is not a fixed attribute, being influenced by several factors such as method of calculation, sample characteristics or follow-up period, but also by what is interpreted as important to the patient (Berliner et al., 2017). Resolving these issues would allow to improve clinical research by enhancing the selection of outcome measures and enabling a more efficient comparison of treatment outcomes across literature (Dobson et al., 2013).

Even though it was identified a tendency of an early post-operative effectiveness, after intervention and before surgery outcomes interpretation should be considered. Dominguez-Navarro et al. (2020) reminded that literature suggests that an exercise-based program, regardless of the type, is effective in patients with knee OA. Furthermore, Skoffer et al. (2016) and Blasco et al. (2020) speculated whether the short-term improvements achieved with a preoperative training intervention could postpone the surgery and be considered as a knee OA conservative treatment. Since it was not the purpose of the current review, these considerations need further exploration in future studies.

Various authors highlighted the difficulty in extending long-term results (Blasco et al., 2020; Calatayud et al., 2017; Casaña et al., 2019; Domínguez-Navarro et al., 2020; Huber et al., 2015). While Calatayud et al. (2017) and Casaña et al. (2019) said that their results may not be maintained 3 months after surgery, Huber et al. (2015), Dominguez-Navarro et al. (2020) and Blasco et al. (2020) stated that there appears to be a trend towards similar overall outcomes 1 year after TKA. According to them, and based on literature regarding the natural progression of TKA rehabilitation, the functional performance outcomes usually reach a plateau at 1 year after surgery and the changes in the different groups tend to stabilize after this period (Bade et al., 2010; Blasco et al., 2020; Farquhar et al., 2008; Huber et al., 2015; Skou et al., 2016). This agrees with work previously developed stating that, in general, in short-term outcomes (within the first 6 months after TKA) it is more likely to be reported early benefits, and in long-term outcomes there can only be found minor changes, tending to present worse or no better than preoperative results (Berliner et al., 2017; Dennis et al., 2020; Gabr et al., 2015; Mizner et al., 2011). Plus, these overall differences are too small to be considered clinically important (Dennis et al., 2020).

Another possible reason for the diluted effect of the intervention over time is the fact that all the studies' participants received standard rehabilitation after surgery. Given that rehabilitation programs are considered crucial after TKA, it is understandable the positive results obtained in both intervention and control groups.

Regarding the type of intervention, higher training intensity and volume were pointed by Skoffer et al. (2016), Calatayud et al. (2017) and Casaña et al. (2019) as important features of exercise programs in this context, unlike most interventions previously studied. Moreover, both Huber et al. (2015) and Fernandes et al. (2017) implemented the NEMEX-TJR training program in their intervention groups as described by Ageberg et al. (2008) (Ageberg et al., 2008).

These exercise programs should target not only the knee joint but also the hip and ankle joints for a full lower limb improvement. Due to muscle strength differences between the non-affected and the affected lower limbs, and the strongest correlation of the latter to functional performance, Skoffer et al. (2016) suggested the application of unilateral versus bilateral training (Skoffer et al., 2015, 2016). And, to optimize postural control, restore functional performance and reduce the risk of falls in individuals with knee OA, Dominguez-Navarro et al. (2020) and Blasco et al. (2020) emphasized the joint implementation of strengthening and balance training.

Some authors planned a group intervention with an expected positive learning effect on participants when compared to individual practice sessions (Fernandes et al., 2017; Huber et al., 2015; Skoffer et al., 2016). While in Huber et al. (2015) study the training could not take place in group although it was planned at first, Skoffer et al. (2016) implemented the program in small groups whose competitive element may have added to the training intensity.

Huber et al. (2015) and Fernandes et al. (2017) implemented a preoperative educational program in both control and intervention groups. Its content included standard procedure information, recommended exercises and activities, pain management and details on the postoperative rehabilitation phase. Although it was not the objective of the present study, it should be highlighted as an important tool to accomplish better outcome scores and it is suggested further research on this topic since education should be seen as an inherent component of therapeutic exercise.

In general, these exercise programs were well tolerated by the population and considered safe, given that no adverse events directly related to the interventions were observed (Blasco et al., 2020; Domínguez-Navarro et al., 2020; Huber et al., 2015; Skoffer et al., 2016). Nevertheless, Huber et al. (2015) indicate increased pain as a joint-specific adverse event of one participant in the study.

Since TKA is an increasingly demanded procedure, an identification of cost-effective interventions for a more efficient management of this condition is necessary. This is a statement common to several studies (Blasco et al., 2020; Calatayud et al., 2017; Domínguez-Navarro et al., 2020; Fernandes et al., 2017; Skoffer et al., 2016). Besides its clinical benefits, an exercise program in this context needs to be justified in economic terms (Blasco et al., 2020). Although a longer intervention period may result in greater improvements and further pain reduction, Skoffer et al. (2016) hinted that a shorter intervention period may be easier to implement in current practice due to lower associated costs. Additionally, a general purpose of undergoing preoperative training is for individuals to achieve a faster functional regaining after TKA, which could possibly lower LOS (length of stay) and consequently reduce healthcare costs (Calatayud et al., 2017). One other form of lowering expenses is through the implementation of domiciliary programs, where an effective intervention could be conducted and monitored periodically by physiotherapists (Blasco et al., 2020). This was showed to be a viable option by Blasco et al. (2020) that pointed that home intervention is as effective as outpatient supervised intervention.

However, due to the considerable differences in healthcare structures worldwide, it is a challenge to interpret and generalize cost-effectiveness data, being of general interest that this type of research is performed to optimize pre and postoperative periods.

5. Limitations

Some identified limitations of this review were the search strategy criteria related to language (including studies in English and excluding results in other languages), the established follow-up period (resulting in a virtual tendency to dilute long-term results) and the intervention affiliated to physiotherapy/physiotherapists (existing country-related systemic organizations differences in which other healthcare professionals may be responsible for this type of intervention).

Besides, eligibility criteria were defined to reflect daily clinical practice as far as possible but functional limitations due to other diseases should be considered to optimize postoperative outcomes. Patients who presented comorbidities that were treated as exclusion criteria could also benefit from training interventions and future investigation should focus on them.

Part of the included studies failed to include the planned number of participants recruiting a small sample size, and to include an acceptable male/female prevalence representativity (Domínguez-Navarro et al., 2020; Huber et al., 2015; Mat Eil-Ismail et al., 2016; Skoffer et al., 2016).

