EFFECT OF QUADRICEPS STRENGTHENING IN POST TOTAL KNEE ARTHROPLASTY PATIENTS: CLINICAL EVIDENCE AND IMPLICATIONS FOR FUTURE RESEARCH

Manjula M[1], Dr Anitha A[2]
[1]PhD Scholar, Saveetha college of Physiotherapy, Saveetha Institute of Medical and Technical Sciences [1]. Columbia college of Physiotherapy [2]. Mail Id: manjuphysio1025@gmail.com
[2]Professor, Saveetha college of Physiotherapy, Saveetha Institute of Medical and Technical Sciences; Mail Id: anithaarul86@gmail.com
***Corresponding author:** Dr Anitha A, Professor, Saveetha college of Physiotherapy, Saveetha Institute of Medical and Technical Sciences; Mail Id: anithaarul86@gmail.com

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INTRODUCTION:

Total knee arthroplasty (TKA) is a popular surgical procedure with controversies over the best alignment philosophy for femoral and tibial components. Conventionally, neutral mechanical alignment is preferred, but recent studies suggest kinematic alignment or functional alignment(1). Over 700,000 knee arthroplasties (TKAs) are performed annually in the United States to alleviate pain and disability associated with knee osteoarthritis (OA) (2). The alignment of the femoral component during rotation is crucial for knee stability and patellofemoral kinematics. Malalignment can cause complications and ligament balancing, potentially leading to total knee arthroplasty failure(3). Patients with knee Osteoarthritis experience pain and function impairments, limiting their daily activities and work participation. Knee replacement surgery, known as total knee arthroplasty (TKA), is a common treatment to reduce pain and with 15% experiencing severe pain after 3-4 years [4]. Metabolic disorders like obesity and diabetes are risk factors for developing knee Osteoarthritis, but their relationship to postoperative chronic pain is unclear. Increased systemic inflammation, characterized by high levels of proinflammatory cytokines, is associated with higher preoperative pain levels in patients with knee Osteoarthritis. This altered central pain processing may contribute to chronic pain development and maintenance. Understanding these factors and markers could improve surgery timing, patient expectations, and preoperative treatment decisions [5].

C-reactive protein (CRP) and serum calcium are crucial for bone health and muscle contractions, but their benefits can also risk the patients. Genetically higher calcium levels may lower osteoarthritis risk but increase hypertension and coronary atherosclerosis. Vitamin D plays a role in immune processes. C reactive protein levels may be elevated in osteoarthritis patients, but evidence is conflicting, with some studies suggesting increased severity of symptoms and progression [6]. Osteoarthritis is a prevalent joint disease in India, affecting 22%-39% of the population. It is more common in women and increases with age, causing mobility impairment and being the 10th leading cause of harmless burden [7].

Quadriceps weakness during gait leads to decreased shock absorption and increased load, potentially causing Osteoarthritis changes in the medial and lateral compartments. This may impair quadriceps muscle contractions [8].

Knee osteoarthritis is characterized by knee extensor weakness, leading to symptomatic and functional decline over time. Studies have investigated its association with disease progression [9]. Quadriceps weakness is a risk factor for the initiation and progression in individuals with lower muscle strength compared to healthy adults of knee osteoarthritis [10]. Quadriceps muscle strength is crucial for functional performance, such as stairclimbing, chair rise performance, walking speed, and implant survival. High muscle strength in the lower limbs is associated with lower mortality risk. Many total knee arthroplasty (TKA) patients want to regain their normal activity level or participate in athletic events [11].

Quadriceps muscle strength loss correlates with pain intensity and functional disability, while higher strength individuals experience less pain and disability. Physical exercise and muscle strengthening are valuable in Osteoarthritis. Lower limb muscle weakness, particularly quadriceps muscle, causes pain and instability, contributing to disease progression. Strength loss correlates with pain intensity and functional disability. Physical exercise and muscle strengthening are beneficial in Osteoarthritis [12].

