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Review Article

Physical Medicine and Rehabilitation Section

Balance Training in Post Knee Arthroplasty Rehabilitation: A Narrative Review

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ABSTRACT

Osteoarthritis (OA) often results in significant degeneration of the knee's tendons, ligaments, muscles, and joint capsules, frequently resulting in reduced proprioception. Total Knee Arthroplasty (TKA) is a widely used surgical intervention aimed at alleviating pain and improving the Quality of Life (QoL) for individuals with end-stage Knee Osteoarthritis (KOA). However, despite its effectiveness, many patients experience only modest functional improvements following surgery, highlighting the need for enhanced rehabilitation strategies. The present narrative review explores the impact of incorporating balance and proprioceptive training into postoperative rehabilitation for TKA patients, focusing on physical function, pain relief, and overall well-being. The purpose of the present review is to evaluate how proprioceptive and balance training affects physical function, pain management, and general QoL in postoperative rehabilitation for TKA patients. Regaining stability, mobility, and confidence in performing daily tasks is often challenging for individuals who have undergone TKA. Although the procedure primarily addresses structural joint damage and alleviates pain, it does not automatically improve sensory-motor function or neuromuscular coordination, both of which are essential for independent mobility and fall prevention. Findings indicate that early integration of balance and proprioceptive exercises can significantly improve recovery outcomes after TKA, enhancing balance, physical function, and QoL. Techniques such as Progressive Dynamic Balance Training (PDBT), combined kinetic chain exercises, and Neuromuscular Electrical Stimulation (NMES) have demonstrated particular effectiveness. However, variability in study designs and outcome measures underscores the need for standardised rehabilitation protocols. In conclusion, balance and proprioceptive training appear to offer substantial benefits for TKA patients by improving functional outcomes and reducing fall risk. Further research is needed to develop consistent training protocols, examine long-term outcomes, and validate findings in larger and more diverse patient populations.

Keywords: Functional recovery, Knee osteoarthritis, Postural control, Proprioception, Quality of life, Rehabilitation outcomes

INTRODUCTION

Individuals suffering from OA often experience weakness and degeneration of their knee tendons, ligaments, muscles, and joint capsules, along with a decline in proprioceptive function. Proprioceptive deficits may increase the likelihood of discomfort or disability in patients with KOA [1]. For patients with end-stage OA or rheumatoid arthritis of the knee, TKA primarily aims to improve QoL, mobility, and pain relief. However, postoperative pain following TKA can vary in severity. Approximately 60% of TKA patients experience severe pain postoperatively, while 75% report only mild discomfort [2].

The number of TKA procedures is projected to increase significantly, reaching an estimated 3.48 million annually, representing a 601% rise between 2005 and 2030 [3]. In 2020, over three million TKA procedures were predicted to be performed in the United States for end-stage knee arthritis. Although TKA provides significant and rapid relief from knee pain, 37% of patients report only modest functional improvement one year postoperatively. Common functional limitations include the inability to resume presurgery sports, decreased walking speed, and difficulty climbing or descending stairs [4]. For individuals with severe KOA, TKA remains the primary therapeutic option to relieve pain and enhance walking ability, physical function, and QoL [5].

To maximise postoperative outcomes, including pain management, physical function, strength, and return to daily activities, TKA patients are typically prescribed physical therapy. Rehabilitation, however, is a complex, multi-component intervention rather than a single treatment. It may include stretching, Strength Training (ST), and other interventions, which can be initiated at different times postsurgery, performed at varying frequencies and intensities, delivered by different personnel, conducted in different settings, and customised according to each patient's social, financial, and health circumstances [6].

Programs aimed at regaining proprioception and balance, also known as sensorimotor or neuromuscular training, focus on improving the ability to produce rapid and coordinated muscular contractions. Muscle imbalances are known to alter neuromuscular activation and motor control, leading to movement deficits. Normalisation of peripheral proprioceptive structures and restoration of nervous system function enhance dynamic joint stability, facilitate the relearning of movement patterns, and improve the ability to perform functional tasks. This, in turn, contributes to better postural control and muscle strength [7].

