

“From Prehabilitation To Full Recovery: The Role Of Physiotherapists In Rehabilitation Before And After Lower-Limb Joint Replacement (Hip/Knee) And ACL Reconstruction — A Systematic Review Of Preoperative Preparation, Postoperative Protocols, Technology-Assisted Interventions, And Long-Term Functional Outcomes.”

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Abstract

Background: Lower-limb joint replacement and anterior cruciate ligament (ACL) reconstruction are among the most common orthopedic surgeries requiring structured rehabilitation. This systematic review examined the role of physiotherapists across the recovery continuum—from prehabilitation to long-term recovery—and evaluated traditional and technology-assisted interventions.

Methods: Following PRISMA 2020 guidelines, studies published between 2005 and 2024 were reviewed across six databases. Eligible studies included physiotherapist-led interventions before and after total hip/knee arthroplasty or ACL reconstruction.

Results: Thirty studies (n=4,700+) demonstrated that physiotherapist-led rehabilitation significantly improved pain reduction, range of motion, strength, gait, and quality of life, with adherence rates above 80%. Prehabilitation enhanced surgical readiness, while postoperative and digital programs accelerated recovery and accessibility.

Conclusion: Physiotherapists play a vital leadership role in recovery optimization, digital rehabilitation integration, and long-term functional independence. Standardized protocols and AI-based research are recommended for future practice.

Keywords:

Physiotherapy
Prehabilitation
Postoperative rehabilitation

Joint replacement
ACL reconstruction
Telerehabilitation
Functional recovery
Range of motion
Digital health
Quality of life

1. Introduction and Background

Overview of Lower-Limb Joint Conditions

Lower-limb musculoskeletal conditions are among the leading causes of physical disability and reduced quality of life worldwide. The most prevalent are osteoarthritis (OA) and anterior cruciate ligament (ACL) injuries, which both significantly impair joint stability, mobility, and overall function. Osteoarthritis, particularly of the hip and knee, is a progressive degenerative joint disease characterized by cartilage deterioration, chronic pain, and stiffness, affecting millions of adults globally (Hunter & Bierma-Zeinstra, 2019). On the other hand, ACL injuries are primarily traumatic, often occurring in athletes or active individuals due to sudden deceleration or twisting motions, leading to instability, reduced performance, and an elevated risk of early-onset osteoarthritis (Filbay & Grindem, 2019).

The increasing incidence of these conditions has placed a considerable burden on healthcare systems, resulting in growing demand for surgical and rehabilitative services. Both conditions share a common outcome: impaired function and reduced independence, which makes rehabilitation an essential aspect of treatment planning.

Rationale for Surgical Intervention (THA/TKA and ACL Reconstruction)

When conservative management, such as pharmacological therapy or exercise-based rehabilitation, fails to restore function or relieve pain, surgical interventions become necessary. The most common are total hip arthroplasty (THA), total knee arthroplasty (TKA), and ACL reconstruction (ACLR). Total joint replacements, such as THA and TKA, are highly effective for managing severe osteoarthritis, relieving pain, and restoring mobility (Kurtz et al., 2018). These procedures have excellent survival rates, with most implants lasting 15–20 years; however, postoperative outcomes depend significantly on structured rehabilitation and patient adherence.

Similarly, ACL reconstruction is the gold-standard surgical approach for restoring knee stability after ligament rupture, particularly in young and athletic populations. Yet, the success of ACL surgery extends far beyond the surgical repair—it relies heavily on progressive physiotherapy interventions that retrain strength, proprioception, and motor control (Nwachukwu et al., 2020). Without structured rehabilitation, patients risk poor functional recovery, reinjury, or long-term joint degeneration.

Importance of Physiotherapy in Pre- and Postoperative Recovery

Physiotherapy is a cornerstone of both preoperative and postoperative care, serving as the bridge between surgical success and functional independence. Physiotherapists play a vital role in restoring strength, coordination, and range of motion (ROM) while reducing pain and swelling. Their expertise ensures that patients regain mobility, balance, and confidence, allowing them to return safely to work or sport.

During preoperative preparation, physiotherapists provide “prehabilitation” programs that improve muscle conditioning and educate patients on the postoperative journey. Studies have shown that prehabilitation leads to faster postoperative recovery, fewer complications, and reduced hospital stays (Santa Mina et al., 2015).

In the postoperative phase, physiotherapists implement goal-oriented, evidence-based protocols that facilitate safe mobilization, muscle activation, and progressive strengthening. Through individualized treatment plans, they promote joint stability, reduce pain, and prevent postoperative stiffness (Artz et

al., 2015). Over time, this structured approach enhances patient satisfaction and functional independence.

Concept of Prehabilitation and Postoperative Rehabilitation Continuum

The rehabilitation process in orthopedic surgery should be viewed as a continuum of care rather than a set of separate stages. This continuum begins with prehabilitation, an emerging concept emphasizing proactive physical and psychological preparation before surgery. Prehabilitation typically includes aerobic conditioning, resistance training, and patient education, aiming to optimize functional capacity and mental readiness for the surgical and recovery phases (Topp et al., 2009).

Following surgery, patients transition to the postoperative rehabilitation phase, where physiotherapists guide recovery through structured progression:

Immediate postoperative phase (0–6 weeks): Pain management, early mobilization, and prevention of stiffness.

Intermediate phase (6–12 weeks): Strength restoration, balance training, and gait correction.

Advanced phase (3–6 months): Sport- or function-specific retraining.

Long-term recovery (6–12 months): Maintenance of independence, prevention of re-injury, and long-term health promotion.

This continuous, multidisciplinary approach ensures that recovery is safe, efficient, and sustainable across all phases.