Quadriceps strength training may reduce pain and improve physical function in people with knee

Osteoarthritis, but no evidence has identified underlying biomechanical mechanisms. It showing improved thigh muscle strength and symptomatic improvements, but no change in quadriceps muscle function or knee joint loads after strengthening. Quadriceps strength training is believed to enhance quadriceps force during locomotion, allowing the muscle and patellar tendon to more effectively unload the knee joint [10]. Neuromuscular Electrical Stimulation (NMES) has been used as an adjunct to conventional strengthening programs in patients post-total knee replacement, potentially increasing muscle strength more effectively than traditional methods. Neuromuscular electrical stimulation effectiveness in strengthening quadriceps muscle in total knee replacement patient [13]. Neuromuscular control changes before and after total knee arthroplasty (TKA) are reported, with many patient experiencing difficulty bearing their full body weight on their legs due to pain, poor activation, or muscle atrophy. It can take over two years to fully regain preoperative levels of quadriceps femoris muscle activation [14]. Exercises like squats can increase lower limb muscle strength and activity, preventing injuries. Squat exercises improve leg, hip, and back strength and are a major exercise in sports performance and knee rehabilitation programs The Swiss ball to measure the depth of the General squat with both feet on the floor, with the Swiss ball placed between the wall and spine The study compares three squat exercises to identify which activate quadriceps femoris and hamstring muscles effectively, providing diverse information for rehabilitation programs and clinicians. It hypothesizes that Side squat exercises show highest muscle activity in quadriceps femoris, without significant differences in hamstring muscles [15].

Vastus medialis 's role in knee osteoarthritis, along with other quadriceps components, Increased Vastus medialis size reduces knee pain and improves knee Osteoarthritis, while the ratio between Vastus lateralis and Vastus medialis cross-sectional area may influence Osteoarthritis progression. This study investigates the relationship between lower limb alignment and knee extensor muscle volume in knee Osteoarthritis [9].

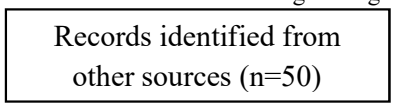
Rehabilitation, focusing on physiotherapy and exercise, is commonly promoted after total knee replacement, aiming to mobilize and achieve functional goals during hospital stay, and post-discharge for re-training and improvement [16].

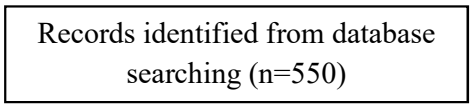
Eccentric isokinetic training improves muscle strength and function, with cardiovascular tolerance advantages over concentric training. Eccentric muscle performance, especially quadriceps femoris, is essential for daily activities. Eccentric contraction training leads to greater muscular strength gains and lower energy costs. Isokinetic dynamometers can be adapted for impaired physical capacities [12].

This study is needed to assess how strengthening the quadriceps can enhance functional outcomes, reduce postoperative complications, and improve overall quality of life in Total knee arthroplasty patients. By identifying the best exercise strategies and their effectiveness, rehabilitation programs can be optimized to ensure faster recovery and better long-term joint function. The findings of this research can help healthcare professionals develop evidence-based rehabilitation protocols that maximize mobility, stability, and patient satisfaction after Total knee arthroplasty.

METHODS

A search of pubmed and other electronic database was conducted in January of 2026 using the mesh terms Strengthening, Post TKR, Quadriceps, Balance training and Quality of life. This study was performed according to the preferred reporting items for this study with PRISMA guidelines. A manual search was also performed in the reference list of included articles and previously published reviews, in order to find articles covered by the database search. Articles selected are screened based on inclusion and exclusion criteria and selected for critical appraisal were, Studies published between 2011 to 2025, articles with full text, articles with aged above 50-85 years age, random controlled trials (RCTs), case study, comparative study and experimental study are considered, articles published in English language, articles examining effect of Neuromuscular electrical stimulation and articles including the quadriceps muscle strengthening for total knee arthroplasty were included in this study. Below 2011 articles were not taken for study, Pilot study was excluded, Articles without full text and Articles excluded that is not related to total knee arthroplasty.