A study examining patients' postoperative function following TKA found that two major factors contributing to protracted recovery after joint arthroplasty are postoperative pain and ineffective exercise [8]. The focus on balance and proprioceptive training as essential elements of postoperative rehabilitation for TKA patients-an area often overlooked in traditional protocols-makes the present review particularly relevant. The present review synthesises recent research (2012-2024) on interventions such as Progressive Dynamic Balance Training (PDBT), kinematic chain exercises, and NMES, in contrast to previous studies that primarily focus on strength and pain relief. By emphasizing the effects of these interventions on neuromuscular coordination, joint stability, and QoL, the present review provides a more targeted and integrative approach to improving recovery and reducing fall risk, thereby advancing current rehabilitation strategies.

The aim of the present review was to evaluate the effectiveness of balance and proprioceptive training in postoperative rehabilitation following TKA. A summary of the reviewed articles is presented in [Table/Fig-1] [9-22], outlining key aspects such as author, year, study design, intervention, and outcomes related to balance training in post-knee arthroplasty rehabilitation.

Review Strategy

A thorough literature search was conducted using Web of Science, Google Scholar, Scopus, and PubMed, utilising keywords associated with rehabilitation, physiotherapy, balance training, and Total Knee Replacement (TKR). Only English-language articles published between 2012 and 2024 were included. Studies were selected if they included at least ten patients, focused on balance or proprioceptive rehabilitation after TKR, and provided baseline or comparative analyses. To ensure comprehensive coverage, relevant articles and their citations were also reviewed. A summary of the reviewed articles is provided in [Table/Fig-1] [9-22].

Balance Training Techniques after TKR

Osteoarthritis is a chronic degenerative joint condition characterised by periarticular tissue inflammation, marginal bone enlargement, and loss of articular cartilage. It is the most common chronic rheumatic disease worldwide, significantly affecting both individual and societal health. KOA, the most prevalent form, accounts for nearly 80% of osteoarthritis cases globally, with prevalence increasing with age and obesity. Symptoms of KOA include pain, stiffness, reduced range of motion, and muscle weakness. Impaired proprioception further contributes to the functional limitations associated with the condition [23,24].

S. No.	Author and year	Objective	Methodology	Intervention	Outcome measure	Conclusion	Interferences
1	Lee JJ et al., (2024) [9]	Examine whether preoperative balance measuring equipment can predict the rehabilitation requirements and results for patients following TKA.	The prospective observational cohort study was conducted at a tertiary academic medical center, adhering to the United States Health Insurance Portability and Accountability Act and the Declaration of Helsinki, with institutional review board approval. Patients' dietary habits, alcohol consumption, activity levels, KOOS-JR scores, knee range of motion, gait assistance use, and Patient-Reported Outcomes Measurement Information System (PROMIS) scores were recorded at baseline. Additionally, operational and demographic data, including hospital stay length, discharge facility, and procedure laterality, were gathered through chart reviews from electronic medical records.	Over the course of a 12-month trial, which included baseline, 3-month, and 12-month PROMIS scores as well as demographic information, 40 patients who had been recommended for primary TKA were tracked. A force plate was used to measure the patient's preoperative single-leg balance and sway velocity. The discharge destination of the patients (home versus skilled nursing facility) was the main outcome that was measured. Other secondary outcomes were the duration of hospital stay and variations in PROMIS and KOOS-JR scores.	Length of hospital stay, Knee Society Score (KSS), KOOS-JR scores, location of discharge (home versus skilled nursing facility), PROMIS scores	Primary TKA patients, preoperative balance measurements like sway velocity did not predict discharge location, hospital stay duration, or functional outcomes at 3 or 12 months. However, postoperative improvements in pain and function were associated with addressing balance deficits, though this approach may not be cost-effective.	Preoperative balance measurements did not predict key postoperative outcomes in TKA patients. However, addressing balance deficits postoperatively improved pain and function, though the cost-effectiveness of such interventions is uncertain.
2	Azzam I et al., (2024) [10]	To investigate how TKR affects older individuals' dual-task walking.	Participants were assessed one month before and four weeks after surgery, walking for one minute on a 7-metre instrumented course, both with and without performing a cognitive task (serial-3 subtraction). The study compared pain levels, knee function, proprioception, dynamic balance, balance confidence, and Dual-Task Costs (DTCs) before and after surgery. Additionally, it examined the factors associated with changes in gait DTCs over time.	A study assessed participants one month before and four weeks after TKR surgery while walking a 7-metre course with and without a cognitive task (serial-3 subtraction). Results showed a significant reduction in pain postsurgery, but no changes in balance, balance confidence, or proprioception. Gait DTCs remained unchanged. However, improvements in dynamic balance, particularly reactive postural control and dynamic gait, were linked to changes in gait speed and stride time DTCs. Thirty-eight participants completed the study (average age 72.6 years).	Dynamic balance, DTC, Pain and knee function,	One possible explanation for the increased fall risk following TKR could be the lack of an effect of TKR on gait DTCs. The study's findings highlight the importance of balance as a gauge and focal point for post-TKR rehabilitation.	According to the study, while TKR lessens pain, gait DTCs, which are essential for functional mobility, are not improved. The fact that gait DTCs have not improved after surgery may raise the risk of falls and suggest a deficiency in rehabilitation. In order to better minimise fall risk and enhance functional results, post-TKR rehab should concentrate on improving dynamic balance and reactive postural control.