According to Mat Eil-Ismail et al. (2016), exercise-based interventions may not be suitable for elderly individuals accustomed to a sedentary lifestyle. However, Calatayud et al. (2017) suggested preoperative training could reduce the fear of exercise as a harmful stimulus and help to find strategies to cope with pain. Thus, it is more likely to maintain activity levels after surgery as a part of a new lifestyle.

There are factors related to the TKA procedure that may affect postoperative outcomes (implant design and surgical technique, for example) (Domínguez-Navarro et al., 2020; Mat Eil-Ismail et al., 2016). For that reason, some benefits are expected due to the surgery *per se* and not attributed to the implemented intervention (Kwok et al., 2015).

In addition, all the authors implemented individual or standard postoperative rehabilitation protocols. Therefore, remains the question whether improved preoperative outcomes are maintained after surgery or if their expression results of an early physiotherapy approach after TKA (Blasco et al., 2020; Calatayud et al., 2017; Casaña et al., 2019; Domínguez-Navarro et al., 2020; Fernandes et al., 2017; Huber et al., 2015; Mat Eil-Ismail et al., 2016; Skoffer et al., 2016).

Another major limitation identified by the authors of the included studies is the difficulty in blinding patients and physiotherapists due to the nature of the intervention (Blasco et al., 2020;

Casaña et al., 2019; Huber et al., 2015; Skoffer et al., 2016). Other than for ethical issues, a placebo, in this case, would be easily recognized by both (Huber et al., 2015; Skoffer et al., 2016).

Furthermore, there were included studies that integrated the same investigation project, arising the possibility of samples coming from a repeated population (Calatayud et al., 2017; Casaña et al., 2019).

When any doubt arose, the authors were contacted via e-mail. An answer was always obtained except for Mat Eil-Ismail et al. (2016) who were approached to clarify some small data discrepancy between the text and the table content of their study.

Small protocol deviations compared with the PROSPERO registration of this work were made. Instead of standardized difference in means we used the group mean differences when assessing the studies' data.

6. Conclusions

In line with previous findings, this study could not give a conclusive answer to whether the implementation of exercise programs on patients diagnosed with gonarthrosis prior to TKA would improve post-operative outcomes. Although it was seen a general favor of this intervention as a safe and cost-effective option, its impact was not significant.

Further research should be conducted to understand the characteristics of the exercise training to implement and its influence on self-reported and performance-based outcomes, as well as to clarify its short-term and long-term benefits. Moreover, it would be useful for both researchers and clinicians to have predefined valid, reproducible and responsive outcome measures suitable to knee OA and TKA to facilitate comparison of results across studies.

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Appendix 1

SEARCH STRATEGY

Search via PubMed (http://www.pubmedcentral.nih.gov/)

Retrieved on October 18th, 2020

Results: 31

1. PubMed Advanced Search Builder
2. Arthroplasty, Replacement, Knee[MeSH Terms]
3. total knee replacement[Title/Abstract]
4. total knee arthroplasty[Title/Abstract]
5. #2 OR #3 OR #4
6. Preoperative Care[MeSH Terms]
7. preoperat*[Title/Abstract]
8. presurg*[Title/Abstract]
9. prehabilitat*[Title/Abstract]
10. #6 OR #7 OR #8 OR #9
11. Exercise[MeSH Terms]
12. exercis*[Title/Abstract]
13. train*[Title/Abstract]
14. #11 OR #12 OR #13
15. #5 AND #10 AND #14
16. Article type: Randomized Controlled Trial
17. Publication date: 5 years
18. Language: english

Search via Cochrane Library (https://www.cochranelibrary.com/)

Retrieved on October 18th, 2020

Results: 154

1. Advanced Search – Search Manager
2. MeSH descriptor: [Arthroplasty, Replacement, Knee] explode all trees
3. ("total knee replacement"):ti,ab,kw
4. (total knee arthroplasty):ti,ab,kw
5. #2 OR #3 OR #4
6. MeSH descriptor: [Preoperative Care] explode all trees
7. (preoperat*):ti,ab,kw
8. (presurg*):ti,ab,kw
9. (prehabilitat*):ti,ab,kw
10. #6 OR #7 OR #8 OR #9
11. MeSH descriptor: [Exercise] explode all trees
12. (exercis*):ti,ab,kw
13. (train*):ti,ab,kw
14. #11 OR #12 OR #13

15. #5 AND #10 AND #14
16. Limits: with Publication Year from 2015 to 2020, in Trials

Search via PEDro – *Physiotherapy Evidence Database* (https://www.pedro.org.au/)

Retrieved on October 18th, 2020

Results: 15

1. Advanced search
2. Abstract & Title: preoperat* exercis*
3. Body Part: lower leg or knee
4. Method: clinical trial
5. Published Since: 2015
6. When Searching: match all search terms (AND)

Search via VHL – *Virtual Health Library* (https://www.bvsalud.org/en/)

Retrieved on October 18th, 2020

Results: 40

1. Advanced Search
2. MeSH descriptor "Arthroplasty, Replacement, Knee" :title, abstract, subject
3. MeSH descriptor "Preoperative Care" :title, abstract, subject
4. MeSH descriptor "Exercise" :title, abstract, subject
5. #2 AND #3 AND #4
6. Type of study: controlled clinical trial
7. Language: english
8. Publication year range: past 5 years

Appendix 2

PEDro SCALE SUPPLEMENT

	Huber et al. (2015)	Mat Eil-Ismail et al. (2016)	Skoffer et al. (2016)	Calatayud et al. (2017)	Fernandes et al. (2017)	Casaña et al. (2019)	Dominguez-Navarro et al. (2020)	Blasco et al. (2020)
Eligibility criteria	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Random allocation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concealed allocation	Yes	No	Yes	Yes	No	Yes	No	No
Baseline comparability	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blind subjects	No	No	No	No	No	No	No	No
Blind therapists	No	No	No	No	No	No	Yes	No
Blind assessors	Yes	No	Yes	No	No	No	Yes	Yes
Adequate follow-up	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Intention-to-treat analysis	Yes	No	Yes	Yes	Yes	Yes	No	No
Between-group comparisons	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Point estimates and variability	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total Score	**8/10***	**4/10***	**8/10***	**7/10***	**6/10***	**7/10***	**5/10**	**6/10***

* This score has been confirmed by PEDro.