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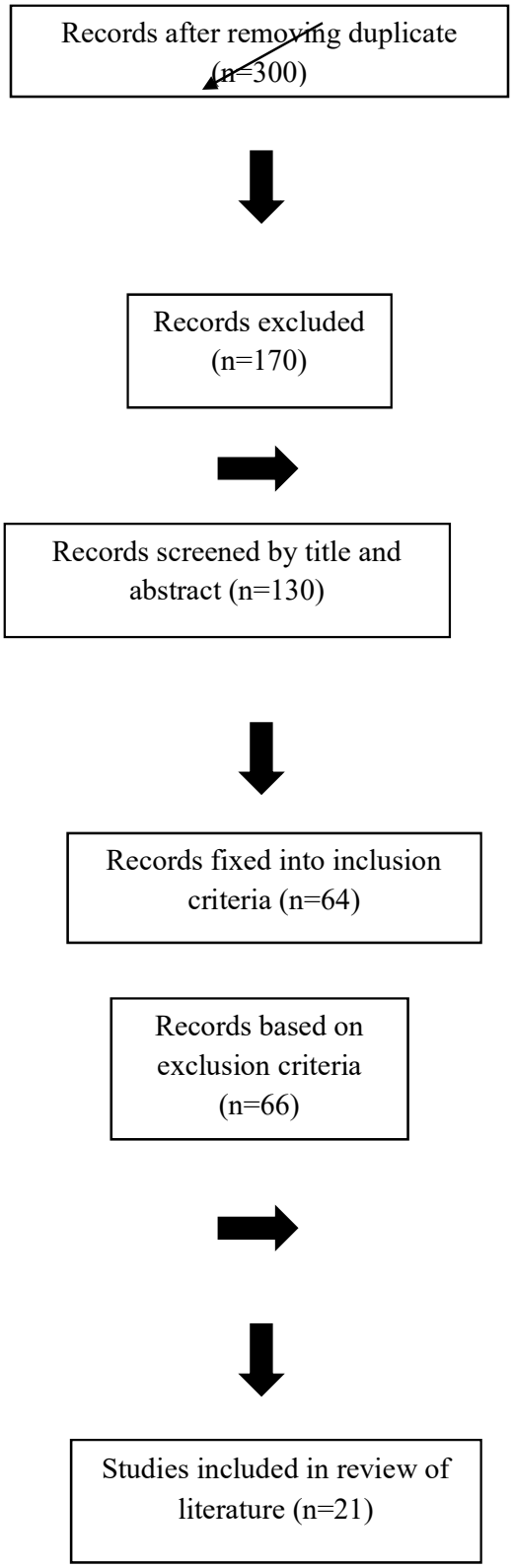

TABLE OF ARTICLES:

S.no	Author and design	Purpose of the study	Procedure and measurement	Result	Conclusion
1	Jennifer E. Stevens-Lapsley, et al (2011) & RCT	Early Neuromuscular Electrical Stimulation to Improve Quadriceps Muscle Strength After Total Knee Arthroplasty	66 participants, control group received standard protocol and other group received NMES. Functional performance measures included the Timed "Up & Go" Test, and the Six-Minute Walk Test	Significant improvements with NMES in quadriceps and hamstring muscle strength, functional performance, and knee extension active range of motion were observed with NMES after 3.5 weeks post-TKA. (P >.09).	The early addition of NMES effectively attenuated loss of quadriceps muscle strength and improved functional performance following TKA.
2	Thomas Linding	Early Progres	82 samples group1	no significi cant differ	7 weeks of

	Jakobsen, et .al 2014 RCT	sive Strength Training to Enhance Recovery After Fast-Track Total Knee Arthroplasty	physical rehabilitation with progressive strength training (PST) and group 2 without PST in patients. Outcome measures: 6-MWT, LE strength and power, knee joint effusion & ROM.	ence in change scores between PST and CON groups for the 6-minute walk test or (P>0.51).	supervised physical rehabilitation with PST was not superior to 7 weeks of supervised PR without PST in improving functional performance, measured as maximal walking distance in 6 minutes,8 weeks after fast-track TKA.
3	Walter Bily, MD, et .al 2016 RCT	Effects of Leg-Press Training with Moderate Vibration on Muscle Strength, Pain, and Function After Total Knee Arthroplasty	55 patients. Patients either underwent isokinetic leg press combined with moderate vibration or functional physiotherapy. Outcome: MVC, VAS, TUG, ROM & WOMAC	Both leg-press and physiotherapy groups showed significant improvements in knee extensor MVC, closed kinetic chain, pain at rest, WOMAC scores (P>.05)	Isokinetic leg-press training with moderate vibration and functional physiotherapy are both effective in regaining muscle strength and function after TKA;
4.	Joaquin Calatayu	High-intensity	50 subjects include	The intervention group	The study sug