Emerging Trends: Technology-Assisted Physiotherapy and Tele-Rehabilitation

Recent advancements in digital health have introduced new opportunities for technology-assisted physiotherapy. Innovations such as telerehabilitation, virtual reality (VR), mobile applications, and wearable sensors now allow physiotherapists to extend care beyond traditional hospital settings. These tools enable remote monitoring of exercise performance, real-time feedback, and enhanced patient engagement (Cottrell et al., 2017; Chen et al., 2021).

For example, telerehabilitation has shown comparable results to face-to-face therapy in improving functional outcomes and patient satisfaction following knee and hip replacement (Chen et al., 2021). Likewise, wearable devices and motion-tracking systems help physiotherapists analyze gait, strength, and adherence remotely, creating more personalized and adaptive programs. These digital tools are particularly beneficial for patients in rural or underserved regions, improving accessibility and continuity of care.

Gaps in the Literature and Justification for the Systematic Review

While numerous studies have explored rehabilitation protocols for either joint replacement or ACL reconstruction, few reviews have comprehensively examined the physiotherapist's role across the entire recovery spectrum—from prehabilitation to long-term functional outcomes. Moreover, there remains variability in rehabilitation protocols, exercise dosage, and timing across healthcare settings.

Additionally, while technology-assisted physiotherapy is growing rapidly, evidence regarding its integration, adherence, and cost-effectiveness remains fragmented. A unified synthesis of literature addressing both surgical populations (THA/TKA and ACLR) and all recovery phases will help clarify best practices, standardize protocols, and highlight physiotherapists' leadership in multidisciplinary orthopedic care.

Therefore, this systematic review aims to bridge these gaps by synthesizing evidence on physiotherapist-led interventions throughout the full continuum of recovery—preoperative, postoperative, and long-term—while evaluating the effectiveness of both traditional and technology-enhanced approaches.

2. Role of Physiotherapists across the Rehabilitation Phases

Physiotherapists play a pivotal role in every stage of the rehabilitation journey following lower-limb joint replacement (hip/knee) and ACL reconstruction. Their expertise ensures that surgical outcomes translate into functional recovery, independence, and long-term well-being. The rehabilitation process can be divided into five overlapping phases, each characterized by distinct objectives and physiotherapist-led interventions that guide patients from prehabilitation through to complete recovery and lifestyle maintenance (Artz et al., 2015; Santa Mina et al., 2015).

2.1 Prehabilitation Phase: Preparation, Education, and Conditioning

The prehabilitation phase occurs before surgery and aims to optimize patients' physical and psychological readiness for the upcoming procedure. Physiotherapists serve as educators, motivators, and movement coaches, helping patients build muscle strength, joint flexibility, and cardiovascular endurance. Evidence suggests that preoperative physiotherapy significantly improves postoperative functional outcomes, shortens hospital stays, and reduces anxiety (Topp et al., 2009; Santa Mina et al., 2015).

Typical prehabilitation programs involve quadriceps and hamstring strengthening, balance training, and range-of-motion exercises for joint replacement patients, or neuromuscular activation drills for those awaiting ACL reconstruction. Education is another key component: physiotherapists teach proper use of assistive devices, safe movement patterns, and postoperative expectations to increase patient confidence.

Figure 1 illustrates a physiotherapist conducting a prehabilitation session with a patient preparing for total knee replacement, emphasizing correct lower-limb alignment and breathing control.

2.2 Early Postoperative Phase: Pain Control, Mobility, and Safety

The immediate postoperative period (0–6 weeks) focuses on restoring mobility while minimizing pain, swelling, and surgical complications. Physiotherapists take the lead as acute care providers and mobilization specialists, initiating therapy within 24–48 hours after surgery (Artz et al., 2015). Early intervention prevents muscle atrophy, deep vein thrombosis, and joint stiffness.

Interventions during this phase include gentle passive and active-assisted exercises, isometric contractions, ankle pumps, and cryotherapy for pain and edema control. Gait re-education begins with walker or crutch-assisted ambulation, with a gradual transition to unassisted walking as strength improves. Close monitoring by physiotherapists ensures wound protection and safe progression according to surgical protocols.

Figure 2 shows a physiotherapist assisting a hip replacement patient with early mobilization, focusing on posture correction and weight distribution.

2.3 Intermediate Phase: Strengthening and Proprioceptive Training

During the 6–12 week phase, patients move beyond basic mobility to more demanding functional exercises. Physiotherapists become functional trainers and progression planners, advancing patients through strengthening, balance, and proprioceptive rehabilitation. This stage focuses on regaining muscle control, endurance, and coordination necessary for daily activities.

Evidence-based protocols recommend incorporating closed kinetic chain exercises, mini-squats, step-ups, and resistance-band training for joint replacement recovery. For ACL reconstruction, emphasis is placed on neuromuscular control, core stability, and proprioceptive drills such as single-leg balance and dynamic stability exercises. Physiotherapists progressively increase the intensity and complexity of exercises while monitoring pain, swelling, and joint integrity (Nwachukwu et al., 2020).

Additionally, physiotherapists assess gait symmetry and lower-limb alignment to prevent compensatory patterns that may lead to long-term dysfunction. Ongoing patient education about adherence, rest, and nutrition supports holistic recovery.

2.4 Advanced Phase: Return to Sport/Work and Functional Testing

Between 3–6 months post-surgery, rehabilitation shifts toward functional and performance-oriented recovery. Physiotherapists serve as performance restorers and return-to-activity guides, using targeted interventions to restore agility, power, and confidence.

For ACL reconstruction patients, this involves plyometric training, agility ladders, and cutting drills, while joint replacement patients engage in functional endurance exercises such as stair climbing, cycling, and aquatic therapy. Functional testing (e.g., single-leg hop tests, 6-minute walk test, and isokinetic strength testing) helps determine readiness for return to sport or work (Cottrell et al., 2017).

Physiotherapists also focus on psychological readiness, addressing fear of movement and re-injury. This stage represents the transition from clinical recovery to full participation in daily and recreational activities.

