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Physiotherapy Outcomes and Return to Sport Criteria Post-ACL Reconstruction: A Systematic Review of Contemporary Measurement Tools

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ABSTRACT

Anterior cruciate ligament (ACL) injuries are among the most common knee injuries in physically active individuals and athletes, often requiring comprehensive physiotherapy rehabilitation following ACL reconstruction (ACLR) to optimize functional recovery and facilitate a safe return to sport (RTS). Although numerous contemporary assessment tools have been developed to evaluate rehabilitation outcomes, evidence integrating physiotherapy outcomes, assessment instruments, and RTS criteria remains limited. This study aimed to synthesize current evidence on physiotherapy outcomes following ACLR, compare contemporary assessment tools, and examine their contributions to evidence-based RTS decision-making. A systematic literature review (SLR) was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Relevant articles were identified through scientific databases using predefined eligibility criteria, including English-language studies published between 2021 and 2026. Thirty eligible studies were included in the final review and analyzed through narrative synthesis. The findings indicated that physiotherapy rehabilitation was associated with improvements in knee function, muscle strength, functional performance, patient-reported outcomes, and psychological readiness for RTS. A comprehensive evaluation of RTS readiness required the integration of objective functional assessments, including hop tests, the Limb Symmetry Index (LSI), and isokinetic strength testing, with patient-reported outcome measures (PROMs), such as the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form and the Knee Injury and Osteoarthritis Outcome Score (KOOS), alongside psychological readiness assessment using the Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) scale. These findings suggested that a multidimensional, criterion-based assessment framework provided a more comprehensive evaluation of RTS readiness than reliance on postoperative time alone, thereby supporting individualized rehabilitation planning and evidence-based physiotherapy practice following ACLR.

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are among the most common knee injuries in physically active individuals and athletes participating in sports that involve pivoting, cutting, and jumping movements (Faleide et al., 2021). ACL reconstruction (ACLR) is widely performed to restore knee stability and facilitate a safe return to preinjury activity levels. However, many patients continue to experience deficits in muscle strength, functional performance, and neuromuscular control following surgery (Snyder-Mackler et al., 2022). These persistent impairments may delay return to sport (RTS) and increase the risk of subsequent ACL injury, even after completion of rehabilitation (Beischer, S., Hamrin Senorski, E., Thomeé, C., Samuelsson, K., & Thomeé, 2022).

Physiotherapy is a fundamental component of postoperative rehabilitation, aiming to restore functional capacity while minimizing the risk of reinjury (Gokeler et al., 2023). Contemporary rehabilitation strategies have increasingly shifted from conventional time-based protocols toward criterion-based approaches that assess patients using objective functional measures before clearance for RTS (Knapik et al., 2024). Clinical decision-making also increasingly incorporates assessments of muscle strength and psychological readiness, enabling physiotherapists to evaluate whether patients have achieved sufficient recovery to resume unrestricted sports participation (Feller et al., 2024).

Contemporary rehabilitation programs incorporate various assessment tools to evaluate multiple dimensions of postoperative recovery. Functional assessments, including hop tests and isokinetic strength testing, are widely used to quantify physical performance, while the Limb Symmetry Index (LSI) is commonly calculated to compare performance between the involved and uninvolved limbs (Hardy et al., 2023). Patient-reported knee function and symptoms are frequently assessed using the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form and the Knee Injury and Osteoarthritis Outcome Score (KOOS) (Zampeli et al., 2024). Psychological readiness is increasingly evaluated using the Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) scale, as psychological factors, including confidence, fear of reinjury, and perceived readiness, substantially influence successful RTS outcomes (Richmond et al., 2026).

Although numerous studies have investigated physiotherapy outcomes following ACLR, considerable methodological and clinical heterogeneity persists across the literature. Rehabilitation protocols vary substantially among studies (McPherson et al., 2023), while differences in follow-up duration, assessment instruments, and outcome measures complicate comparisons across clinical investigations (Manojlovic et al., 2024). Furthermore, variations in RTS criteria contribute to inconsistent recommendations regarding postoperative assessment, rehabilitation progression, and clinical decision-making (Filbay et al., 2025).