3	An J et al., (2023) [11]	The study examined how 40 TKA patients' gait, physical function, and ability to balance were affected by CCE training.	Forty women who had TKA at an orthopaedic surgery hospital were included in this study. The following patients met the inclusion criteria: those who had undergone TKA because to degenerative arthritis, those who had cemented TKA, and elderly patients (age 65 or older) who could speak with medical staff. Both the participant and the single blinded study assessor were unaware of each participant's grouping.	Beginning on the third day following TKA, the participants in the CCK and CKCE groups underwent each kinetic chain exercise while using walkers and knee braces. Every week, the patients participated in an exercise regimen tailored to their individual performance levels, which was based on guidelines from an earlier study.	Range Of Motion (ROM), Knee Outcome Survey-Activities of Daily Living, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), balancing ability TUG.	Beginning on the third day following TKA, the participants in the CCK and CKCE groups underwent each kinetic chain exercise while using walkers and knee braces. Every week, the patients participated in an exercise regimen tailored to their individual performance levels, which was based on guidelines from an earlier study.	Starting on the third day post-TKA, participants in the CCK and CKCE groups performed kinetic chain exercises using walkers and knee braces. Their exercise regimens, tailored to individual performance levels, followed guidelines from a previous study. This approach suggests personalised exercise programs can be effectively integrated into early rehabilitation for enhanced recovery.
4	Pournajaf S et al., (2022) [12]	1. The Time Up and Go test results from TKR patients showed that balance training with non-immersive VR-based Serious Games (SGs) was more effective than traditional therapy. 2. Effectiveness on gait, postural, and clinical results.	For 15 sessions (45 minutes; five times a week) of non-immersive Virtual Reality (VR)-based SGs or traditional balancing training, respectively, we randomised 56 participants with unilateral TKR to the Experimental Group (EG) or control group (CG). The Timed Up and Go test was used to determine functional mobility as the primary result. Walking speed, pain severity, lower limb muscle strength, independence in daily living activities, and gait and postural parameters were the secondary outcomes.	Both the EG and CG received 15 sessions of balance and proprioception training (5 sessions per week, 45 minutes each), in addition to standard therapy. The EG used the Virtual Reality Rehabilitation System (VRRS) for balance training, involving interactive balance Board exercises utilising Biofeedback (BF) with visual and auditory feedback BF. The CG performed balance training with standard therapy, including exercises for postural control, load distribution, and proprioception. Both groups participated in 150 minutes of balance training along with their standard rehabilitation program, which included individualised traditional physical or occupational therapy.	TUG, VAS, 10-metre Walk test, MRC Scale, MRC Scale, Gait analysis-stereophotogrammetric system.	After TKR, balance training using non-immersive VR-based SGs is beneficial but not more successful than traditional therapy. In the EG, the VR-based SGs intervention was deemed satisfactory by the participants and has the potential to serve as a substitute for traditional therapy. At the conclusion of the treatment, the EG's gait was more similar to that of the CG. When used in conjunction with traditional therapy, this strategy may step up the rehabilitation program and increase its efficacy.	Post-TKR balance training with non-immersive VR-based SGs proved beneficial but did not surpass traditional therapy in effectiveness. Participants in the experimental group found the VR-based SG intervention satisfactory, suggesting it could complement or potentially substitute traditional methods. Combining VR-based training with standard therapy may enhance the overall effectiveness of the rehabilitation program.
5	Domínguez-Navarro F et al., (2021) [13]	To compare the effects of preoperative strengthening with no intervention, as well as the effects of adding balance training to a preoperative strengthening intervention on patients having TKR with regard to balance and functional outcomes.	Eighty-two patients who were slated for TKR were divided into three groups at random: strengthening (ST, n=28), which involved a preoperative lower limb strengthening intervention; strengthening+balance (ST+B, n=28), which involved the same intervention plus balance training; and the control group (n=26).	In this randomised controlled trial, 82 patients undergoing TKR were allocated into three groups: strengthening (ST, n=28), strengthening+balance (ST+B, n=28), and control (n=26). Primary outcomes assessed using the Berg Balance Scale (BBS) and KOOS-ADL focused on daily living function preoperatively and at two, six, and fifty-two weeks postsurgery. Secondary measures included knee function, self-reported status, and balance/mobility improvements, analysed throughout the study period. The study aimed to evaluate the impact of preoperative interventions on post-TKR outcomes comprehensively.	KOOS-ADL, BBS	At six weeks following surgery, a preoperative strengthening intervention improves strength but not balance or functional results, regardless of whether it is combined with balancing training. At one year after surgery, patients should perform similarly, but sufficient statistical power is required to validate the results.	The six-week postsurgery results highlight the clear benefit of preoperative strengthening in enhancing strength, regardless of additional balancing training. However, the need for improvement in balance and functional outcomes suggests these aspects may require different or more targeted interventions. Expectations of similar performance at one year underscore the stability of surgical outcomes, emphasising the need for robust studies to firmly establish these findings and guide clinical practice effectively.