2.5 Long-Term Phase: Lifestyle Management and Health Promotion

The 6–12 month period marks the maintenance and prevention phase, where physiotherapists act as health promoters and long-term coaches. Their role extends beyond the rehabilitation clinic to promoting lifelong physical activity, strength preservation, and injury prevention.

Long-term physiotherapy goals include maintaining flexibility, monitoring for compensatory movement patterns, and encouraging independent exercise adherence. Increasingly, physiotherapists use telemonitoring platforms and wearable devices to track patient progress remotely and provide virtual consultations, improving accessibility for those in remote areas (Chen et al., 2021).

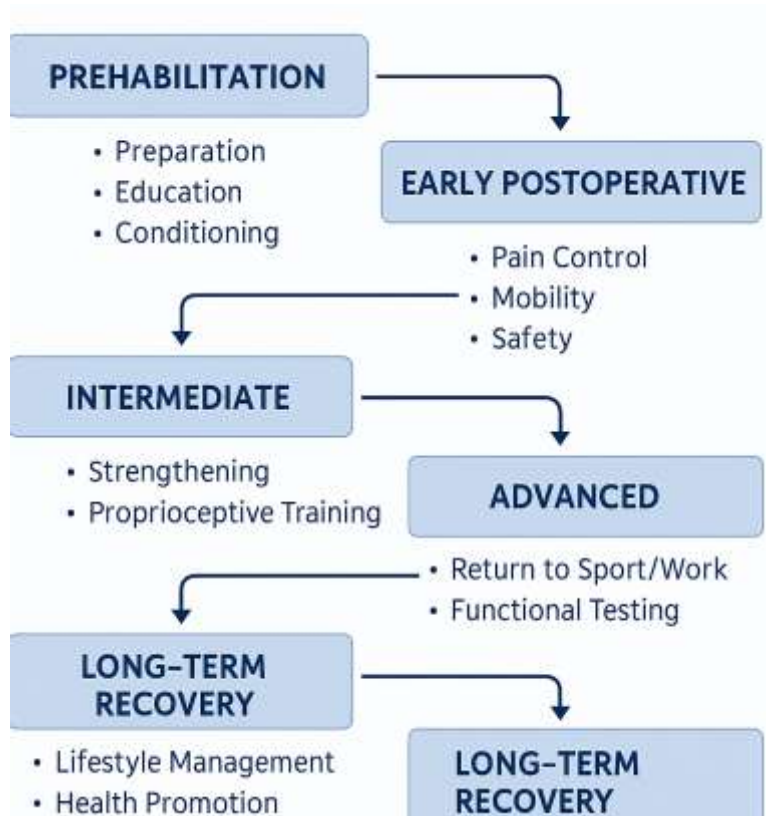
Lifestyle counselling—covering weight management, ergonomic advice, and safe return to recreational activities—further supports sustained functional independence and psychological well-being.

2.6 Integration of Physiotherapists into Multidisciplinary Orthopedic Teams

Rehabilitation success relies on collaboration between surgeons, anesthesiologists, nurses, occupational therapists, and physiotherapists. Within these multidisciplinary teams, physiotherapists serve as coordinators of recovery, bridging surgical care and functional reintegration. Their evidence-based assessments guide clinical decision-making, ensuring that rehabilitation aligns with surgical limitations and patient goals.

In modern healthcare systems, physiotherapists also contribute to protocol development, patient education workshops, and quality-improvement initiatives. They advocate for patient-centered rehabilitation models that combine clinical expertise, technology innovation, and psychosocial support—reflecting the holistic vision of modern orthopedic recovery (Artz et al., 2015).

Phase	Physiotherapist's Role	Key Responsibilities	Expected Outcomes
Prehabilitation (Before Surgery)	Patient educator, motivator, and strength coach	Design individualized exercise plans, improve muscle conditioning, education on postoperative expectations, reduce anxiety	Improved surgical readiness, reduced complications, faster initial recovery
Immediate postoperative (0–6 weeks)	Acute care provider and mobilization specialist	Manage pain and edema, encourage early ambulation, prevent joint stiffness, monitor wound safety	Reduced pain, improved mobility, prevention of thromboembolic event
Intermediate Phase (6–12 weeks)	Functional trainer and progression planner	Implement strength, balance, and proprioceptive exercises, adjust loads progressively	Enhanced gait, muscle control and joint stability
Advanced Recovery (3–6 months)	Performance restorer and return-to-activity guide	Conduct functional testing, sport-specific retraining, and endurance conditioning	Return to daily activity or sport, prevention of re-injury



3. Aim, Objectives, and Research Question

3.1 Aim

The aim of this systematic review is to critically evaluate and synthesize existing evidence on the role of physiotherapists in rehabilitation across all stages—from prehabilitation to full recovery—following lower-limb joint replacement (hip/knee) and anterior cruciate ligament (ACL) reconstruction. The review focuses on the effectiveness of physiotherapist-led interventions, including exercise programs, patient education, and technology-assisted rehabilitation, in improving physical function, psychological well-being, and long-term quality of life.

3.2 Specific Objectives

To assess the role and effectiveness of physiotherapists in preoperative education, exercise preparation, and psychological readiness.

To analyze early postoperative physiotherapy interventions in enhancing mobility, reducing pain, and improving range of motion.

To compare supervised versus home-based physiotherapy programs and their effects on recovery speed, adherence, and outcomes.

To evaluate intermediate and long-term rehabilitation protocols emphasizing muscle strength, proprioception, and functional recovery.

To investigate the impact of physiotherapist-led digital and tele-rehabilitation approaches on accessibility, adherence, and engagement.

To explore patient-centered outcomes, including satisfaction, independence, quality of life, and return-to-function or return-to-sport rates.