Several recent systematic reviews have examined specific aspects of ACL rehabilitation, including muscle strength recovery (Gill et al., 2024), functional performance assessment (van Haren et al., 2025), and psychological readiness for RTS (Richmond et al., 2026). Nevertheless, relatively few reviews have comprehensively compared contemporary assessment tools while simultaneously evaluating their relevance to physiotherapy outcomes and evidence-based RTS decision-making. Consequently, a broader synthesis of the available

evidence is needed to clarify the clinical utility, strengths, and limitations of these instruments and identify remaining gaps in postoperative rehabilitation assessment.

This systematic review aimed to synthesize current evidence on physiotherapy outcomes following ACLR, compare contemporary measurement tools used throughout rehabilitation (Knapik et al., 2024), evaluate their contributions to evidence-based RTS decision-making (van Haren et al., 2025), and identify implications for clinical physiotherapy practice and future research (Richmond et al., 2026). The review focused on peer-reviewed studies published between 2021 and 2026 that investigated postoperative physiotherapy rehabilitation following ACLR, with particular emphasis on functional recovery, patient-reported outcomes, psychological readiness, and RTS assessment criteria.

METHOD

This study employed a systematic literature review (SLR) to synthesize evidence on physiotherapy outcomes and return-to-sport (RTS) criteria following anterior cruciate ligament (ACL) reconstruction. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure a transparent and structured study selection process.

A comprehensive literature search was conducted using six electronic platforms and publication repositories: PubMed Central (PMC), MDPI, SpringerOpen, BioMed Central (BMC), ScienceDirect Open Access, and SAGE Journals Open Access. The search strategy combined relevant keywords and controlled vocabulary, where applicable, related to ACL reconstruction, physiotherapy, rehabilitation, RTS, functional assessment, patient-reported outcome measures, psychological readiness, and muscle strength. Boolean operators (AND and OR) were used to identify relevant publications.

Eligible publications included original research articles and systematic reviews published in English between 2021 and 2026, available in full-text open-access format, and addressing physiotherapy outcomes, rehabilitation assessment, or RTS evaluation following ACL reconstruction. Studies examining functional performance, patient-reported outcomes, psychological readiness, and contemporary assessment instruments were included. Editorials, conference abstracts, letters, expert opinions, animal studies, duplicate publications, articles without accessible full texts, and studies focusing exclusively on surgical techniques without reporting postoperative rehabilitation outcomes were excluded.

The initial search identified 75 records, of which 8 duplicates were removed, leaving 67 records for title and abstract screening. Following screening, 22 records were excluded because they did not address relevant physiotherapy outcomes, RTS criteria, or postoperative rehabilitation. The remaining 45 articles underwent full-text eligibility assessment, during which 15 studies were excluded for failing to meet the predefined eligibility criteria or report relevant rehabilitation outcomes and assessment measures. Consequently, 30 studies were included in the final qualitative synthesis.

Data were extracted using a standardized extraction form. The extracted information included publication characteristics, study design, participant characteristics, rehabilitation interventions, outcome measures, assessment instruments, RTS criteria, and principal findings. Particular attention was given to the Anterior Cruciate Ligament–Return to Sport after Injury

(ACL-RSI) scale, International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), hop tests, Limb Symmetry Index (LSI), and isokinetic strength testing.

A narrative synthesis was conducted because of heterogeneity in study designs, participant characteristics, rehabilitation protocols, and outcome assessment methods. The synthesis examined commonly used assessment instruments, their clinical utility, reported physiotherapy outcomes, and criterion-based approaches to RTS decision-making following ACL reconstruction. The findings were compared across studies to identify consistent patterns, methodological differences, and gaps in the available evidence.