	d, et.al 2017 RCT	preoperative training improves physical and functional recovery in the early post-operative periods after total knee arthroplasty	d in the study. The intervention group underwent an 8-week training program, consisting of dynamic joint movements, strength training exercises, balance training, and a cool-down. Outcome: WOMAC, SF-36, VAS, Isometric strength, active knee ROM and TUG.	showed greater improvements in isometric knee flexion, hip abduction the compared to the control group. ($p < 0.001$)	gests that preoperative training in end-stage OA patients can enhance postoperative outcomes.
5.	Meert, L., et.al 2022 RCT	To identify metabolic factors and inflammatory markers that	A systematic review was conducted using databases like PubMed, Web of Science, and Embase up to	A total of 49 studies were included. Findings showed conflicting evidence regarding	The study suggests that Due to methodological limitations
		can predict postoperative outcomes after total knee arthroplasty (TKA) in patients with knee osteoarthritis, focusing on pain, function, quality of life, and satisfaction.	August 2022. Studies involving preoperative metabolic or inflammatory markers and postoperative outcomes (≥6 months) were included. Data extraction, eligibility screening, and risk of bias assessment (QUIPS tool) were performed.	the impact of factors like BMI, diabetes, cytokines, and dyslipidaemia on postoperative pain, function, and satisfaction. ($p < 0.001$)	and variability among studies, clear conclusions could not be drawn. Further large-scale longitudinal research is required.
6.	Fu, K., et .al 2024 RCT	Randomized controlled trial aimed	UK Biobank data (over 500,000 participants). Around 49,082	High or low calcium levels, vitamin D insufficienc	Serum biomarkers are important

		to examine the association between serum biomarkers—calcium, vitamin D, and C-reactive protein (CRP)—and all-cause as well as cause-specific mortality among individuals with osteoarthritis, using	osteoarthritis patients were analyzed. Serum biomarkers were measured at baseline, and mortality outcomes were tracked over 12–15 years. Statistical methods like Cox regression and survival models were applied.	y, and elevated CRP were significantly associated with increased mortality, especially cardiovascular-related deaths.	predictors of mortality in osteoarthritis patients, highlighting the need for monitoring and preventive interventions.

		large-scale longitudinal data.			
7.	YUYA tsukada, et. al 2020 RCT	Randomized control trail of standard rehabilitation versus standard rehabilitation and hybrid training Recovery After Total Knee Arthroplasty.	53 subjects were included the study intervention group had 26 underwent standard rehab and hybrid training - **control group only underwent standard rehabilitation** Outcomes VAS JKOM 10MW, TUG TEST, QUAD RECEPS CIRCUMFRENCE ISOMETRIC KNEE FLEXOR/EXTENSOR STRENGTH	The HTS group showed improvements in quadriceps AND hamstring strength, physical function, and knee pain compared to control group at 6 weeks. measuring **bilateral maximal voliti onal isometric knee extension/flexion strength** ($p < 0.05$)	HTS was **effective in preventing quadriceps weakness and in improving physical function and QOL after TKA.**

8.	Iijima, H, et. al 2019 RCT	Whether individuals with mild medial knee osteoarthritis (OA) and coexisting lateral OA have reduced muscle strength compared to those without lateral OA. It specifically focused on quadriceps weakness and its role in disease severity and progression.	A total of 153 participants aged 48–88 years with medial OA were selected. Radiographic assessments (OARSI atlas and KL grading) identified lateral OA. Muscle strength of quadriceps, hip abductors, and extensors was measured using a handheld dynamometer. Pain, range of motion, and demographic data were also recorded and analyzed.	Individuals with both medial and lateral OA showed significantly weaker quadriceps and higher pain levels than those with only medial OA. Quadriceps weakness increased the likelihood of lateral OA by up to seven times.	Quadriceps weakness is strongly associated with bicompartmental OA and may play a key role in its development. Monitoring and strengthening this muscle could improve clinical outcomes.
9.	Bae, K.-C, et. al 2024 RCT	Relationship between lower limb alignment and quadriceps muscle composition in patients with advanced knee osteoarthritis (OA), focusin	A total of 75 participants (50 OA patients and 25 healthy controls) were included. Radiographic imaging and scanography were used to measure knee alignment (tibiofemoral angle). MRI scans (shown in the diagram on page 3) were used to calculate the cross-sectional area (CSA)	OA patients showed reduced overall quadriceps muscle size. The vastus lateralis muscle was significantly smaller in patients with severe varus alignment. Positive and negative correlations were observed between align	Severe varus alignment is associated with vastus lateralis atrophy. Strengthening this muscle may help manage knee OA, althoug