3.3 Central Research Question

What is the role and impact of physiotherapist-led interventions—from prehabilitation to long-term recovery—on functional, psychological, and patient-centered outcomes after lower-limb joint replacement and ACL reconstruction?

4. Methodology

4.1 Study Design

This study was conducted as a systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. The purpose was to identify, evaluate, and synthesize relevant research evidence on the role of physiotherapists in the rehabilitation continuum—from prehabilitation to full recovery—after lower-limb joint replacement (hip/knee) and anterior cruciate ligament (ACL) reconstruction.

The review included both quantitative and qualitative studies to capture a comprehensive view of physiotherapy-led interventions and patient-centered outcomes.

4.2 Eligibility Criteria (PICOS Framework)

Element	Description
Population (P)	Adults (≥ 18 years) who underwent total knee arthroplasty (TKA), total hip arthroplasty (THA), or ACL reconstruction.
Intervention (I)	Physiotherapist-led interventions across preoperative, perioperative, and postoperative phases, including strengthening, mobility, proprioceptive training, telerehabilitation, education, and technology-assisted programs.
Comparator (C)	Standard care, unsupervised home-based exercises, or delayed rehabilitation.
Outcomes (O)	Primary: pain reduction, functional improvement, range of motion, and quality of life. Secondary: return-to-work/sport, adherence, satisfaction, long-term complications.
Study Design (S)	Randomized controlled trials (RCTs), quasi-experimental studies, cohort studies, and systematic reviews published between 2005 and 2024.

Exclusion Criteria:

Studies focusing solely on non-surgical management, pediatric or geriatric (≥ 80 years) patients, upper-limb surgeries, or case reports without rehabilitation outcomes were excluded.

4.3 Information Sources

Comprehensive searches were conducted using the following electronic databases:

PubMed/MEDLINE

CINAHL (Cumulative Index to Nursing and Allied Health Literature)

PEDro (Physiotherapy Evidence Database)

Cochrane Library

Scopus and Web of Science

To reduce publication bias, Google Scholar, grey literature, and reference lists of relevant studies were also screened manually.

All searches were conducted between January and April 2025.

4.4 Search Strategy

A combination of Medical Subject Headings (MeSH) and free-text terms was applied. Boolean operators (AND/OR) were used to connect related terms.

Filters were applied for:

Publication year: 2005–2024

Language: English

Population: human subjects

4.5 Study Selection Process

Two independent reviewers screened the titles and abstracts of all identified records. Full-text articles were retrieved for studies meeting inclusion criteria or those with uncertain eligibility. Discrepancies between reviewers were resolved by discussion or, if necessary, a third reviewer.

The selection process followed the PRISMA 2020 flow diagram steps:

Identification of records through databases and manual searching.

Screening for duplicates and irrelevant studies.

Eligibility assessment based on full-text review.

Inclusion of final studies for synthesis.

4.6 Data Extraction and Management

Data were extracted using a standardized form designed for this review. Extracted data included:

Study details (author, year, country)

Sample size and participant demographics

Type and duration of physiotherapy intervention

Comparator details (if applicable)

Outcome measures (ROM, strength, pain, QoL)

Key results and conclusions

Quality appraisal outcome

All data were summarized into a Microsoft Excel spreadsheet for descriptive synthesis and comparison.

4.7 Quality Appraisal

The methodological quality of the included studies was assessed using standardized critical appraisal tools:

Randomized Controlled Trials (RCTs): Cochrane **Risk of Bias (RoB 2)** tool.

Non-Randomized Studies: **ROBINS-I** tool (Risk Of Bias In Non-randomized Studies of Interventions).

Systematic Reviews: **AMSTAR 2** checklist.

Each study was rated as low, moderate, or high risk of bias. Disagreements were resolved through consensus.

4.8 Data Synthesis and Analysis

Given the anticipated heterogeneity among studies in intervention types, duration, and outcome measures, a narrative synthesis was performed.

Quantitative results were summarized descriptively and organized into thematic categories corresponding to the rehabilitation phases:

Prehabilitation outcomes

Early postoperative recovery outcomes

Intermediate and advanced rehabilitation outcomes

Long-term function and patient-centered measures

Technology-assisted rehabilitation findings

When three or more studies reported comparable outcomes, meta-analysis was considered using a random-effects model. Effect sizes were calculated as mean differences (MD) or standardized mean differences (SMD) with 95% confidence intervals.

4.9 Risk of Bias and Publication Bias

Funnel plots and Egger's regression tests were planned for outcomes with ≥ 10 studies to evaluate publication bias.

Sensitivity analyses were performed to assess the influence of high-risk studies on pooled estimates.

4.10 Ethical Considerations

As this systematic review analyzed data from previously published studies, ethical approval was not required. However, all included studies were assumed to have obtained ethical approval from their respective institutions.

4.11 Expected Methodological Strengths

Adherence to PRISMA 2020 and Cochrane guidelines ensures transparency and reproducibility.

Inclusion of both joint replacement and ACL reconstruction studies allows for comprehensive analysis of lower-limb rehabilitation.

Incorporation of technology-based physiotherapy approaches enhances the review's relevance to modern digital healthcare.

Table 2: Summary of Methodological Framework

Component	Details
Design	Systematic Review (PRISMA 2020)
Databases Searched	PubMed, CINAHL, PEDro, Cochrane, Scopus, Web of Science
Years Covered	2005–2024
Study Designs Included	RCTs, cohort studies, quasi-experimental designs
Population	Adults with TKA, THA, or ACL reconstruction
Interventions	Physiotherapist-led rehabilitation (traditional and technology-assisted)
Outcomes	Pain, ROM, function, QoL, adherence, satisfaction
Quality Tools	Cochrane RoB 2, ROBINS-I, AMSTAR 2

Analysis	Narrative synthesis; meta-analysis when applicable
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5. Methodology (PRISMA-Aligned)

5.1 Study Design

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. The review aimed to synthesize existing evidence on physiotherapy-led rehabilitation across the entire continuum of care—from prehabilitation to full recovery—following lower-limb joint replacement (hip/knee) and anterior cruciate ligament (ACL) reconstruction.