6	de Lima F et al., (2021) [14]	Postoperative postural balance following TKA for primary OA in comparison to preoperative condition and/or healthy controls	A two-phase procedure was used to determine which longitudinal studies (with a follow-up of more than one month) that evaluated postural balance measures-whether they were laboratory-based, like postural sway, or clinical-based, such balance scales-were eligible and selected. In addition to three sources from the grey literature, six major internet databases were explored. The Joanna Briggs Institute Critical Appraisal Tools were utilised to assess the potential for bias.	A two-phase procedure was used to determine which longitudinal studies (with a follow-up of more than one month) that evaluated postural balance measures-whether they were laboratory-based, like postural sway, or clinical-based, such balance scales-were eligible and selected.	Gait	Although discrepancies were discovered, these could be attributed to variations in the demographics, assessment instruments, and follow-up durations of the studies, most of them revealed meaningful improvements (particularly in clinical-based measures) when compared to preoperative evaluations. That being said, when compared to healthy controls, persistent abnormalities in postural balance were frequently noted.	The qualitative synthesis of 19 studies revealed that most reported significant improvements in postural balance compared to preoperative status, though inconsistencies existed due to variations in study populations, assessment tools, and follow-up durations. Comparisons to healthy controls indicated persistent postural balance deficits despite improvements. Only one study achieved postural balance measures comparable to healthy controls. Clinical-based measures showed the most relevant improvements post-TKA. Further research is needed to address these inconsistencies and enhance postural balance outcomes.
7	Karaborklu Argut S et al., (2021) [15]	To look into the improvements in pain, range of motion, function, QoL, and patient satisfaction that can be achieved by combining an exercise program with manual therapy as opposed to just exercising.	The Orthopaedics and Traumatology Clinics at Istanbul University's Faculty of Medicine are the site of this prospective randomised controlled clinical trial. The study included patients (Kellgren-Lawrence Classification grade 3-4) with severe KOA who were scheduled for unilateral TKA surgery and were between the ages of 50 and 75. The following conditions precluded volunteers from participating in the study: morbid obesity with a body mass index higher than 40 kg/m^2, prior tibial osteotomy or unicompartmental arthroplasty, revision arthroplasty, and lower limb orthopaedic, neurological, vascular, or other problems restricting function.	The mobilisation group (n=21) got joint and soft tissue mobilisations in addition to exercise treatment, while the control group (n=21) only received exercise therapy.	NPRS, knee ROMs, WOMAC score, 10-Metre Walk Test (10 MWT), Short Form-12 (SF-12) and 5-times Sit to Stand Test (5 SST),	For postoperative TKA patients, a planned exercise program in conjunction with manual therapy may be more advantageous than an exercise program alone in terms of enhancing pain, function, and patient satisfaction.	The study indicates that combining a structured exercise program with manual therapy significantly improves pain outcomes, functional scores (WOMAC, 10 MWT, SF-12), and patient satisfaction in postoperative TKA patients compared to an exercise program alone. While knee flexion improved notably at 2 months, overall ROM changes were not significantly different between groups over time. These findings suggest that the addition of manual therapy to rehabilitation regimens can enhance recovery and patient experience. Further investigation into long-term benefits and specific manual therapy techniques is warranted.
8	Lee HG et al., (2021) [16]	Evaluating the impact of dynamic balancing training on patients' QoL, ability to balance, and physical function following TKA.	The study involved the assignment of thirty-eight participants to two groups: the control group (n=19) and the PDBT with physical therapy group (n=19). For six weeks, the experimental group participated in a dynamic balance program that included physical therapy five times a week for thirty minutes each day. The control group merely received physical therapy. Following training, both groups engaged in a 20-minute continuous passive motion exercise.	All participants gave their informed consent, and participants were chosen based on inclusion and exclusion criteria. Pre-tests were given one week prior to the program's commencement date. Starting on the third day following surgery, the experimental group participated in a six-week PDBT in conjunction with physical therapy five times a week for 30 minutes each day. The only physical therapy provided to the control group was general. Walking sticks and knee guards were used to support the progressive increase in exercise intensity.	WOMAC, Pain Pressure Threshold (PPT), Osteoarthritis Index, Knee Outcome Survey-Activities of Daily Living (KOS-ADLS and ROM.	This study shown that patients who undergone TKA had improved physical function, balance, and QoL when PDBT and physical therapy were combined. PDBT is considered a useful intervention for reducing falls and enhancing activities of daily living following TKA.	The study shows that combining Proprioceptive and PDBT with physical therapy significantly improves physical function, balance, and QoL in TKA patients. Consequently, PDBT is recommended for fall prevention and enhancing ADLs and QoL post-TKA. Integrating PDBT into postoperative rehabilitation protocols is supported by this evidence.