		g on individual muscle components like vastus lateralis, medialis, and intermedius. Total Knee Arthroplasty.	of quadriceps muscles, and ratios of each muscle were analyzed.	ment angles and specific muscle CSA values.	h causality between muscle loss and alignment remains unclear.
10.	Paul DeVita, et.al 2018 RCT	The effect of quadriceps strengthening on quadriceps muscle force, power, and work and tibi	randomized, controlled trial. *Intervention*: Patients with knee osteoarthritis were randomly allocated to quadriceps strengthening program (3 times weekly) or no attentio	30 patients were randomized to receive either training (n = 15) or no attention (n = 15). At follow-up, there were no statistical differ	Quadriceps strength training leads to increased muscle strength and improved sympt

		o-femoral compressive loads during walking in adults with knee osteoarthritis.	n control group. *Main outcome measures*: Primary outcome was change from baseline in peak quadriceps force during walking at 12 weeks. Secondary outcomes included quadriceps power and work, knee compression forces during walking estimated with musculoskeletal modelling, muscle strength and pain and function. Outcomes were	ences between groups for maximum quadriceps force, quadriceps positive power, negative work, and positive work, and knee compressive force. Maximum negative quadriceps power in early stance was statistically significantly increased 36% in the training group compared to the control group which was most likely	omatic and functional outcomes but does not change quadriceps or knee joint biomechanics during walking. The biomechanical mechanism of improved health with strength training in knee osteoart

			measured at baseline and 12 weeks.	partially a response to faster walking velocity at follow-up. Muscle strength and patient reported pain and function were improved in the training group compared to the control group.	hritis patients remains unknown.
11.	Vigdis s. husby, et .al 2018 RCT	Randomized controlled trial of maximal strength training vs. standard reh	17 subjects in each group. The intervention MST group received 3 training session per week for 8 weeks including leg press and knee	The MST group significantly increased muscle strength in leg press and knee extension, surpassing preoperative levels	Participants with MST showed superior increases in leg press and knee

		abilitation following total knee arthroplasty	extension. The SR group received fast track treatment by hospital. Study. Outcome: 1-RM leg press, 1-RM knee extension and 6-MWT.	, and both groups recovered to normative levels at 12 months (P≤0.001)	extension muscle strength compared to those managed with SR, maintaining this difference at 12-month follow-up.
12.	Emmanuel Coudeyre, et. al 2024 RCT	Eccentric Muscle Strengthening Using Maximal Contractions Is Deleterious in Knee	The study reveals that eccentric muscle strengthening using maximal contractions is harmful in knee osteoarthritis. Participants were **the study**	The study compared eccentric and concentric individuals, finding that eccentric individuals showed more significant quadriceps	Eccentric training **leads to less quadriceps strength improvement and is**

		Osteoarthritis	**used isokinetic muscle strengthening for OA knee pain, targeting quadriceps and hamstring muscles. Participants were seated with hips and knees flexed at 110 degrees, with progressive intensity and maximum force development. The primary outcome was concentric quadriceps peak torque at 60°/s. Secondary measures included hamstring**	strength increase at 6 weeks, while concentric individuals experienced 25% more major adverse events. **The study measured outcomes at baseline, 6 weeks, and 6 months, focusing on changes in concentric isokinetic knee extension peak torque, hamstring PT, walking speeds, pain.**	**linked to a higher risk of muscle injury**, especially to the hamstring muscles. Concentric training is safer and more beneficial for improving muscle strength and function.

			strength, walking speed (10 m and 200 m), pain (VAS), and functional status (WOMAC index).		
13.	Monaghan, B., et. al 2010 RCT	To evaluate the effectiveness of surface neuromuscular electrical stimulation (NMES) in improving quadriceps muscle strength before and after total	A systematic review of randomized and controlled clinical trials was conducted using multiple databases. Two studies were included. Measurements involved quadriceps strength, endurance, muscle activation, and functional performance using validated tools	The findings showed no significant improvement in quadriceps strength or endurance between NMES and control groups. However, one study reported temporary improvement in muscle activation at six weeks, which was	The evidence is insufficient and inconclusive due to limited studies and high risk of bias, making it unclear whether NMES is effective for quadric