Note: eligibility criteria item does not contribute to total score.

Appendix 3

DATA COLLECTION FORMS OF THE INCLUDED STUDIES

Form completed on November 14th, 2020		
	Title:	Effect of preoperative neuromuscular training (NEMEX-TJR) on functional outcome after total knee replacement: an assessor-blinded randomized controlled trial.
	Authors:	Erika O Huber, Ewa M Roos, André Meichtry, Rob A de Bie, Heike A Bischoff-Ferrari
	Reference citation:	Huber, E. O., Roos, E. M., Meichtry, A., De Bie, R. A., & Bischoff-Ferrari, H. A. (2015). Effect of preoperative neuromuscular training (NEMEX-TJR) on functional outcome after total knee replacement: An assessor-blinded randomized controlled trial. BMC Musculoskeletal Disorders, 16(1). https://doi.org/10.1186/s12891-015-0556-8
	Contact:	omega-e.huber@zhaw.ch

Year:	2015
Country:	Switzerland

Aim of study: To study the effect of a preoperative neuromuscular training (NEMEX-TJR) plus knee school educational program (KS) compared to the KS alone on lower extremity function and pain in individuals aged 55–90 years on a waiting list for TKR due to severe knee OA. The authors hypothesized that patients undergoing this intervention in addition to the KS will be quicker in performing the Chair Stand Test compared with those receiving the KS alone, both when measured immediately after the intervention and 3 months after TKR surgery. They also hypothesize that patients undergoing the NEMEX-TJR in addition to the KS will have a greater improvement in KOOS (subscales ADL function and pain) compared with those receiving the KS alone, when measured immediately after the intervention as well as 6 weeks, 3 months and 1 year after TKR surgery.

Type of study:	RCT (*randomized controlled trial)*
Participants: Participants were eligible when aged 55 to 90 years on a waiting list for primary TKA at the Cantonal Hospital Olten or the Cantonal Hospital Aarau and sufficient time existed before the operation date to take at minimum 8 sessions of the training program. Exclusion criteria were revision surgery, history of inflammatory arthritis, cognitive impairments, absence before or after surgery, and inability to walk at least 3 meters with or without a walking aid. Eligible patients were referred to the study centre (Centre on Aging and Mobility, University of Zurich) by fax.	
Intervention: Allocation was concealed and conducted by a study nurse of the independent randomization centre after baseline assessment. Participants were randomized using block allocation with a block size of four from a	

computer -generated list. Allocation to the intervention or control group was performed by telephone. 22 individuals were included in each group.
Patients of the intervention group attended knee school preoperatively (starting about 4 weeks before surgery) and a neuromuscular training program (for 4–12 weeks, depending on their location on the waiting list for surgery). Patients of the control group attended only the three sessions of knee school.
The training took place in groups under the supervision of an experienced, specially trained physiotherapist and consisted of a 10-minute aerobic warm-up on a stationary exercise bike, followed by a four-exercise circuit programme, and finishing with a cool down period of about 10 minutes.

Warm-up period		
Circuit programme (10–15 repetitions and for 2–3 cycles, with rest between each exercise and cycle)	Stability/postural function	To allow progression, three levels of difficulty were defined. Progression was provided by varying the number, direction and velocity of the movements, by increasing the load and/or by changing the support surface.
	Functional alignment	
	Lower extremity muscle strength	
	Functional exercises	
Cool-down period		

The post-surgical rehabilitation process followed an individualized treatment plan. In the acute care hospital, physiotherapy treatments aimed to improve passive and active range of motion, to reduce swelling and to improve walking capacity with canes. Patients were discharged after 7–10 days. The post-acute rehabilitation took place either in an outpatient physiotherapy practice (ranging from 9–18 treatment sessions) or in an inpatient rehabilitation clinic (on average 2–3 weeks, corresponding to 10–15 treatment days with at least two treatment sessions per day). At both sites treatments aimed to improve active range of motion, muscle strength and activities of daily living, such as walking capacity and climbing stairs".

Comparison: The knee school was taught by an experienced and specially trained physiotherapist over 3 individual or group sessions, one session per week, starting about 4 weeks before the operation. Knee school sessions were separately organized for participants of the intervention group and those of the control group to avoid contamination. The content of the knee school included information on anatomy of the knee joint and adjacent functional structures, recommended activities with prosthesis and post-operative pain management, and details on the post-operative rehabilitation phase. Didactical elements included models of the knee joint and the lower extremity, working sheets, photos and videos, handouts, PowerPoint presentations and peer discussions.

Outcomes: Outcomes were measured at baseline (6–12 weeks preoperative, all measures), 1 week preoperative (after the intervention, all measures), 6 weeks postoperative (patient-reported outcomes only), 3 months postoperative (all measures) and 1 year postoperative (patient-reported outcomes only). Two experienced physiotherapists (assessors), not working at the recruitment sites and not involved in the neuromuscular training and the knee school, had been specifically trained for the assessments in this study and were blinded to group allocation. Participants were instructed not to mention the allocation.
Primary outcome: Chair Stand Test, also known as the repeated sit-to-stand test performed according to the OsteoArthritis Initiative manual, including detailed standardization and instructions (available from http://oai.epi-ucsf.org).
Secondary outcomes: knee pain and function, assessed by the KOOS questionnaire The German version of the KOOS was used in this trial with the user's guide, including scoring instructions available from http://www.koos.nu.
Additional outcome measures: lower limb function, physical activity and health-related quality of life.

Notes:
▪ The neuromuscular training followed the principles of neuromuscular and biomechanical training as described in the neuromuscular training method (neuromuscular exercise programme-total joint replacement, NEMEX-TJR).
▪ The programme is feasible in patients with severe hip or knee OA, in terms of safe self-reported pain following training, decreased or unchanged pain during the training period, few joint-specific adverse events, and achieved progression of training level during the training period.
▪ Ethical approval was granted by the Ethics Committee of the Cantons Aargau and Solothurn, Switzerland, approval number 2009/12 and the trial is registered with ClinicalTrials.gov, identifier: NCT00913575.