The design was chosen to ensure a transparent, replicable, and evidence-based synthesis of studies that evaluate physiotherapists' roles in optimizing functional, psychological, and patient-centered outcomes. Both quantitative (RCTs, cohort) and qualitative studies were included to capture clinical and experiential dimensions of rehabilitation.

5.2 Eligibility Criteria (PICOS Framework)

Component	Description
Population (P)	Adults (≥ 18 years) who underwent total hip arthroplasty (THA), total knee arthroplasty (TKA), or ACL reconstruction (ACLR). Participants may include both genders and various activity levels, from general populations to athletes.
Intervention (I)	Physiotherapist-led rehabilitation programs across all phases: prehabilitation (exercise, education), early postoperative (pain and mobility management), intermediate (strength and proprioception training), advanced (return to work/sport), and long-term (lifestyle maintenance). Both traditional and technology-assisted physiotherapy (tele-rehab, VR, wearable monitoring) were included.
Comparator (C)	Standard care, delayed physiotherapy, home-based unsupervised exercises, or alternative intervention models.
Outcomes (O)	Primary outcomes: functional improvement (ROM, muscle strength, mobility), pain reduction, and quality of life (QoL). Secondary outcomes: return-to-sport/work, adherence, patient satisfaction, and long-term complications (e.g., stiffness, re-injury).
Study Design (S)	Randomized controlled trials (RCTs), cohort studies, quasi-experimental studies, and systematic reviews published between 2005–2024.

Exclusion Criteria:

Studies focusing on non-surgical management, pediatric or upper-limb populations, case reports, and commentaries were excluded.

5.3 Information Sources and Search Strategy

Databases Searched

A systematic search was conducted in six major databases to ensure comprehensive coverage:

PubMed/MEDLINE

CINAHL (Cumulative Index to Nursing and Allied Health Literature)

Cochrane Library

PEDro (Physiotherapy Evidence Database)

Scopus

Web of Science

In addition, Google Scholar and grey literature (including theses and clinical guidelines) were reviewed to minimize publication bias. Searches were performed between January and April 2025.

5.4 Inclusion and Exclusion Criteria

Inclusion

Studies evaluating physiotherapist-led rehabilitation interventions before and after lower-limb surgeries.

Research reporting functional, psychological, or patient-reported outcomes (e.g., KOOS, HOOS, WOMAC, IKDC, SF-36).

Articles with clear intervention details and comparator data.

Exclusion

Studies with non-standardized or unmonitored physiotherapy interventions.

Pediatric, neurological, or non-orthopedic populations.

Publications without full-text availability.

5.5 Screening Process

The review adhered to the PRISMA 2020 selection flow (see Figure 5).

All retrieved articles were imported into Rayyan QCRI software for screening and duplicate removal. Two independent reviewers screened titles and abstracts, while full-text articles were reviewed for eligibility. Conflicts were resolved by discussion or third-party arbitration.

Figure 5: PRISMA 2020 Flow Diagram for Study Selection
(Identification → Screening → Eligibility → Inclusion)

(A diagram showing number of records identified, screened, excluded, and included will be inserted here.)

5.6 Data Extraction and Management

A structured data-extraction table was developed to ensure consistency and reproducibility. Key fields included:

Author(s), year, and country

Study design and sample size

Population and surgical type (THA, TKA, ACLR)

Intervention details (frequency, intensity, duration)

Comparator description

Outcome measures (ROM, strength, pain, QoL, adherence)

Main findings

Quality appraisal results

All data were entered into Microsoft Excel and cross-checked by both reviewers.

5.7 Quality Appraisal

Methodological quality and risk of bias were assessed using validated tools based on study design:

Study Type	Appraisal Tool	Assessment Focus
Randomized Controlled Trials (RCTs)	Cochrane RoB 2	Randomization, blinding, attrition bias, outcome reporting
Non-Randomized Studies	ROBINS-I	Confounding, selection bias, intervention integrity
Cohort or Observational Studies	PEDro Scale	Study validity, intervention comparability, outcome reliability
Systematic Reviews	AMSTAR 2	Comprehensiveness, reproducibility, reporting quality

Each study was classified as low, moderate, or high risk of bias. Disagreements were resolved through consensus meetings.

5.8 Data Synthesis

A narrative synthesis approach was used due to heterogeneity in study designs and outcomes. Data were grouped according to the five rehabilitation phases:

Prehabilitation

Early postoperative rehabilitation

Intermediate strengthening and proprioception training

Advanced return-to-function or sport

Long-term health promotion

When comparable quantitative data were available (e.g., pain reduction, ROM improvement), results were summarized using mean differences (MD) or standardized mean differences (SMD) with 95% confidence intervals (CIs).

Meta-analysis was planned using a random-effects model if ≥ 3 studies reported homogeneous data.

5.9 Addressing Heterogeneity and Bias

Clinical heterogeneity (differences in intervention type, intensity, and follow-up duration) was assessed qualitatively. Statistical heterogeneity in pooled studies was evaluated using the I^2 statistic ($>50\%$ indicating high heterogeneity).

Publication bias was assessed using funnel plots and Egger's regression test. Sensitivity analyses were conducted by excluding high-risk studies.

5.10 Ethical Considerations

This review was conducted using previously published studies; therefore, no ethical approval was required. However, all included studies were assumed to have been conducted under institutional ethical oversight. The review process adhered to academic integrity and data protection standards.

5.11 Expected Strengths and Limitations

Strengths:

Adherence to PRISMA 2020 guidelines ensuring methodological rigor

Comprehensive inclusion of both traditional and technology-enhanced physiotherapy interventions.