		knee replacement surgery in patients with osteoarthritis.	such as timed tests and isometric torque assessment.	not sustained at twelve weeks.	eps strengthening.
14	Kyo-in Koo, et.al 2020 RCT	Prospective randomized Control trail undergoing TKA using an end-effector gait robot as a neuromodulation blending tool for deafferentation, wei	Out of 20 patients enrolled 6 dropped out 9 patients were allotted to EEGR group versus 6 patients n WF group Outcomes-cross sectional area of thigh, peak torque, motor neuron excitability, EAL time use EMG quadriceps and hamstrings	All patients showed **clear evoked responses in one-third of 20 stimulations higher normalized peak torque of knee flexors and improved EMG activity compared to the walker group. only, real-time EMG activi**	EEGR-assisted rehabilitation improved **biceps femoris and vastus medialis strength** after unilateral TKA, but did not restore muscular volume or
		ght offloading and stereotyped movement.		**ties decreased during rehabilitation**. (p<0.05)	activation. Further studies are needed
15.	Lee, J.-H., et. al 2022 RCT	Compare muscle activation of the quadriceps femoris and hamstrings during three squat exercises—general squat (GS), wall squat (WS), and Spanish squat	22 participants performing GS, WS, and SS in random order. Muscle activity was measured using electromyography (EMG) sensors placed on key thigh muscles. Data were normalized using maximal voluntary isometric contractions (MVIC) and analyzed using statistical tests like the Kruska	The Spanish squat showed significantly higher activation in the rectus femoris and vastus lateralis compared to GS and WS. However, hamstring muscles showed no significant differences across exercises.	The study concludes that the Spanish squat is more effective for activating key quadriceps muscles and can be useful in rehabilitation and strength training pro

		(SS). It focused on identifying which exercise most effectively increases muscle activity to support knee stability and injury prevention.	l–Wallis H test.		grams to prevent knee injuries.
16.	Artz, N., et. Al 2015 RCT	To evaluate the effectiveness of post-discharge physiotherapy exe	Researchers analyzed randomized controlled trials from multiple databases. Outcomes measured include	Physiotherapy exercise showed short-term improvements in physical function and pain (3–4	Physiotherapy exercise provides short-term benefits after
		rcise in patients who underwent total knee replacement using a systematic review and meta-analysis approach.	d pain, physical function, knee range of motion, and walking performance using standardized tools like WOMAC and KOOS scales.	months). However, there were no significant differences between home-based and outpatient therapy, and long-term benefits were limited.	knee replacement, but evidence for long-term improvement is weak, highlighting the need for more robust future research.
17.	Alison K. Klika, MS, et. al 2020 RCT	Neuromuscular electrical stimulation use after total knee arthroplasty	The study outlines the procedure for implementing Neuromuscular Electrical Stimulation (NMES) after Total Knee Arthroplasty	A study involving 66 patients found that patients using Neuromuscular Electrical Stimulation (NMES) experi	The study reveals that incorporating a **home-based application-control**

		improves early return to function	(TKA). **The study involved patients undergoing standard physical therapy and Neuromuscular Electrical Stimulation (NMES) to restore function and strength post-surgery. The NMES group received 45 minutes of stimulation twice daily for 14 days, targeting fast-twitch muscle Fibers for muscle power output**.	enced quadriceps strength gains at 3-, 6-, and 12-weeks post-surgery. **Postoperative outcomes included quadriceps strength, range of motion, resting pain, functional timed up and go, stair climb test, knee injury and osteoarthritis outcome (KOOS)**. (p<0.003).	**led NMES therapy system into standard care treatment** significantly enhances quadriceps strength and TUG post-TKA, facilitating quicker functional recovery.
18.	Aseer PA, et.al 2016 RCT	Effectiveness of structur	Eighty subjects, control group receives	The experimental group showed	The structured exercise

		ed exercise program on the functional outcomes in total knee replacement	standard care and experimental group receive structured exercise program comprising range of motion, Staged quadriceps training, targeting the vastus medialis, early balance training, and functional. Outcome: 6-mwt, KOOS scale	significantly lower pain severity, knee joint extension range, and hamstring strength compared to the control group, (p<.0001)	program was effective in improving the primary and secondary outcomes following primary total knee replacement
19.	Federico Pozzi, et.al 2020 RCT	randomized controlled trial comparison of progressive strengthening vs stan	165 subjects divided into 2 groups undergoing progressive rehabilitation versus standard rehabilitation with NMES with 88 healthy control	Significant differences were observed between groups, with the control group showing better outcomes. **progr**	**progressive strengthening rehabilitation may be more effective in restori**