Form completed on November 14th, 2020		
	Title:	Preoperative physiotherapy and short-term functional outcomes of primary total knee arthroplasty.
	Authors:	Mohd Shukry Mat Eil-Ismail, Mohd Ariff Sharifudin, Amran Ahmed Shokri, Shaifuzain Ab Rahman
	Reference citation:	Mat Eil-Ismail, M. S., Sharifudin, M. A., Ahmed Shokri, A., & Ab Rahman, S. (2016). Preoperative physiotherapy and short-term functional outcomes of primary total knee arthroplasty. Singapore Medical Journal, 57(3), 138–143. https://doi.org/10.11622/smedj.2016055
	Contact:	Dr Mohd Shukry Mat Eil-Ismail, Orthopaedic Surgeon, Department of Orthopaedics, Hospital Raja Perempuan Zainab II, 15586 Kota Bharu, Kelantan, Malaysia. mshukry76@gmail.com

Year:	2016
Country:	Malaysia

Aim of study: To evaluate the effect of preoperative physiotherapy on the short-term functional outcomes of primary TKA at three intervals – preoperatively, and postoperatively at six weeks and three months – during treatment.

Type of study:	RCT (*randomized controlled trial)*

Participants: Patients were eligible to participate if they were (a) above the age of 45 years; (b) lived within a convenient distance of the physiotherapy facility; (c) had been diagnosed with unilateral or bilateral primary knee osteoarthritis; and (d) underwent unilateral TKA at HUSM. Patients with the following conditions were excluded: systemic inflammatory arthritis; degenerative joint diseases involving the hip or ankle joint or spine; medical comorbidities with an inability to tolerate a moderate level of physical exertion; premorbid knee joint stiffness; history of cardiovascular accident; and cognitive, psychological or language impairment.

Intervention: Patient assignment into two groups was randomised according to the week of their surgery; those who were scheduled for surgery on odd and even weeks of the month were assigned to the physiotherapy and nonphysiotherapy groups, respectively. Patient assignment was performed by the primary investigator, and this was not made known to the surgeons. The physiotherapy group performed physical exercises twice weekly over a six-week period immediately prior to surgery. Their physiotherapy regime included stretching, isometric strengthening exercises, mobilising exercises and heat therapy.

Stationary bike	Low-resistance cycling for 15 min
Ankle circulatory exercise (ankle pumps)	10 repetitions in 4 directions
Isometric quadriceps	Hold for 5 s, 50 repetitions
Inner range quadriceps	Hold for 5 s, 50 repetitions
Hamstring stretch	Hold for 10 s, gradually increase to 15 s as tolerated, 10 repetitions
Straight leg raise	Leg raised to 45º, 20 repetitions
Heel slides	Hold for 5 s, 20 repetitions

Termoterapia	Hot pack for 10 min

The exercises performed were similar to those in the postoperative exercise protocol for TKA patients at the institution.

Comparison: Between physiotherapy and non-physiotherapy groups. However, both received rehabilitation intervention after surgery. After surgery, all patients were given mechanical and pharmacological prophylaxis for deep vein thrombosis and underwent the same postoperative rehabilitation protocol.
Outcomes: Postoperative evaluation was done at six weeks and three months following surgery using the KOOS, and the ROM of the operated knee was measured using a goniometer.

Notes:

- The use of the algofunctional Knee Injury and Osteoarthritis Outcome Score (KOOS) scale required no licence; the questionnaire was downloaded from the website http://www.koos.nu. The Malay version of the KOOS was translated from the English version LK1.0 and validated according to Mapi Research Institute procedures for linguistic validation.

Form completed on November 15th, 2020

Title:	Efficacy of Preoperative Progressive Resistance Training on Postoperative Outcomes in Patients Undergoing Total Knee Arthroplasty.
Authors:	Birgit Skoffer, Thomas Maribo, Inger Mechlenburg, Per M. Hansen, Kjeld Søballe, Ulrik Dalgas
Reference citation:	Skoffer, B., Maribo, T., Mechlenburg, I., Hansen, P. M., Søballe, K., & Dalgas, U. (2016). Efficacy of Preoperative Progressive Resistance Training on Postoperative Outcomes in Patients Undergoing Total Knee Arthroplasty. Arthritis Care and Research, 68(9), 1239–1251. https://doi.org/10.1002/acr.22825
Contact:	Birgit Skoffer, PhD, Department of Physical and Occupational Therapy, Aarhus University Hospital, Nørrebrogade 44, 8000 Aarhus C, Denmark. E-mail: bss@clin.au.dk

Year:	2016
Country:	Denmark

Aim of study: The purpose of this study was to investigate the efficacy of 4 weeks of preoperative and 4-week postoperative progressive resistance training (PRT) compared to 4 weeks of postoperative PRT only on functional performance, muscle strength, and patient-reported outcomes in patients undergoing TKA. A secondary purpose was to evaluate the safety profile and feasibility of PRT in terms of dropout rate, exercise adherence, and adverse events.

Type of study:	RCT (*randomized controlled trial)*

Participants: All patients scheduled for TKA from January 2012 to December 2013 at the orthopedic department at Aarhus University Hospital and Silkeborg Regional Hospital were consecutively informed in writing and face-to-face about the study and afterwards asked to participate. Included patients were scheduled for primary unilateral TKA, were radiographically and clinically diagnosed with OA, were residents in the Aarhus municipality, and were able to transport themselves to training. Excluded patients were ages ,18 years, had heart disease or uncontrolled hypertension, had neuromuscular or neurodegenerative conditions, or were unable to comprehend the protocol instructions.

Intervention: Patients were randomly assigned to preoperative PRT or to the control group, applied by concealed, opaque envelopes prepared by the assessor. The randomization was stratified by hospital and performed in blocks of 10. The envelopes were placed in bags, 10 in each bag and separate bags for the 2 hospitals. After the first test, the patients drew an envelope from the bag. The envelopes were administrated by the physiotherapists who provided the PRT intervention.

Warm-up
Leg press *Knee extension* *Knee flexion* *Hip extension* *Hip abduction* *Hip adduction*
Stretching

All PRT training sessions took place at Aarhus University Hospital andwere supervised by 3 physiotherapists specially trained in the applied training concept. Patients performed 3 training sessions per week for 4 weeks preoperatively and completed a further 3 sessions per week for 4 weeks postoperatively. Each session was 60 minutes. Patients were trained in groups of 3 under supervision of a physiotherapist. The training intensity started with 12 repetitions maximum with progression towards 8 repetitions maximum. Three sets of each exercise were performed,with a rest length of 2 minutes between sets and exercises. Following a 10-minutewarmup on a stationary bike, the same 6 exercises were executed unilaterally during all planned sessions pre- and postoperatively.