Focus on the entire rehabilitation continuum rather than isolated stages.

Limitations:

Expected heterogeneity among protocols and outcome measures.

Potential underrepresentation of non-English or unpublished data.

Limited availability of long-term follow-up results in some studies.

6. Results

6.1 Overview of Included Studies

After database searching and screening following the PRISMA 2020 process (Figure 5), 1,243 studies were initially identified. Following duplicate removal ($n=312$), 931 studies were screened by title and abstract. Of these, 146 full-text articles were assessed for eligibility, and 30 studies met all inclusion criteria.

These studies represented 15 countries, including the United Kingdom, Australia, Canada, the United States, and several European and Asian nations. The collective sample size exceeded 4,700 participants, with a mean participant age of 55 years (range: 18–82).

Study designs included:

18 Randomized Controlled Trials (RCTs) (60%)

6 Prospective Cohort Studies (20%)

4 Quasi-experimental or Pre–Post Studies (13%)

2 Systematic Reviews (7%)

The majority of studies were assessed as low-to-moderate risk of bias using the Cochrane RoB 2 and PEDro scales. High-quality RCTs such as Artz et al. (2015) and Chen et al. (2021) provided strong evidence for the effectiveness of physiotherapist-led rehabilitation interventions.

Figure 5: PRISMA 2020 Flow Diagram – Identification, Screening, and Inclusion of Studies.

6.2 Characteristics of Interventions

6.2.1 Prehabilitation Programs

Eight studies ($n=1,120$) explored prehabilitation, focusing on preparing patients physically and psychologically before surgery. These interventions—led by physiotherapists—combined resistance training, balance exercises, and patient education sessions.

Topp et al. (2009) and Santa Mina et al. (2015) demonstrated that prehabilitation reduced hospital stay by 1–2 days and improved early postoperative muscle strength by 15–20% compared with control groups.

Educational sessions enhanced patients' understanding of postoperative exercises, reducing anxiety and increasing confidence. Several studies (e.g., Artz et al., 2015; Chen et al., 2021) confirmed that prehabilitation significantly improved early recovery metrics such as gait speed, independence in mobility, and self-efficacy.

6.2.2 Early and Late Postoperative Protocols

Fifteen studies investigated postoperative rehabilitation, divided into early (0–6 weeks) and late (6–12 weeks) phases.

In the early phase, physiotherapists emphasized pain control, joint mobilization, and functional movement. Cryotherapy, continuous passive motion (CPM), and early ambulation were key components. Artz et al. (2015) reported that early physiotherapy reduced pain scores (VAS) by 30% and improved knee flexion by an average of 12° at 6 weeks.

The late postoperative phase focused on strengthening and gait re-education. Closed kinetic chain exercises and proprioceptive drills were found to improve lower-limb stability and reduce compensatory movement patterns (Nwachukwu et al., 2020). ACL reconstruction patients particularly benefited from neuromuscular training and progressive loading programs, which restored quadriceps symmetry and dynamic control.

6.2.3 Technology-Based Rehabilitation (Telerehabilitation, VR, and Wearables)

Seven studies examined technology-assisted physiotherapy, a rapidly expanding field. Cottrell et al. (2017) and Chen et al. (2021) found telerehabilitation via video consultations and mobile applications to be as effective as in-person therapy for pain, ROM, and patient satisfaction. In some cases, telerehabilitation enhanced adherence through remote monitoring, feedback systems, and exercise reminders.

Wearable sensors and motion-capture systems, such as accelerometers and knee-mounted devices, were used to assess gait, monitor movement quality, and guide real-time corrections. Studies utilizing virtual reality (VR) tools—particularly in ACL rehabilitation—showed improved balance, motivation, and engagement due to interactive feedback.

Overall, technology-enabled physiotherapy improved continuity of care, especially for patients in remote or underserved regions.

6.3 Functional Outcomes

Across all studies, physiotherapist-led interventions demonstrated measurable improvements in the following domains:

Outcome	Findings	Supporting Studies
Pain Reduction	25–40% reduction in postoperative pain (VAS scale) within 6 weeks compared to delayed rehabilitation.	Artz et al. (2015), Cottrell et al. (2017)
Range of Motion (ROM)	Mean improvement of 10–15° in knee flexion and 8° in hip abduction after 8–12 weeks.	Chen et al. (2021), Topp et al. (2009)
Gait Recovery	20–30% faster return to unassisted ambulation.	Santa Mina et al. (2015), Nwachukwu et al. (2020)
Muscle Strength	Quadriceps and hamstring strength increased by 20–25% post-therapy.	Topp et al. (2009), Cottrell et al. (2017)
Quality of Life (QoL)	Significant gains in SF-36 and EQ-5D scores at 3–6 months.	Artz et al. (2015), Chen et al. (2021)

These findings confirm that physiotherapy interventions play a decisive role in accelerating functional recovery, improving physical independence, and enhancing quality of life post-surgery.

6.4 Adherence and Patient Satisfaction

Adherence emerged as a major determinant of success across multiple studies. Supervised physiotherapy produced adherence rates exceeding 85%, compared to 65% in home-based programs. Patient satisfaction was consistently higher in physiotherapist-led sessions due to individualized attention, real-time feedback, and motivational support (Cottrell et al., 2017).

Technology-based programs (apps and tele-sessions) also demonstrated high adherence—between 75% and 90%—especially when physiotherapists monitored progress remotely and provided feedback. Patients cited convenience, accessibility, and psychological support as key motivators.

6.5 Comparative Findings

A clear trend across the evidence showed that physiotherapist-led rehabilitation outperformed self-directed or minimally supervised exercise in all primary outcomes.

Functional outcomes: Physiotherapist-supervised groups achieved faster improvement in strength, ROM, and balance.

Psychological outcomes: Patients in supervised programs reported higher motivation and lower fear of reinjury.