		dard physical therapy with NMES	s controlled clinical **Outcomes TUGTEST ,6MW, SCTKOS-ADL, MVC KNEE EXTENSOR**	**essive strengthening group participants achieved lower bound cutoffs in knee extension ROM, quadriceps strength, and stair climbing time.** (p <0.001)	**ng** normative levels of function after (TKA) compared to standard of care.
20.	Thomas Linding Jakobsen, et. al 2019 RCT	Quadriceps muscle activity during commonly used strength training exercises shortly afte	24 subjects. Were included in the cross-sectional observational study. The intervention provided were machine-based strength training and elastic band	Knee extensions with elastic band showed significantly higher voluntary peak quadriceps muscle activity than knee extensions in machine.	Simple home-based strength training exercises, such as elastic bands or patients' own
		r total knee arthroplasty: implications for home-based exercise selection	based exercises for TKR patients for 4-8 weeks contraction Outcome: EMG, electronic goniometer, VAS.	(P <0.0001)	bodyweight, can help alleviate muscle strength early after TKA.
21.	Mei-Chu Chen, et. al 2020 RCT	The effects of immediate programmed cryotherapy and continuous passive motion in patients after computer-assisted tota	68 subjects underwent CAS-TKA were included. Intervention group received CPM and programmed cryotherapy within 1 hour while returning to the ward on the day of surgery. Control group received CPM	The intervention group showed higher ROM and lower joint swelling compared to the control group, despite no significant difference in NRS score or joint swelling. (P <0.004)	Immediate programmed cryotherapy and CPM can significantly enhance ROM after CAS-TKA, and should be inte

		l kne e arth ropl asty	on POD-1. Outco me: NRS, SF-MPQ & goniom eter.		grat ed into dail y nur sin g pla ns for pati ents .

DISCUSSION:

Neuromuscular electrical stimulation (NMES) is a common treatment in total knee arthroplasty (TKA) rehabilitation to address quadriceps weakness post-surgery. NMES enhances muscle recruitment and strength, preventing postoperative atrophy and enhancing functional recovery. It also reduces arthrogenic muscle inhibition, accelerates rehabilitation, and manages pain and swelling [1]. Research suggests that NMES, applied early, enhances quadriceps strength more effectively than exercise alone. However, patient compliance is a limiting factor and optimal protocols are still being refined. Not all patients respond equally, and factors like preoperative strength and overall health influence outcomes [17].

The progressive strengthening rehabilitation leads to better recovery and function 12 months post-TKA. Isokinetic leg-press training with vibration and functional physiotherapy significantly improves strength and function post-TKA. Most patients experience significant pain relief and functional improvement, but a small percentage require revision surgery or experience complications. Studies originate from the United States, Austria and Australia indicates that approximately 90% of patients report satisfaction following TKA, experiencing significant reductions in knee pain and enhancements in joint function. For instance, a reported that 92.2% of patients experienced improvement in knee pain one year after surgery, with a median absolute improvement of 41.7 points on the Knee injury and Osteoarthritis [18].

A study in India found that a structured rehabilitation program that includes a postoperative phase focusing on pain management, early mobilization, walking and weight-bearing progression, and gait training. The next phase focuses on early strengthening and functional recovery, with goals of increasing knee flexion, quadriceps, and hamstring strength. The final phase aims to achieve full range of motion, improve strength for daily activities, and develop neuromuscular control and stability. Significantly improved pain relief, knee joint mobility, muscle strength, and functional outcomes in patients after Total Knee Arthroplasty (TKA).

The study found significant improvements in pain severity, knee extension range, isometric quadriceps strength, six-minute walk test performance, and quality of life. Progressive strength training also led to better functional performance, but muscle weakness persisted even after 26 weeks. The success rate aligns with global findings, emphasizing the importance of post-TKA rehabilitation. While TKA has a high success rate, some patients may experience complications requiring revision surgery. The annual failure rate of total knee replacements is estimated between 0.5% and 1%. The success rate of rehabilitation after Total Knee Arthroplasty (TKA) is largely dependent on the type of rehabilitation. Progressive strengthening rehabilitation improves functional outcomes more than standard care, but many patients still struggle to reach normal levels of function [19].

Quadriceps weakness is common due to surgical trauma, post-surgical pain, and loss of neuromuscular control. Quadriceps strengthening is crucial in post-total knee arthroplasty (TKA) rehabilitation due to its vital role in knee stability, function, and mobility. Weak quadriceps can lead to poor functional outcomes, gait abnormalities, and increased fall risk. Strengthening the quadriceps helps stabilize the knee joint, prevents quadriceps inhibition after surgery, and is essential for functional movements. Key quadriceps strengthening exercises include quadriceps sets, straight leg raises, and leg press exercises. Hamstrings dysfunction can lead to altered gait mechanics and increased reliance on the quadriceps for knee movement. Gluteal weakness can cause hip abductor weakness, affecting single-leg balance and increased fall risk. Calf muscles, such as the gastrocnemius and soleus, aid in ankle plantarflexion and knee stabilization [1].