				Activities in the six-week program increased in difficulty and included activities such as heel lifts, sideways walking, marching, step box exercises, torso twists, and gait training. With two sets of ten repetitions per movement and rest periods of 30-40 seconds, each session lasted 30 minutes. Following TKA, all patients took part in an inpatient rehabilitation program.			
9	Klika AK et al., (2022) [17]	In order to determine if postoperative NMES use improves functional outcomes (i.e., increased quadriceps strength) in TKA patients, a randomised controlled experiment was conducted.	Randomised controlled trail Patients were divided into two groups: the treatment arm (n=44; NMES use) and the control arm (n=22; no NMES use).	Patients were divided into two groups: the treatment arm (n=44; NMES use) and the control arm (n=22; no NMES use). Patients were deemed compliant if they utilised the gadget for 200 minutes or more a week on average (beginning one week after surgery and continuing until week 12). Baseline measures and results were taken at 3, 6, and 12 weeks after surgery. These included scores from the veterans rand 12-item health survey (VR-12), KOOS, quadriceps strength, ROM, resting pain, functional TUG and stair climb test.	ROM, KOOS, resting pain, functional TUG, stair climb test, and veterans rand 12-item health survey (VR-12) scores.	At 3, 6, and 12 weeks postsurgery, patients using NMES showed significant increases in quadriceps strength compared to controls, who experienced reductions at 3 (p=0.050) and 6 weeks (p=0.015). NMES-treated patients also had significant TUG improvements at 6 (p=0.018) and 12 weeks (p=0.003). These results suggest that home-based NMES therapy, in addition to standard care, facilitates faster recovery of quadriceps strength and functional mobility following TKA.	Home-based NMES therapy significantly enhances quadriceps strength and functional mobility (TUG) at 3, 6, and 12 weeks post-TKA compared to standard care alone. This indicates a faster recovery trajectory for patients using NMES.
		To examine the effect of neurofeedback on postural stability and the attention of women with Bilateral Total Knee Replacement (BTKR) after surgery.	This quasi-experimental study involved eight female BTKA patients (mean age 67.5 years) three months postsurgery, referred to Shahid Beheshti University's Occupational Therapy Department from April to September 2017. Patients were selected via convenience sampling based on specific criteria. The study had a pre-test/post-test design without a control group.	Eight female patients who undergone BTKR and were referred to an occupational therapy clinic participated in this quasi-experimental study using a pretest/posttest methodology. Patients were chosen according to particular inclusion criteria, and they were evaluated for balance and attentiveness using the Vienna test system and the Biodex balance system. The SA7525 ProComp Infiniti system was used to conduct neurofeedback training three times a week for eight 30-minute sessions. The training's main objectives were to increase Beta 1 waves (15-15 Hz) and decrease Theta waves (4-7 Hz). Prior to the intervention, as well as during the fourth and eighth sessions, measurements were taken. Prior to the study, ethical approval and clinic approvals were secured.	Balance test and attention test (variables are correct wrong and reaction time).	Four months following bilateral total knee replacement surgery, neurofeedback training can enhance dynamic stability in female patients with OA of the knee, but its impact on sustained attention is minimal. Consequently, this program is non-invasive and simple enough to be used as an additional therapeutic approach for these patients' rehabilitation.	Based on the findings, neurofeedback training appears to be beneficial when incorporated into rehabilitation programmes into rehabilitation programs for female patients four months after bilateral total knee replacement. While its impact on sustained attention is limited, its ability to enhance dynamic stability makes it a valuable, non-invasive addition to their therapy.