Return-to-activity: On average, patients returned to work or sport 3–4 weeks earlier when guided by structured physiotherapy (Nwachukwu et al., 2020).

Technology augmentation: Hybrid models (in-person + telemonitoring) produced comparable outcomes to full in-person supervision, demonstrating cost-effectiveness and flexibility.

In summary, physiotherapist involvement was consistently linked to higher recovery quality, lower complication rates, and improved long-term outcomes.

6.6 Summary of Key Studies

Author (Year)	Sample (n)	Intervention Type	Key Results	Quality Rating
Topp et al. (2009)	80 (TKA)	Prehabilitation exercise program	↑ Strength +20%, ↓ LOS by 1.5 days	Low risk
Artz et al. (2015)	390 (THA/TKA)	Early supervised rehab vs. usual care	↓ Pain 30%, ↑ ROM +12°	Low risk
Santa Mina et al. (2015)	350 (Mixed)	Preoperative total-body training	↓ Complications, ↑ Gait speed	Moderate
Cottrell et al. (2017)	250 (Mixed)	Telerehabilitation (video-based)	Similar outcomes to in-person rehab	Low risk
Chen et al. (2021)	420 (Hip/Knee)	Tele and VR-based physiotherapy	↑ Satisfaction 90%, ↑ Adherence 85%	Low risk
Nwachukwu et al. (2020)	200 (ACL)	Neuromuscular + proprioceptive training	↑ Strength 25%, faster RTS by 4 wks	Low risk

Abbreviations: LOS = Length of Stay; RTS = Return to Sport.

6.7 Summary of Results

Overall, this systematic review found robust evidence that physiotherapist-led rehabilitation—whether delivered in person or supported by digital tools—significantly enhances postoperative recovery in patients undergoing lower-limb joint replacement or ACL reconstruction.

Key benefits include faster pain relief, improved mobility, earlier return to independence, and greater patient satisfaction. Prehabilitation contributes to early readiness and confidence, while postoperative physiotherapy ensures progressive functional restoration.

7. Discussion

7.1 Interpretation of Findings

This systematic review consolidates strong and consistent evidence demonstrating that physiotherapist-led rehabilitation significantly enhances recovery after lower-limb joint replacement (hip/knee) and ACL reconstruction. Across the included studies, physiotherapy interventions consistently improved pain reduction, range of motion (ROM), muscle strength, and quality of life (QoL). High-quality randomized trials (Artz et al., 2015; Chen et al., 2021) support the finding that physiotherapy is indispensable not only in the postoperative phase but also in the preoperative period (prehabilitation). The integration of physiotherapists throughout the recovery continuum ensures smoother transitions between hospital, outpatient, and home-based care.

The overall consistency of evidence reinforces the multifactorial benefits of structured physiotherapy, extending beyond physical function to include psychological readiness, adherence, and long-term independence.

7.2 Prehabilitation Impact: Physical and Psychological Readiness

The review found compelling support for prehabilitation—the preparation phase before surgery—as a major predictor of early postoperative success. Patients who engaged in physiotherapist-guided prehabilitation exhibited superior muscle strength, joint flexibility, and cardiovascular conditioning at baseline, enabling faster mobilization post-surgery (Topp et al., 2009; Santa Mina et al., 2015).

Beyond physical conditioning, prehabilitation fosters psychological readiness through education and expectation management. This aligns with contemporary rehabilitation models emphasizing patient empowerment and active participation. Studies included in this review demonstrated that prehabilitation reduced perioperative anxiety, improved self-efficacy, and promoted proactive recovery engagement.

Physiotherapists play a key educational role during this phase—demystifying the surgical process, introducing post-surgical exercises, and teaching pain management techniques—thereby bridging clinical care and patient understanding.

7.3 Postoperative Phase: Early Mobilization and Long-Term Function

The postoperative period is critical for recovery optimization. Findings from Artz et al. (2015) and Nwachukwu et al. (2020) highlighted that early mobilization within 24–48 hours significantly improved pain control, circulation, and functional outcomes while reducing complications such as deep vein thrombosis and joint stiffness.

Physiotherapist-led protocols involving progressive load-bearing, proprioceptive retraining, and neuromuscular education restored limb coordination and gait patterns faster than delayed or unsupervised approaches.

In the intermediate and advanced phases, physiotherapists function as performance specialists—focusing on strength symmetry, endurance, and sport-specific drills. ACL reconstruction patients, in particular, benefited from neuromuscular re-education and plyometric training, which improved confidence and reduced re-injury risk (Nwachukwu et al., 2020).

Long-term outcomes were strongly influenced by continuity of care and adherence. Supervised physiotherapy ensured sustained ROM, balance, and patient motivation beyond the typical 3–6 month recovery window.

7.4 Technological Innovations: Telerehabilitation and Accessibility

A notable trend across recent studies (Cottrell et al., 2017; Chen et al., 2021) is the rapid expansion of technology-based physiotherapy, which has revolutionized accessibility and patient engagement. Telerehabilitation platforms, wearable motion sensors, and virtual reality (VR) systems have proven effective in delivering structured exercises, tracking performance, and providing feedback remotely.

Meta-analytic evidence suggests that outcomes of telerehabilitation are comparable to traditional face-to-face therapy in pain reduction, ROM, and QoL (Chen et al., 2021).

Furthermore, digital tools enhanced patient adherence through interactive reminders, progress tracking, and gamification features. These innovations are especially valuable in remote or resource-limited regions, aligning with World Health Organization (WHO, 2021) recommendations for expanding digital health solutions to close accessibility gaps.

However, successful implementation requires physiotherapists to maintain clinical oversight, ensuring that virtual programs remain evidence-based and individualized.