RESULTS AND DISCUSSION

Characteristics of the Included Studies

The final qualitative synthesis included 30 studies published between 2021 and 2026, reflecting recent developments in physiotherapy rehabilitation and return-to-sport (RTS) assessment following Anterior Cruciate Ligament (ACL) reconstruction. The selected literature consisted of prospective cohort studies, retrospective cohort studies, systematic reviews, scoping reviews, and meta-analyses, providing evidence from different methodological perspectives. Research originated predominantly from the United States, the United Kingdom, the Netherlands, Sweden, Norway, France, Germany, Italy, and multinational collaborations across Europe and North America.

A considerable proportion of the included studies investigated factors influencing successful return-to-sport after ACL reconstruction. Several researchers focused on the relationship between physical recovery and psychological readiness, demonstrating that both components contribute substantially to rehabilitation outcomes. Faleide et al. (2021), Snyder-Mackler et al. (2022), Beischer et al. (2022), Sell et al. (2024), Hardy et al. (2024), and Grazzini et al. (2026) consistently reported that higher ACL-Return to Sport after Injury (ACL-RSI) scores were associated with greater confidence, improved knee function, and a higher likelihood of returning to the pre-injury level of sport.

Another group of studies concentrated on objective functional assessment during postoperative rehabilitation. Kuroda et al. (2021), Gokeler et al. (2023), Knapik et al. (2024), Feller et al. (2024), Zampeli et al. (2024), Richmond et al. (2026), Russo et al. (2025), de Girolamo et al. (2023), and Schröter et al. (2024) evaluated measurement tools such as International Knee Documentation Committee (IKDC), Knee Injury and Osteoarthritis Outcome Score (KOOS), Limb Symmetry Index (LSI), Hop Tests, Isokinetic Strength Testing, Lysholm Score, and functional jump assessments. These investigations demonstrated that objective measurements remain essential for determining functional recovery before athletes resume sporting activities.

Several review articles expanded the evidence by synthesizing findings from multiple primary investigations. Van Haren et al. (2025), Filbay et al. (2025), Manojlovic et al. (2024), McPherson et al. (2023), Francone et al. (2025), Gill et al. (2024), and Knapik et al. (2024) highlighted that no single measurement tool is sufficient to determine readiness for return-to-sport. Their findings consistently supported a multidimensional evaluation combining physical performance, muscle strength, patient-reported outcome measures (PROMs), and

psychological readiness to improve clinical decision-making and reduce the risk of reinjury after ACL reconstruction.

Across the included publications, frequently reported outcome measures included ACL-RSI, IKDC, KOOS, Lysholm Score, Tegner Activity Scale, Hop Tests, Limb Symmetry Index, Isokinetic Quadriceps Strength, and various functional performance tests. The repeated use of these instruments demonstrates their prominent role in contemporary physiotherapy practice for monitoring rehabilitation progress and supporting evidence-based return-to-sport decisions after ACL reconstruction.

Table 1. Characteristics of the Included Studies (n = 30)

Characteristics	Description
Number of included studies	30 studies
Publication period	2021–2026
Countries/Regions	United States, Norway, Sweden, the Netherlands, France, Germany, Italy, the United Kingdom, and multinational collaborations across Europe and North America
Journal types	*The American Journal of Sports Medicine, Arthroscopy, Sports Medicine–Open, Sports Health, Journal of Clinical Medicine, Healthcare, Sports, Current Reviews in Musculoskeletal Medicine, Journal of ISAKOS, Physical Therapy in Sport, BMC Musculoskeletal Disorders, Annals of Physical and Rehabilitation Medicine, Applied Sciences, International Journal of Environmental Research and Public Health, and others*
Main research topic	*Physiotherapy outcomes, functional recovery, return-to-sport assessment, psychological readiness, and contemporary measurement tools after ACL reconstruction*
Common assessment tools	*ACL-RSI, IKDC, KOOS, Lysholm Score, Tegner Activity Scale, Hop Tests, Limb Symmetry Index (LSI), Isokinetic Strength Testing, and functional performance tests*
Types of participants	*Recreational athletes, competitive athletes, elite athletes, football players, and patients following ACL reconstruction*

Distribution of Study Designs and Participant Characteristics

the reviewed literature was methodologically diverse. It included prospective and retrospective cohort studies, systematic reviews, scoping reviews, and meta-analyses. Prospective studies generally followed patients from the early postoperative phase into long-term follow-up, retrospective studies assessed functional outcomes after rehabilitation had finished, and review-based studies pooled many primary investigations to identify common patterns in assessment after Anterior Cruciate Ligament (ACL) reconstruction.