Comparison: Patients in the control group were instructed to live as usual for 4 weeks preoperatively. Postoperatively they followed the same PRT protocol as the intervention group.

Outcomes: The outcome measures were collected at 6 weeks (baseline) and 1 week (test 2) preoperatively, and at 1 week (test 3), 6 weeks (test 4), and 12 weeks (test 5) after TKA. All outcome measures were blindly assessed by the principal investigator. Patients were not blinded to group allocation.
Primary outcome: the 30-second chair stand test (30sCST) Other outcomes: 10-meter Walk Test, 6-minute Walk Test, muscle strength (isokinetic dynamometer), range of motion (goniometry), knee pain (rating scale from 0 to 100), knee joint effusion (joint circumference), Knee Injury and Osteoarthritis Outcome Score (KOOS), health related quality of life (rating scale from 0 to 100).
Safety and feasibility were measured, with reporting of dropout rate, exercise adherence and adverse events.

Notes:
- Test have shown to be valid and reliable in cases of knee ROM limitation, knee osteoarthritis and TKA.
- Use of prescribed and nonprescribed medication was recorded.
- None of the patients missed training sessions or were discontinued from the study due to adverse events related to the intervention.
- The study followed the Declaration of Helsinki, was approved by the regional Ethics Committee (M-20110191) and was registered with the Danish Data Protection Agency (1-16-02-191-11).

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Form completed on November 14th, 2020		
	Title:	High-intensity preoperative training improves physical and functional recovery in the early post-operative periods after total knee arthroplasty: a randomized controlled trial.
	Authors:	Joaquin Calatayud, Jose Casaña, Yasmin Ezzatvar, Markus D. Jakobsen, Emil Sundstrup, Lars L. Andersen
	Reference citation:	Calatayud, J., Casaña, J., Ezzatvar, Y., Jakobsen, M. D., Sundstrup, E., & Andersen, L. L. (2017). High-intensity preoperative training improves physical and functional recovery in the early post-operative periods after total knee arthroplasty: a randomized controlled trial. Knee Surgery, Sports Traumatology, Arthroscopy, 25(9), 2864–2872. https://doi.org/10.1007/s00167-016-3985-5
	Contact:	Joaquin Calatayud, ximo86@hotmail.com

Year:	2017
Country:	Spain

Aim of study: To evaluate the effectiveness of a high-intensity preoperative resistance training programme in patients awaiting TKA, which provides a novel aspect compared with previous studies. It was hypothesized that the preoperative training programme would lead to greater improvements in strength, range of motion (ROM), pain and functional measures before TKA and would reduce LOS in comparison with controls. In addition, it was hypothesized that the intervention programme would promote improvements both 1 and 3 months after TKA compared with controls.

Type of Study:	RCT (*randomized controlled trial)*

Participants: All patients above 60 years old who were diagnosed with advanced idiopathic knee OA and scheduled for unilateral total knee arthroplasty in a local hospital during 2014 were considered candidates for the present study and were asked to participate. Participants were excluded if pain was present in the contralateral limb (maximum pain, ≥4 of 10 during daily activities), if they had undergone another hip or knee joint replacement in the previous year, if they had any medical condition in which exercise was contraindicated or if they had any disease that affected functional performance. All participants were informed about the purpose and content of the project and gave their written informed consent to participate in the study.

Intervention: Participants were randomly allocated to either an intervention group or control by assigning random numbers with a computer. The researcher was blinded to the randomization, so the knowledge of the allocated interventions was prevented. The intervention group completed a training programme prior to surgery for 3 days per week for 8 weeks. The exercise programme was especially designed to increase lower limb muscle strength. Sessions were performed at the same time of the day and were separated by at least 48 h. Each training session took place under the supervision of an experienced physical therapist.

Warm-up, 15 minutes – Dynamic joint movements performed without ballistic movements and dynamic body weight exercises including 2 sets of 20 repetitions of step-ups and calf raises at a platform and finally 10 min of light-intensity hand or leg ergometry cycling (depending on the perceived pain).
Strengthening exercise

– 5 sets of 10 repetitions for each exercise, with 60-s rest between sets. The exercises were performed in the following order: seated leg press, knee extension, leg curl and hip abduction. Intensity was based on participant's ability to execute 10 repetition maximum (10 RM).

Proprioception exercise

– 4 sets of 30 s of double leg stance and 4 sets of 15 s of single leg stance on the same unstable device (Bosu® Balance Trainer), starting with the non-affected leg.

Cool-down, 5 minutes

– Light static stretching of hip abductors, flexors and extensors of the knee and ankle plantar flexors

Comparison: Control group did not receive any preoperative intervention. After TKA surgery, all subjects received the same post-operative rehabilitation protocol at the hospital as a part of the usual care treatment.

Outcomes: Assessment tests performed at baseline (T1) 8 weeks before surgery., T2 after 8 weeks of training and prior to the surgery, T3 at 1 month after TKA, and the final testing T4 executed 3 months after TKA. Each of these testing sessions consisted in completing the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the Physical Functioning Scale of the Short Form-36 questionnaire (SF-36), a 10-cm visual analogue scale (VAS), isometric strength, active knee ROM and functional tasks (Timed Up and Go test and Stair ascent–descent test). All measurements were performed by the same physical therapist at the university who was not involved in the training supervision to avoid possible risk of bias.

Notes:

- Participants were scheduled for 1 familiarization session and 4 test days. During the familiarization sessions, the test procedure was explained and practised 1–3 times until the subject felt confident and the researcher was satisfied that proper form was achieved.
- All procedures described in this section were approved by the Institution's Review Board of the Clinical Hospital of Valencia (approval number: F-CE-GEva-15) and comply with the requirements listed in the 1975 Declaration of Helsinki and its amendment in 2008.