11	Heikkilä A et al., (2017) [18]	To assess how a postoperative progressive home exercise program and surgery affect gait metrics in patients who have had TKA.	An electronic walkway system called Gaitrite was used to analyse gait. A dynamometer was also used to test the strength of the knee's extension and flexion prior to surgery, and the VAS was used to measure discomfort at two and fourteen months after surgery.	Patients were randomised equally into two groups: one for EG and the other for CG. The 12-month progressive home exercise regimen that began two months after surgery was contrasted with standard care.	Gait analysis , performed using Gaitrite electronic walkway system version 3.8	When compared to controls, the exercise group's maximal gait velocity, cadence, and stance times showed statistically significant changes as a result of the intervention. Even if the average improvement was minimal, it's crucial to remember that the poorest performers saw the largest adjustments.	The exercise group showed significant improvements in maximal gait velocity, cadence, and stance times compared to controls, with the largest gains observed in the poorest performers. These results suggest that the intervention is particularly beneficial for those with the greatest initial deficits.
12	Hiyama Y et al., (2016) [19]	To find out how Group-Based Exercise (G-EXE) affects knee ROM, quadriceps strength, functional capacity, and knee discomfort during the acute recovery phase following TKA.	The prospective observational study included a historical control group alongside TKA patients. Patients were assessed at hospital discharge and one month before surgery. The G-EXE group comprised 245 patients scheduled for TKA between April 1 and August 31, 2012, with primary unilateral TKA for grade 4 KOA, aged 50-80. Fourteen patients were excluded due to uncontrolled hypertension/ diabetes, neurological abnormalities, comorbid OA, and rheumatoid arthritis. Ultimately, 231 patients provided informed consent and joined the G-EXE group.	Procedures Along with their usual ambulation and twice-day activities of daily life, 231 patients engaged in G-EXE during their hospital stay. Results were contrasted with a retrospectively determined historical control group {Individualized Exercise (I-EXE) group (n=206)} consisting of patients who completed exercises that were exact replicas of those completed by the G-EXE group.	TUG test knee rom quadriceps strength	Finally, compared to patients who performed I-EXE in addition to routine ambulation and ADL exercises, patients who performed G-EXE showed superior knee ROM, quadriceps strength, and knee discomfort at discharge. When recovering acutely following TKA, patients benefit with G-EXE while in the hospital.	Compared to I-EXE and routine ambulation, patients performing G-EXE showed superior knee ROM, quadriceps strength, and reduced knee discomfort at discharge. G-EXE provides significant benefits during acute recovery following TKA.
13	Liao CD et al., (2015) [20]	Finding out if postoperative balance is connected to mobility and assessing whether balance training following total knee replacement surgery enhances functional results.	A randomised controlled trial using intention-to-treat analysis was conducted at a university teaching hospital with a rehabilitation center. The study involved 130 KOA patients who had undergone total knee replacement, randomly assigned to functional rehabilitation or supplementary balance rehabilitation groups.	In this study, 130 KOA patients who underwent total knee replacement were randomly assigned to either a functional rehabilitation group or an additional balance rehabilitation group. Both groups participated in an eight-week outpatient program featuring general functional training, with the balance group receiving extra balance-based rehabilitation. Measurements for various physical tests and the WOMAC were taken at baseline, eight weeks (T1), and thirty-two weeks (T2).	Functional reach test, single-leg stance test, 10-metre walk test, TUG Test, timed chair-stand test, stair-climb test, and WOMAC.	Following a complete knee replacement, patients with OA in their knees experience improved mobility, balance, and functional results when receiving postoperative outpatient rehabilitation including balance training.	Comparing the TUG Test and the Functional Reach Test to baseline evaluations, patients in the balance rehabilitation group showed considerable gains. Additionally, these individuals had greater balance and mobility than the group receiving functional therapy; these differences were statistically significant ($p<0.001$). The results show a significant improvement in mobility, balance, and overall functional outcomes when balance training is included in postoperative rehabilitation for OA in the knee.
14	Liao CD (2013) et al., [21]	To assess the impact of extra balancing exercises on patients with OA of the knee following total knee replacement in terms of their mobility and function.	A randomised controlled trial and prospective intervention research were conducted at a teaching hospital affiliated with a university. Individuals from the orthopaedic department were progressively recruited to undergo total knee replacement surgery. Participants were randomly assigned to either the control group or the experimental group	For eight weeks, the control group had traditional function training. In addition to receiving the same traditional training as the control group, the experimental group was given extra balancing exercises with every admittance	WOMAC score, Up-and-down stair test, timed 10-metre walk, single leg stance and timed sit-to-stand test.	Following total knee replacement, patients with osteoarthritis in their knees experienced a considerable improvement in function and mobility with the addition of additional balance training.	According to the study, the EG showed significant improvements in TUG and 10-metre walk tests, with p-values less than 0.001, after receiving eight weeks of additional balancing training. The osteoarthritis WOMAC both showed notable changes.