Participants were mostly recreational and competitive athletes who had undergone primary ACL reconstruction, with a few studies focusing on elite athletes or football players.

Sample sizes ranged from fewer than fifty in single-centre studies to several hundred in large cohorts, while systematic reviews and meta-analyses covered much larger populations by combining multiple studies.Follow-up duration also varied, from about six months after surgery, to assess early functional recovery and psychological readiness, up to two, three, or even five years, to examine long-term sport participation and performance. This suggests that recovery continues beyond routine rehabilitation, so athletes need periodic reassessment before returning to unrestricted sport.

Outcomes were measured with both objective and subjective tools. Objective measures included hop tests, Limb Symmetry Index (LSI), isokinetic quadriceps strength, drop vertical jump, vertical hop, side hop, and agility tests. Subjective measures were patient-reported outcome measures (PROMs) such as IKDC, KOOS, the Lysholm Score, the Tegner Activity Scale, and ACL-RSI. The repeated use of these instruments across study designs reflects their broad acceptance for monitoring functional recovery, psychological readiness, and return-to-sport decisions after ACL reconstruction.

Table 2. Distribution of Study Designs and Participant Characteristics of the Included Studies

Characteristics	Description
Total included studies	30 studies
Publication period	2021–2026
Countries/Regions	United States, Norway, Sweden, the Netherlands, France, Germany, Italy, the United Kingdom, and multinational collaborations across Europe and North America
Study designs	Prospective cohort, retrospective cohort, *systematic review*, *scoping review*, and *meta-analysis*
Study population	Recreational athletes, competitive athletes, elite athletes, football players, and patients following ACL reconstruction
Sample size	Ranged from fewer than 50 participants in clinical studies to several hundred participants in cohort studies; review articles synthesized evidence from multiple primary studies
Follow-up duration	Approximately 6 months to 5 years after ACL reconstruction
Common outcome measures	*ACL-RSI*, *IKDC*, *KOOS*, *Lysholm Score*, *Tegner Activity Scale*, *Hop Tests*, *Limb Symmetry Index (LSI)*, *Isokinetic Strength Testing*, *Drop Vertical Jump*, and *Vertical Hop Test*
Primary research focus	Physiotherapy outcomes, functional recovery, psychological readiness, measurement tools, and *return-to-sport* decision-making

Contemporary Measurement Tools Following ACL Reconstruction

assessment after ACL reconstruction has shifted from isolated clinical examinations to multidimensional evaluation. The included studies consistently combined objective performance tests, patient-reported outcome measures (PROMs), and psychological assessment to judge rehabilitation progress and readiness for return to sport (RTS). Successful recovery is seen as depending on physical function, muscle performance, patient perception, and psychological confidence rather than any single indicator.

On the psychological side, the ACL-RSI scale was the most frequently reported tool. Faleide et al. (2021), Snyder-Mackler et al. (2022), Beischer et al. (2022), Sell et al. (2024),

Hardy et al. (2023; 2024), and Grazzini et al. (2026) found that higher ACL-RSI scores were associated with greater confidence, better knee function, and a higher likelihood of returning to the pre-injury level of sport. Physical recovery alone does not guarantee a successful return to athletic participation.

On the objective side, the IKDC, KOOS, hop tests, Limb Symmetry Index (LSI), and isokinetic strength testing appeared repeatedly across the studies. Gokeler et al. (2023), Knapik et al. (2024), van Haren et al. (2025), Russo et al. (2025), and Richmond et al. (2026) emphasized that these measures reveal knee function, muscle strength, movement symmetry, and functional performance, and that RTS decisions should rely on several measurements rather than time since surgery alone.