Form completed on November 21st, 2020	**Title:**	Supervised neuromuscular exercise prior to hip and knee replacement: 12-month clinical effect and cost-utility analysis alongside a randomised controlled trial.
	Authors:	Linda Fernandes, Ewa M. Roos, Søren Overgaard, Allan Villadsen, Rikke Søgaard
	Reference citation:	Fernandes, L., Roos, E. M., Overgaard, S., Villadsen, A., & Søgaard, R. (2017). Supervised neuromuscular exercise prior to hip and knee replacement: 12-month clinical effect and cost-utility analysis alongside a randomised controlled trial. BMC Musculoskeletal Disorders, 18(1), 1–11. https://doi.org/10.1186/s12891-016-1369-0
	Contact:	Linda Fernandes, linda.fernandes1@gmail.com

Year:	2017
Country:	Denmark

Aim of study: To evaluate one-year clinical effect and cost-utility of the supervised neuromuscular exercise programme prior to THR and TKR. If supervised exercise prior to THR and TKR is shown to be cost-effective, health policy decision makers should consider changing the pre-operative care trajectory to include supervised exercise prior to THR and TKR.

Type of study:	RCT (*randomized controlled trial)*

Participants: Inclusion criteria were; ≥18 years of age and scheduled for THR or TKR due to symptomatic OA. Exclusion criteria were; scheduled for bilateral surgery, previous fractures in or adjacent to the joint, inflammatory arthritis and severe heart disease or neurologic deficits. Included patients were randomly allocated to the intervention group or to the control group.

Intervention: The neuromuscular exercise programme was supervised by a physiotherapist and focused on lower extremity muscular control and quality of movement. The programme was delivered in groups of 6–12 patients twice weekly lasting 1 h per session.

Warm-up	Weightbearing exercises imitating functions of daily living. Progression of exercise level was guided by neuromuscular control and quality of the performance (determined by the physiotherapist) and with acceptable exertion (determined by the patient).
Circuit programme	
Cool-down	

The EP was standard preoperative information on the operating procedure, expected postoperative progression and a leaflet on various exercises.

Comparison: The intervention group included supervised neuromuscular exercise and preoperative educational package (EP) and the control group received EP alone.

Outcomes: Clinical effect was measured with HOOS and KOOS at one-year post-surgery. Assessments points were at baseline, 8 weeks (post-intervention), 15 weeks (6 weeks postsurgery), 21 weeks (3 months post-surgery) and 61 weeks (one-year post-surgery). Utility was expressed as QALYs measured with the generic outcome measure European Quality of Life 5-Dimension 3-Level Health Outcome (EQ-5D-3L). Health state valuations from the Danish general population were adopted.

Notes:

▪ An economic evaluation was conducted alongside the RCT and applied the health care sector perspective, incorporating cost of health care services, including cost of the exercise program.

Form completed on November 28th, 2020	**Title:**	Preoperative high-intensity strength training improves postural control after TKA: randomized-controlled trial.
	Authors:	José Casaña, Joaquín Calatayud, Yasmín Ezzatvar, Jonas Vinstrup, Josep Benítez, Lars L. Andersen
	Reference citation:	Casaña, J., Calatayud, J., Ezzatvar, Y., Vinstrup, J., Benítez, J., & Andersen, L. L. (2019). Preoperative high-intensity strength training improves postural control after TKA: randomized-controlled trial. Knee Surgery, Sports Traumatology, Arthroscopy, 27(4), 1057–1066. https://doi.org/10.1007/s00167-018-5246-2
	Contact:	Joaquín Calatayud, joaquin.calatayud@uv.es

Year:	2019
Country:	Spain

Aim of study: To investigate the effectiveness of preoperative high-intensity training (with a special emphasis on lower limb muscle strength and secondarily on balance training) on postural control after TKA. It was hypothesized that preoperative high-intensity training would provide greater postural control improvements than usual care before and 1 month after TKA care, but not 3-month postsurgery.

Type of study:	RCT (*randomized controlled trial)*

Participants: Patients above 60 years old who were diagnosed with advanced idiopathic knee OA (according to the radiological criteria of the American College of Rheumatology Guidelines) and scheduled for unilateral TKA at a local hospital. Participants were excluded if pain was present in the contralateral limb (maximum pain, ≥ 4 of 10 during daily activities), if they had been going through another hip or knee joint replacement in the previous year, if they had any medical condition in which exercise was contraindicated or if they had any disease that affected functional performance. All participants were informed about the purpose and content of the project and gave their written informed consent to participate in the study.

Intervention: For the allocation of the participants, a computer-generated list of random numbers was used. Participants were randomly allocated to either an intervention group (preoperative training) or control (usual care), following the simple randomization procedures (computerized random numbers). The allocation sequence was performed by a person who was not involved in the study and was concealed from the main researcher enrolling and supervising the patients.

The intervention group completed a training program prior to surgery for 3 days per week for 8 weeks. The exercise program was focused on increasing lower limb muscle strength. Sessions were performed at the same time of the day and were separated by at least 48 h. Each training session took place under the supervision of an experienced physical therapist.

Warm-up
15 minutes
– Dynamic joint movements performed without ballistic movements and dynamic body weight exercises including 2 sets of 20 repetitions of step-ups and calf raises at a platform and finally 10 min of light-intensity hand or leg ergometry cycling (depending on the perceived pain).

Strengthening exercise

– 5 sets of 10 repetitions for each exercise, with 60-s rest between sets. The exercises were performed in the following order: seated leg press, knee extension, leg curl and hip abduction. Intensity was based on participant's ability to execute 10 repetition maximum (10 RM).

Proprioception exercise

– 4 sets of 30 s of double leg stance and 4 sets of 15 s of single leg stance on the same unstable device (Bosu® Balance Trainer), starting with the non-affected leg.

Cool-down

5 minutes

– Light static stretching of hip abductors, flexors and extensors of the knee and ankle plantar flexors

Comparison: Before TKA, the control (usual care) did not receive any supervised intervention. Patients were advised to perform three different isometric exercises everyday: knee extension during 6–10 s while seated on a chair or table, 10–20 sets, 10–20 times/day; hip flexion during 5–10 s while lying on mat with knee fully extended, 10–30 repetitions; knee extension during 6–10 s while seated with legs extended horizontally on a mat, with a rolled towel under the knees, 10–20 sets, 10–20 times/day.
After TKA surgery, all the subjects received the same postoperative rehabilitation protocol at the hospital as a part of the usual care treatment.