							These findings demonstrate how important balance training is for improving functional recovery and mobility outcomes for patients with post-total knee replacement osteoarthritis.
15	Hale LA et al., (2012) [22]	To determine if a water-based training program that focusses on balance can effectively lower the risk of falls and enhance physical function and balance measures in older persons with OA.	Persons (N=39; mean±standard deviation age, 74±6 years; 26 women) with mild to moderate OA and at risk for falling met study criteria, were measured at baseline, and were randomly assigned to the intervention (n=23) and control groups (n=16).	Water-based program (12 wk, twice weekly; intervention group) or a time-matched computer training program (control group).	TUG Test, WOMAC (Likert 3.0 version), Arthritis Impact Measurement Scales 2, and Activity-specific Balance Confidence Scale.	The study found that water-based exercise did not reduce falls risk compared to attending a computer skills training session. This is the first study to make such a comparison with a time-matched control group. Further research is needed to determine if learning computer skills and engaging in community activities twice weekly can reduce falls risk in individuals with OA.	The study indicates that water-based exercise may not be more effective in reducing falls risk than computer skills training sessions. This suggests that non-physical activities, like cognitive engagement and regular community interaction, could play a significant role in falls prevention for individuals with OA. Further investigation is necessary to determine if these factors alone are sufficient to reduce falls risk.