Table 3. Contemporary Measurement Tools Reported in the Included Studies

Measurement Tool	Purpose	Studies Reporting the Tool
ACL-Return to Sport after Injury (*ACL-RSI*)	Evaluates psychological readiness and confidence to return to sport	Faleide et al. (2021); Kuroda et al. (2021); Snyder-Mackler et al. (2022); Beischer et al. (2022); Sell et al. (2024); Zampeli et al. (2024); Feller et al. (2024); van Haren et al. (2025); Hardy et al. (2023; 2024); de Girolamo et al. (2023); Richmond et al. (2026); Grazzini et al. (2026)
International Knee Documentation Committee (*IKDC*)	Assesses subjective knee function and symptoms	Faleide et al. (2021); Snyder-Mackler et al. (2022); Gokeler et al. (2023); Zampeli et al. (2024); van Haren et al. (2025); Russo et al. (2025); Hardy et al. (2023; 2024)
Knee Injury and Osteoarthritis Outcome Score (*KOOS*)	Measures pain, symptoms, sport, daily function, and quality of life	Snyder-Mackler et al. (2022); Gokeler et al. (2023); Knapik et al. (2024); Filbay et al. (2025); van Haren et al. (2025)
Hop Tests (*Single*, *Triple*, *Crossover*, *Side Hop*)	Evaluates lower-limb functional performance and symmetry	Faleide et al. (2021); Kuroda et al. (2021); Feller et al. (2024); Knapik et al. (2024); Richmond et al. (2026); Hardy et al. (2023); Grazzini et al. (2026)
Limb Symmetry Index (*LSI*)	Compares functional symmetry between injured and uninjured limbs	Knapik et al. (2024); Richmond et al. (2026); de Girolamo et al. (2023); Schröter et al. (2024)
Isokinetic Strength Testing	Measures quadriceps and hamstring muscle strength	Faleide et al. (2021); Knapik et al. (2024); Feller et al. (2024); van Haren et al. (2025); Hardy et al. (2024); Grazzini et al. (2026)
Lysholm Score	Evaluates knee function and symptoms	Russo et al. (2025); Hardy et al. (2023); de Girolamo et al. (2023)
Tegner Activity Scale	Measures activity level before and after ACL reconstruction	Hardy et al. (2023; 2024); de Girolamo et al. (2023); Filbay et al. (2025)

Measurement Tool	Purpose	Studies Reporting the Tool
Vertical Jump, *Drop Vertical Jump*, *Single-Leg Vertical Hop Test*	Assesses explosive performance and dynamic lower-limb function	Hardy et al. (2023); de Girolamo et al. (2023); Schröter et al. (2024)
MRI Graft Maturation	Evaluates biological graft healing	Francone et al. (2025)

Functional Performance Assessment

Functional performance assessment was identified as one of the most important components of postoperative evaluation following Anterior Cruciate Ligament (ACL) reconstruction. The reviewed studies consistently demonstrated that restoration of muscle strength alone is insufficient to determine readiness for return-to-sport (RTS). Instead, contemporary rehabilitation emphasizes evaluating patients' ability to perform sport-specific movements that require strength, balance, coordination, neuromuscular control, and movement symmetry. Functional performance assessments therefore provide clinicians with objective evidence regarding an athlete's capacity to tolerate the physical demands of competitive sport while minimizing the risk of reinjury.

Among the functional assessment methods identified in the reviewed literature, Hop Tests represented the most frequently reported performance measures. These assessments included the Single Hop for Distance, Triple Hop for Distance, Crossover Hop, and 6-Meter Timed Hop, each evaluating different aspects of lower-limb performance following ACL reconstruction. Kuroda et al. (2021), Faleide et al. (2021), Feller et al. (2024), Knapik et al. (2024), Richmond et al. (2026), and Grazzini et al. (2026) consistently demonstrated that superior hop performance was associated with improved functional recovery and greater likelihood of successful RTS. Athletes achieving symmetrical hop performance between the injured and uninjured limbs generally exhibited higher functional capacity and fewer residual deficits than individuals with persistent asymmetry.