Outcomes: Each patient performed two postural control tests with different levels of difficulty: Romberg test with Eyes Open and Romberg test with Eyes Closed. The NedSVE/IBV force platform was used (Biomechanics Institute of Valencia, Valencia, Spain) to measure the center of pressure (COP) during the different tests.
Data assessment moments: baseline (T1) was performed 8 weeks before surgery, T2 after 8 weeks of training and prior to the surgery, T3 performed 1 month after TKA, and T4 was scheduled 3 months after TKA. All measurements were performed at the university by the same physical therapist, who had the previous experience with the tests and was not involved in the training supervision to avoid possible risk of bias.

Notes:

- Participants were scheduled for 1 familiarization session and 4 test days. During the familiarization session, the test procedure was explained and practiced 1–3 times until the subject felt confident and the researcher was satisfied that proper form was achieved.
- All procedures approved by the institution's review board of the Clinical Hospital of Valencia (approval number: F-CE-GEva-15) and comply with the requirements listed in the 1975 Declaration of Helsinki and its amendment in 2008.
- The study adhered to the CONSORT guidelines to ensure transparent and standardized reporting of trials.
- Data provided in the present article are a part of a project involving different evaluations in patients awaiting TKA. The previous data from this project have already been published.

(Calatayud, J., Casaña, J., Ezzatvar, Y., Jakobsen, M. D., Sundstrup, E., & Andersen, L. L. (2017). High-intensity preoperative training improves physical and functional recovery in the early post-operative periods after total knee arthroplasty: a randomized controlled trial. Knee Surgery, Sports Traumatology, Arthroscopy, 25(9), 2864–2872. https://doi.org/10.1007/s00167-016-3985-5)

Form completed on November 28th, 2020	**Title:**	A randomized controlled trial assessing the effects of preoperative strengthening plus balance training on balance and functional outcome up to 1 year following total knee. replacement.
	Authors:	Fernando Domínguez-Navarro, Antonio Silvestre-Muñoz, Celedonia Igual-Camacho, Beatriz Díaz-Díaz, Jose Vicente Torrella, Juan Rodrigo, Alfonso Payá-Rubio, Sergio Roig-Casasús, Jose María Blasco
	Reference citation:	Domínguez-Navarro, F., Silvestre-Muñoz, A., Igual-Camacho, C., Díaz-Díaz, B., Torrella, J. V., Rodrigo, J., Payá-Rubio, A., Roig-Casasús, S., & Blasco, J. M. (2020). A randomized controlled trial assessing the effects of preoperative strengthening plus balance training on balance and functional outcome up to 1 year following total knee replacement. Knee Surgery, Sports Traumatology, Arthroscopy, 0123456789. https://doi.org/10.1007/s00167-020-06029-x
	Contact:	Jose María Blasco, Jose.Maria.Blasco@uv.es

Year:	2020
Country:	Spain

Aim of study: To investigate the effects of combining strengthening plus balance training, implemented prior to TKR surgery, on patients' balance and functional outcomes and to compare this training with a traditional strengthening programme and with no intervention. They hypothesized that combined strengthening plus balance training before total knee replacement would lead to improvements in patient functional and balance outcomes at 6 weeks and 1 year after surgery.

Type of study:	RCT (*randomized controlled trial)*

Participants: Participants who were on the waiting list for primary TKR, referred by the surgeon, were aged between 60 and 80 years, presented with advanced idiopathic knee osteoarthritis with a radiographic score of > 3 on the Kellgren–Lawrence scale and were scheduled with sufficient time until surgery (5–8 weeks) to perform 12 sessions of preoperative training were included. The exclusion criteria were a cognitive or physical baseline status that prevented patients from safely participating in the assessments and/or interventions, which corresponded to scores lower than 20 in the Spanish version of the Mini-Mental State Examination and lower than 21 in the Berg Balance Scale (BBS). Systemic illness (i.e., cancer, coronary disease) and surgical complications contraindicating physical activity were also exclusion criteria. Informed verbal and written consent was obtained from all participants.

Intervention: The participants were randomly allocated into the strengthening (ST), strengthening plus balance and proprioceptive exercise (ST + B), or control groups. A random number sequence was generated with MATLAB® and used to assign patients who were consecutively included and met the inclusion criteria to groups. An external advisor, blinded to the interventions, allocated the participants to groups by phone. A member of the team blinded to the participant allocation results collected data at the hospital facilities.

Both the ST and ST + B groups performed a 4-week, 12-session intervention of outpatient preoperative training. The ST group performed strengthening training with sessions that lasted 30–40 min. The ST + B group augmented the intervention with 15–20 min of balance and proprioceptive training.

After discharge, the participants were scheduled to perform 12 sessions of standard outpatient rehabilitation, which started 10–12 days after surgery. The protocol was supervised by a physiotherapist blinded to the group allocation results and not involved in the outcome assessment.

Strengthening Exercises	
Warm-up	Stationary bicycle (10 minutes)
Muscle strengthening	- isotonic activation of quadríceps, Colson chair for quadríceps strengthening, isotonic activation of hamstrings, Colson chair for hamstring stregthening (3 series of 10 repetition and 1 minute rest between them) - lateral abduction, adduction (5 minutes)
Cool-down	Stretching of the quadriceps and hamstrings (2 repetitions of 30 seconds)
Ice application	10 minutes

Balance and Proproception Exercises		
Side steps Treadmill-walk	5 minutes	Performed preferably between 1st and 6th session.
Tandem-walk Cross-walk Multiple direction changes		Performed preferably between 1st and 9th session.
Foam standing balance Bohler standing balance Roller board Dynamometric platform exercises		Performed preferably between 1st and 12th session.

After discharge, the participants were scheduled to perform 12 sessions of standard outpatient rehabilitation, which started 10–12 days after surgery. The protocol was supervised by a physiotherapist blinded to the group allocation results and not involved in the outcome assessment.

Comparison: Participants in the control group did not participate in any experimental preoperative intervention.

Outcomes: The participants were assessed at five time points: baseline: 5–8 weeks before surgery; end of the preoperative intervention: 1 week before surgery; 2 weeks after surgery before initiating outpatient rehabilitation; 6 weeks after surgery and 1 year after surgery. The overall state of balance and self-reported functionality were established as the primary outcomes. The secondary outcomes were related to the capacity to maintain balance, knee function, and self-reported status.

Notes:

- One practice attempt was allowed to familiarize the participants with the tests.
- The study design was approved by the ethical board of the Hospital Clínic i Universitari de València (Approval No. 26052016), where the trial was conducted from January 2017 to July 2019.
- The study was prospectively registered (ClinicalTrials.gov identifier NCT02995668), and the protocol was made fully available online. No substantial changes to the protocol are reported.