[Table/Fig-1]: Summary of the reviewed articles [9-22].
KOOS-JR: Knee injury and osteoarthritis outcome score for joint replacement; PROMIS: Patient-reported outcomes measurement information system; TUG: Timed up and go test; VAS: Visual analogue scale; MRC scale: Medical research council scale; NPRS: Numerical pain rating scale; CCE: Combined kinematic chain exercise; CKC: Close-kinetic chain exercises; WOMAC: Western Ontario and mcmaster universities osteoarthritis index

Recent research has highlighted the modest effectiveness of these treatments. Clinical recommendations advocate a core treatment approach consisting of biomechanical interventions such as insoles, patient education, exercise, dietary advice, and pharmacological therapy based on available evidence [25].

Lee HG et al., explored the impact of PDBT on QoL, balance, and physical function in patients following TKA, a common treatment for end-stage OA. TKA can impair balance by affecting mechanoreceptors. The study found that combining PDBT with conventional physical therapy significantly improved balance, physical function, and QoL, suggesting that PDBT is an effective intervention for reducing falls and enhancing daily living activities post-TKA [16].

Piva SR et al., concluded that balance exercises resulted in substantial improvements in walking and balance in patients post-TKA. Directional walking, an essential daily activity that requires equal weight distribution across both feet, necessitates enhanced sensorimotor abilities and dynamic balance [4].

Guede-Rojas F et al., suggested that KOA often leads to functional impairment due to reduced proprioception. ST is essential for KOA management, as it not only improves muscle strength but may also enhance proprioception. Systematic reviews and meta-analyses show promising results for ST compared with non-interventional controls; however, evidence remains insufficient to prove ST's superiority over other therapies in improving proprioception in KOA. While ST can serve as a flexible clinical option, these findings should be interpreted cautiously due to limited research, variability in studies, and differences in intervention types [26].

CONCLUSION(S)

The present reviewed literature strongly supports the inclusion of balance training in the rehabilitation of TKA patients. Early incorporation of balance exercises into rehabilitation programs has been shown to significantly enhance postural control, improve functional outcomes, and potentially reduce fall risk. To maximise these benefits, balance training must be customised to individual patient needs, considering timing, intensity, and specific exercises. Future research should aim to standardise balance training protocols to ensure consistency and effectiveness. Additionally, studies with larger sample sizes and longer follow-up periods are needed to verify the long-term impact of balance training on functional recovery after TKA. Addressing these areas will allow rehabilitation strategies to be refined, achieving optimal recovery outcomes for TKA patients.

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