The Limb Symmetry Index (LSI) also emerged as a central indicator of functional recovery across the included studies. This measurement compares the functional capacity of the reconstructed limb with the contralateral limb and is commonly applied during hop performance testing and strength assessment. Richmond et al. (2026), Knapik et al. (2024), de Girolamo et al. (2023), and Schröter et al. (2024) reported that greater limb symmetry reflected more complete neuromuscular recovery and improved readiness for sport participation. Persistent asymmetry, particularly in quadriceps strength and dynamic movement performance, remained associated with reduced functional ability and an increased potential for secondary ACL injury after returning to sport.

Assessment of muscle strength constituted another essential aspect of functional performance evaluation. Isokinetic Strength Testing was widely used to quantify quadriceps and hamstring strength throughout rehabilitation. Faleide et al. (2021), Feller et al. (2024), van Haren et al. (2025), Hardy et al. (2024), and Grazzini et al. (2026) consistently reported that restoration of quadriceps strength was strongly associated with better functional performance and higher rates of successful RTS. These findings reinforce the importance of progressive resistance training during physiotherapy because inadequate quadriceps recovery may

compromise dynamic knee stability even when patients report satisfactory subjective knee function.

Several investigations expanded functional assessment by incorporating biomechanical and movement-quality analyses. Hardy et al. (2023) evaluated Vertical Jump performance to examine lower-limb power during rehabilitation, whereas de Girolamo et al. (2023) utilized the Drop Vertical Jump Limb Symmetry Index to assess landing mechanics. Schröter et al. (2024) further validated the Single-Leg Vertical Hop Test using digital sensor technology, demonstrating that technology-assisted assessment may improve measurement precision during rehabilitation. These approaches extend conventional functional testing by evaluating movement quality in addition to performance outcomes, thereby providing clinicians with a more comprehensive understanding of neuromuscular recovery following ACL reconstruction.

Evidence synthesized from the included systematic reviews, scoping reviews, and meta-analyses consistently concluded that functional performance assessment should not rely on a single performance test. Knapik et al. (2024), Manojlovic et al. (2024), Filbay et al. (2025), van Haren et al. (2025), and Richmond et al. (2026) recommended integrating multiple functional assessments with strength testing, patient-reported outcome measures (PROMs), and psychological evaluation to provide a comprehensive assessment of rehabilitation progress. Collectively, the reviewed literature indicates that multidimensional functional performance assessment offers a more accurate basis for RTS decision-making than isolated physical measurements, supporting safer rehabilitation outcomes and reducing the likelihood of reinjury after ACL reconstruction.

Strength Assessment and Limb Symmetry Index (LSI)

Assessment of muscle strength and the Limb Symmetry Index (LSI) represented one of the most consistently reported components of postoperative rehabilitation following Anterior Cruciate Ligament (ACL) reconstruction. Across the included studies, restoration of muscular strength, particularly quadriceps function, was regarded as a prerequisite for successful return-to-sport (RTS). Contemporary physiotherapy no longer considers postoperative time sufficient to determine recovery but instead emphasizes objective evaluation of muscular performance and inter-limb symmetry. This approach enables clinicians to identify persistent functional deficits that may remain undetected through subjective assessment alone, thereby supporting safer RTS decision-making and reducing the likelihood of reinjury.

Quadriceps strength recovery emerged as the primary indicator of successful rehabilitation throughout the reviewed literature. Faleide et al. (2021), Feller et al. (2024), Hardy et al. (2024), van Haren et al. (2025), and Grazzini et al. (2026) consistently reported that greater quadriceps strength was associated with superior knee function, improved dynamic performance, and higher rates of successful RTS. In contrast, persistent quadriceps weakness remained one of the most common impairments after ACL reconstruction and was frequently linked to reduced functional performance, movement compensation, and increased susceptibility to secondary ACL injury. These findings highlight the importance of progressive strengthening programmes throughout postoperative rehabilitation to restore lower-limb capacity before athletes resume unrestricted sporting activities.