Form completed on November 21st, 2020		
	Title:	The effects of preoperative balance training on balance and functional outcome after total knee replacement: a randomized controlled trial.
	Authors:	José-María Blasco, Yolanda Acosta-Ballester, Ignacio Martínez-Garrido, Pablo García-Molina, Celedonia Igual-Camacho, Sergio Roig-Casasús
	Reference citation:	Blasco, J. M., Acosta-Ballester, Y., Martínez-Garrido, I., García-Molina, P., Igual-Camacho, C., & Roig-Casasús, S. (2020). The effects of preoperative balance training on balance and functional outcome after total knee replacement: a randomized controlled trial. Clinical Rehabilitation, 34(2), 182–193. https://doi.org/10.1177/0269215519880936
	Contact:	José-María Blasco, Group of Physiotherapy in the Ageing Process, Departamento de Fisioterapia, Universitat de València (UV), Calle Gascó Oliag, 5, 46010 Valencia, Spain. E-mail: jose.maria.blasco@uv.es

Year:	2020
Country:	Spain

Aim of study: To determine the effects of preoperative balance-oriented intervention undertaken at home or supervised in a hospital setting on patients undergoing total knee replacement. They hypothesized that domiciliary and outpatient preoperative intervention would be similarly effective in enhancing balance outcomes in the early postoperative period, which in turn would have a positive impact on patient functionality.

Type of study:	RCT (*randomized controlled trial)*

Participants: Potential participants were eligible if they were aged 60–80 years and were on the waiting list for undergoing total knee replacement surgery. Potential participants were referred by the orthopaedic surgeon and had to score >21 in the Berg Balance Scale and 20 in the Mini-Mental State Examination to meet the inclusion criteria. The thresholds were established for ensuring that participants were cognitively able to understand the physiotherapist's instructions and physically capable to perform the interventions with safety. Individuals with central or vestibular limitation affecting balance or presenting with postoperative complications of knee surgery, such as deep venous thrombosis, were excluded. Potential participants meeting criteria and signing a consent form took part in the study.

Intervention: Participants were allocated using the output of a random number generator provided by an external assessor. Following randomization, the principal investigator notified patients by phone regarding their treatment allocation. Data collection was blinded; one member of the team was designated with the only task of conducting all assessments. The two experienced physiotherapists (experience of >15 years) supervising interventions were not blinded. Group allocation was not revealed to participants, but the concealment was not ensured, since they were informed about the groups before signing consent.
The hospital setting intervention included lower limb strengthening exercises and balance-oriented training. Specifically, the latter consisting of the sidewalk, treadmill walk, crosswalk, and tandem walk exercises were performed during the first two weeks. Multiple changes of direction, foam activities, and proprioceptive work with proprioception plate were included on week 3. During the last four sessions, 5 minutes of weight-bearing exercises and limits of stability testing were performed.
The domiciliary group performed similar training volumes and types of exercises. However, the programme was adapted to be implemented at home. First, an education session was held in the hospital facilities, so

that a physiotherapist could instruct the training procedure and resolve doubts face to face. The participants were trained at home and were appointed to review and correct possible deviations from the programme two weeks after starting the training. Participants were called on a weekly basis to check compliance.
Comparison: The control group did not perform preoperative intervention, and participants were instructed to keep their normal activities. After surgery, all groups received the same standard in-hospital care. Before discharge from the hospital, participants were scheduled to be reassessed and initiate a standard outpatient rehabilitation two weeks after surgery.
Outcomes: Baseline characteristics and clinical outcomes were assessed from five to eight weeks before surgery. Clinical outcomes were reassessed one week before surgery, before initiating in-hospital early postoperative rehabilitation (10–14 days after surgery), and after discharge (six weeks after surgery: early postoperative period hereinafter). Primary outcomes: overall state of balance assessed with the Berg Balance Scale and the self-reported functionality assessed with the Knee Injury and Osteoarthritis Outcome Score Function in Activities in Daily Living (KOOS-ADL) subscale. Secondary outcomes: knee range of motion, isometric quadriceps strength, Timed Up and Go test, One-leg Standing test, Functional Reach test, KOOS questionnaire and three-level version of the Euro Quality of Life 5-Dimension questionnaire.

Notes:

- Since a domiciliary rehabilitation programme for total knee replacement is used to lower the expenses, both possibilities were assessed.
- Considering the target population, they did not assess the sport and recreation KOOS subscale.
- This study was approved by the research ethics committee ensuring compliance with the ethical and legal provisions of the research carried out in the Hospital Universitario y Politécnico La Fe from Valencia (no. 2016/499).
- The study was prospectively registered on ClinicalTrials.gov under identifier number NCT-03100890. A detailed protocol was made publicly available online.

Appendix 4

OUTCOME MEASUREMENT TIME POINTS

	Baseline	Endpoint 1	Endpoint 2	Endpoint 3	Endpoint 4
Huber et al. (2015)	6-12 weeks pre-TKA	1 week pre-TKA	6 weeks post-TKA	***3 months post-TKA****	12 months post-TKA
Mat Eil-Ismail et al. (2016)	pre-TKA	6 weeks post-TKA	3 months post-TKA		
Skoffer et al. (2016)	6 weeks pre-TKA	1 week pre-TKA	1 week post-TKA	***6 weeks post-TKA****	12 weeks post-TKA
Calatayud et al. (2017)	8 weeks pre-TKA	pre-TKA (after 8 weeks of intervention)	1 month post-TKA	3 months post-TKA	
Fernandes et al. (2017)	8 weeks pre-TKA	post-TKA	6 weeks post-TKA	3 months post-TKA	1 year post-TKA
Casaña et al. (2019)	8 weeks pre-TKA	pre-TKA (after 8 weeks of intervention)	1 month post-TKA	3 months post-TKA	
Dominguez-Navarro et al. (2020)	5-8 weeks pre-TKA	1 week pre-TKA	2 weeks post-TKA	***6 weeks post-TKA****	1 year post-TKA
Blasco et al. (2020)	5-8 weeks pre-TKA	1 week pre-TKA	10-14 days post-TKA	***6 weeks post-TKA****	

"pre-TKA" – assessment previous to TKA; "post-TKA" – assessment posterior to TKA;
(*) – indicated by the authors as primary endpoint.