Evidence states that, the effects of high-intensity preoperative training on post-surgical recovery in total knee arthroplasty (TKA) patients. The results indicate that patients who underwent an 8-week preoperative training program had better muscle strength, range of motion, and functional performance after surgery compared to those who did not. Additionally, these patients experienced reduced pain and a shorter hospital stay. The findings suggest that prehabilitation with resistance training can enhance early post-operative recovery [4].

Evidence states that, the impact of quadriceps-strengthening exercises on knee biomechanics in individuals with knee osteoarthritis. While strength training significantly improved quadriceps strength,

reduced pain, and enhanced functional outcomes, it did not alter
knee joint biomechanics during walking. The results suggest that the benefits of strength training in knee osteoarthritis patients stem from increased muscle capacity and pain reduction rather than changes in joint loading isotonic exercises resulted in greater quadriceps activation compared to isometric exercises like straight leg raises. These findings suggest that home-based rehabilitation using bodyweight and elastic band exercises can be effective in addressing muscle strength deficits after TKA [20].

Evidence states that, simple strength training exercises, such as knee extensions with elastic bands, sit-to-stand movements, and one-legged squats, result in greater quadriceps muscle activation than machine-based exercises after total knee arthroplasty (TKA). This suggests that home-based exercises can be an effective alternative to machine workouts in early rehabilitation. The findings challenge the assumption that machine-based exercises provide superior muscle activation and support the use of simple, accessible exercises for patients recovering from TKA [21].

Studies states that, he effects of eccentric muscle strengthening using maximal contractions in knee osteoarthritis (OA). The study found that eccentric training resulted in less quadriceps strength improvement compared to concentric training and was associated with a high risk of muscle injuries, particularly in the hamstrings. Due to the high rate of adverse events, the trial was prematurely terminated. These findings suggest that eccentric training with maximal contractions may not be suitable for OA rehabilitation, and alternative strengthening methods should be considered [12].

The Vastus Medialis Oblique (VMO) is crucial for knee stability, patellar tracking, and functional recovery after Total Knee Arthroplasty (TKA). It prevents lateral displacement of the patella, ensuring smooth movement within the trochlear groove. Post-surgery, weak or delayed VMO activation can lead to patellar malt racking, causing anterior knee pain and instability. VMO strength typically declines by post-TKA, with early activation correlated with better functional outcomes. Rehabilitation strategies like Neuromuscular Electrical Stimulation and End-Effector Gait Robots can enhance VMO activation and restore quadriceps strength. Progressive strengthening programs focusing on closed-chain exercises, isometric contractions, and resistance training can improve knee stability and mobility. Effective post-TKA rehabilitation should emphasize VMO activation for optimal recovery, improved joint stability, and a higher quality of life for patients [9].

With this study, we bring forward that quadriceps muscle strengthening has a significant impact on improving functional mobility and post-surgical recovery in total knee arthroplasty (TKA) patients. Strengthening exercises enhance muscle activation, reduce post-operative pain, and improve knee stability, leading to better rehabilitation outcomes. This will make recovery more effective and beneficial, allowing patients to regain independence and improve their overall quality of life.

CONCLUSION:

The result of this study concludes that quadriceps muscle strengthening is a crucial component in the rehabilitation of patients following total knee arthroplasty (TKA). Strengthening exercises play a vital role in restoring knee function, reducing post-operative pain, and improving overall mobility. By enhancing quadriceps activation, patients experience better knee stability, which contributes to increased independence and a higher quality of life after surgery. The Vastus Medialis Obliquus (VMO) is a key medial stabilizer in total knee arthroplasty (TKA), reducing the risk of patellar malt racking and anterior knee pain. Dysfunction can lead to poor post-operative outcomes. Targeted rehabilitation focusing on VMO strengthening is essential for restoring knee function and improving patient outcomes. Strengthening exercises and prehabilitation strategies can accelerate recovery and enhance mobility in the post-operative phase. Future studies can focus on the long-term effects of quadriceps strengthening on knee function, mobility, and pain management post-TKA. Development of patient-specific rehabilitation programs based on factors such as age, gender, preoperative muscle strength, and comorbidities.

Comparison of Strengthening Methods: Large-scale clinical trials to compare different quadriceps strengthening techniques, including neuromuscular electrical stimulation and eccentric training.

Reference:

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