Isokinetic Strength Testing was the most frequently reported method for objectively evaluating lower-limb muscle performance. Several studies employed isokinetic dynamometry

to quantify quadriceps and hamstring strength throughout rehabilitation and to monitor recovery over time. Faleide et al. (2021), Knapik et al. (2024), Feller et al. (2024), van Haren et al. (2025), and Hardy et al. (2024) demonstrated that patients exhibiting greater restoration of isokinetic strength consistently achieved better outcomes in functional testing and were more likely to satisfy RTS criteria. These findings indicate that objective strength measurement provides valuable information beyond routine clinical examination by detecting residual muscular deficits that may influence athletic performance following ACL reconstruction.

The Limb Symmetry Index (LSI) was repeatedly identified as an essential indicator of functional recovery because it quantifies performance differences between the reconstructed and contralateral limbs. Rather than evaluating absolute muscle strength alone, LSI provides insight into whether functional capacity has been restored symmetrically following rehabilitation. Richmond et al. (2026), Knapik et al. (2024), de Girolamo et al. (2023), and Schröter et al. (2024) consistently reported that higher LSI values were associated with improved movement quality, enhanced neuromuscular control, and greater readiness for RTS. Athletes demonstrating persistent asymmetry frequently exhibited lower functional performance and remained at greater risk of reinjury despite satisfactory postoperative recovery time, emphasizing that restoration of symmetry is as important as overall strength recovery.

Several studies further demonstrated that strength assessment and LSI should be interpreted alongside functional performance rather than as isolated measurements. Hop-based performance tests, dynamic jumping assessments, and sport-specific movement evaluations consistently showed stronger predictive value for successful RTS when combined with objective measures of muscle strength and limb symmetry. This integrated assessment enables clinicians to determine whether restored muscular capacity translates into efficient movement patterns during functional activities, thereby providing a more comprehensive evaluation of rehabilitation progress than isolated strength measurements alone.

Evidence synthesized from the included systematic reviews, scoping reviews, and meta-analyses consistently concluded that muscle strength and LSI remain indispensable components of contemporary RTS assessment but should not be used as the sole criteria for clinical decision-making. Knapik et al. (2024), Manojlovic et al. (2024), Filbay et al. (2025), van Haren et al. (2025), and Richmond et al. (2026) recommended integrating objective strength assessment with functional performance testing, patient-reported outcome measures (PROMs), and psychological readiness evaluation to provide a multidimensional assessment of postoperative recovery. Collectively, the reviewed evidence indicates that restoration of quadriceps strength and inter-limb symmetry forms the physiological foundation for successful rehabilitation, while comprehensive assessment remains essential to ensure a safe and sustainable return to sport following ACL reconstruction.

Patient-Reported Outcome Measures (PROMs)

Patient-Reported Outcome Measures (PROMs) were among the most frequently utilized assessment instruments identified in the reviewed literature, reflecting their important role in evaluating patient perceptions of recovery following Anterior Cruciate Ligament (ACL) reconstruction. Unlike objective performance tests that primarily measure physical function, PROMs provide direct insight into patients' experiences regarding symptoms, pain, knee function, activity limitations, quality of life, and confidence during rehabilitation. The included

studies consistently demonstrated that integrating PROMs with functional performance assessment and psychological evaluation provides a more comprehensive understanding of postoperative recovery than relying solely on objective clinical measurements.