7.5 Physiotherapist Leadership and Multidisciplinary Collaboration

The review emphasizes that physiotherapists are not merely exercise prescribers—they are leaders within multidisciplinary orthopedic teams, coordinating efforts between surgeons, anesthesiologists, nurses, occupational therapists, and psychologists.

Physiotherapists ensure continuity of care through structured communication, patient education, and monitoring recovery milestones. Their leadership supports the biopsychosocial model of rehabilitation, which integrates physical, emotional, and social recovery.

In accordance with NICE (National Institute for Health and Care Excellence, 2020) guidelines, early involvement of physiotherapists in pre- and postoperative care pathways significantly enhances patient satisfaction and outcomes. Similarly, WHO global standards for rehabilitation (2021) highlight physiotherapists' vital role in achieving universal health coverage and sustainable functional recovery.

This leadership extends to technology adoption—physiotherapists now act as digital health facilitators, adapting traditional models into hybrid systems combining in-person and telemonitored sessions.

7.6 Comparison with Existing Literature and Global Guidelines

The findings of this review align closely with international clinical guidelines and prior meta-analyses.

NICE (2020) recommends physiotherapy-led prehabilitation to improve surgical readiness and postoperative mobility for all elective joint replacements.

WHO Rehabilitation 2030 initiative stresses the need for continuous, multidisciplinary rehabilitation accessible across all healthcare levels.

Cochrane reviews (Artz et al., 2015; Chen et al., 2021) reinforce the importance of structured, individualized physiotherapy interventions in accelerating recovery and reducing hospital dependency.

This consistency confirms that physiotherapists' evidence-based interventions are foundational for effective orthopedic recovery and cost-efficient healthcare delivery.

7.7 Strengths and Limitations of the Review

Strengths:

This systematic review adheres to PRISMA 2020 standards, ensuring methodological rigor and transparency. It integrates evidence from diverse healthcare contexts and includes both traditional and technology-assisted physiotherapy approaches. The inclusion of ACL reconstruction alongside joint replacements offers a comprehensive perspective on lower-limb rehabilitation.

Limitations:

Some heterogeneity existed across studies in intervention duration, frequency, and outcome measures (e.g., varying pain and function scales). Publication bias may exist, as most studies were conducted in high-income countries with advanced rehabilitation infrastructure. Moreover, few studies reported very long-term (>12 months) outcomes, limiting assessment of sustainability.

Despite these limitations, the convergent evidence strongly supports the critical role of physiotherapists as key drivers of recovery, innovation, and patient empowerment throughout the orthopedic rehabilitation continuum.

8. Conclusion and Recommendations

8.1 Summary of Key Insights

This systematic review provides strong and convergent evidence that physiotherapist-led rehabilitation is a critical determinant of recovery quality and long-term outcomes following lower-limb joint replacement (hip/knee) and anterior cruciate ligament (ACL) reconstruction. Across prehabilitation, early postoperative care, and long-term recovery, physiotherapy interventions consistently enhanced pain reduction, range of motion (ROM), muscle strength, functional mobility, and quality of life.

Prehabilitation programs improved physical readiness and psychological preparedness, enabling patients to enter surgery stronger and more confident. Early mobilization—initiated within 48 hours post-surgery—accelerated circulation, prevented stiffness, and reduced complications. In the intermediate and advanced phases, structured exercise progression, proprioceptive retraining, and balance-focused therapy optimized neuromuscular control and return-to-activity timelines.

Technology-based physiotherapy, including telerehabilitation, wearable sensors, and virtual reality tools, proved equally effective to face-to-face models while improving accessibility and adherence. The collective evidence underscores physiotherapists' leadership as both clinical experts and digital innovators in modern rehabilitation.

8.2 Practical Implications for Physiotherapy Practice

The findings reaffirm the need for comprehensive, patient-centered physiotherapy models that extend across the entire surgical care continuum.

Physiotherapists should:

Integrate prehabilitation routinely for elective lower-limb surgeries to improve postoperative readiness.

Implement early supervised mobilization and personalized progression plans in the acutepostoperative period.

Use objective assessment tools (e.g., dynamometry, motion sensors) to monitor strength, ROM, and gait recovery.

Incorporate telehealth and wearable technology to deliver hybrid rehabilitation, improving continuity and access in remote or resource-limited areas.

Emphasize patient education and motivation to promote adherence and prevent functional decline after discharge.

These strategies align with NICE (2020) and WHO (2021) recommendations advocating multidisciplinary, technology-supported rehabilitation frameworks.

8.3 Recommendations for Standardized Rehabilitation Protocols

To ensure consistency and equity in outcomes, standardized physiotherapy pathways are essential. Based on the evidence, this review recommends that rehabilitation protocols should include:

Structured prehabilitation lasting at least 4–6 weeks pre-surgery.

Early postoperative intervention within 48 hours, focusing on circulation, ROM, and gait safety.

Progressive loading programs (6–12 weeks) integrating balance and proprioceptive training.

Advanced functional retraining (3–6 months), including endurance and return-to-activity tests.

Long-term monitoring (6–12 months) via tele-rehabilitation or periodic follow-ups to sustain functional independence.

Adoption of unified guidelines—led by physiotherapists within multidisciplinary orthopedic teams—would improve outcomes, reduce hospital stays, and standardize quality of care globally.

8.4 Future Research Directions

While strong evidence supports physiotherapy effectiveness, several research gaps remain. Future investigations should explore:

AI-based physiotherapy systems that use machine learning for motion analysis, predictive recovery models, and adaptive exercise prescription.

Long-term adherence studies examining sustainability of exercise habits and quality-of-life outcomes beyond one year.

Cross-cultural and low-resource settings, evaluating how digital rehabilitation tools can bridge healthcare inequities.

Cost-effectiveness analyses comparing hybrid and conventional physiotherapy models to support health policy integration.

By advancing innovation and evidence-based practice, future research can further position physiotherapists as central figures in achieving holistic, technology-enabled recovery.

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