The International Knee Documentation Committee (IKDC) questionnaire was one of the most commonly reported PROMs across the included studies. Faleide et al. (2021), Snyder-Mackler et al. (2022), Gokeler et al. (2023), Zampeli et al. (2024), Hardy et al. (2024), van Haren et al. (2025), and Russo et al. (2025) employed the IKDC to evaluate patients' perceptions of knee symptoms, function, and ability to perform daily and sporting activities. Improvements in IKDC scores consistently paralleled gains in muscle strength, functional performance, and rehabilitation progression, indicating that subjective perceptions of knee function generally improved alongside objective recovery. Nevertheless, several investigations reported that satisfactory IKDC scores did not always correspond to complete psychological readiness, suggesting that patient-reported knee function should be interpreted together with other rehabilitation outcomes.

The Knee Injury and Osteoarthritis Outcome Score (KOOS) also appeared frequently throughout the reviewed literature as a multidimensional PROM assessing pain, symptoms, activities of daily living, sport and recreation function, and knee-related quality of life. Snyder-Mackler et al. (2022), Gokeler et al. (2023), Knapik et al. (2024), Filbay et al. (2025), and van Haren et al. (2025) reported progressive improvements in KOOS scores following structured rehabilitation programmes. These findings indicate that successful physiotherapy extends beyond restoring mechanical knee stability by also improving patients' perceptions of their physical capabilities and overall quality of life after ACL reconstruction.

Additional PROMs identified across the included studies included the Lysholm Knee Score and the Tegner Activity Scale. The Lysholm Score was primarily used to evaluate symptoms such as pain, instability, swelling, and functional limitations, whereas the Tegner Activity Scale assessed patients' activity levels before injury and during postoperative recovery. Russo et al. (2025), Hardy et al. (2023; 2024), de Girolamo et al. (2023), and Filbay et al. (2025) demonstrated that improvements in these instruments reflected enhanced knee function and greater participation in physical activities following rehabilitation. Collectively, these PROMs provided complementary information regarding patients' perceived recovery that could not be fully captured through objective functional testing alone.

The reviewed studies consistently emphasized that PROMs should not be interpreted as independent indicators of readiness for return-to-sport (RTS). Several investigations demonstrated that patients may report satisfactory knee function while continuing to exhibit strength deficits, movement asymmetry, or psychological barriers that remain undetected through subjective questionnaires alone. Conversely, some athletes achieved excellent objective functional performance but continued to report reduced confidence or fear of reinjury, limiting successful RTS despite favourable clinical findings. These observations reinforce the importance of interpreting PROMs alongside objective strength assessment, functional performance testing, and psychological evaluation to obtain a comprehensive understanding of postoperative recovery.

Evidence synthesized from the included systematic reviews, scoping reviews, and meta-analyses consistently supported the routine incorporation of PROMs into contemporary

rehabilitation following ACL reconstruction. Knapik et al. (2024),Manojlovic et al. (2024), Filbay et al. (2025), van Haren et al. (2025), and Richmond et al. (2026) concluded that patient-reported outcomes provide valuable information regarding symptom resolution, perceived functional ability, activity participation, and quality of life. However, the literature uniformly recommended combining PROMs with objective functional measures and psychological assessment to improve the accuracy of RTS decision-making. Collectively, the reviewed evidence indicates that PROMs constitute an indispensable component of multidimensional physiotherapy evaluation, contributing substantially to evidence-based rehabilitation following ACL reconstruction.

Comparison of Contemporary Measurement Tools

The reviewed studies demonstrated that no single assessment instrument was capable of comprehensively evaluating recovery following Anterior Cruciate Ligament (ACL) reconstruction. Contemporary physiotherapy practice increasingly relies on combining objective performance tests, patient-reported outcome measures (PROMs), and psychological assessments to obtain a comprehensive understanding of postoperative recovery. Each measurement tool contributes unique information regarding different dimensions of rehabilitation, including physical function, muscular performance, movement quality, patient perception, and psychological readiness. Consequently, the selection of assessment instruments should be guided by the specific objectives of rehabilitation rather than relying on a single outcome measure.

Among the subjective assessment instruments, the International Knee Documentation Committee (IKDC), Knee Injury and Osteoarthritis Outcome Score (KOOS), Lysholm Score, and Tegner Activity Scale were the most frequently utilized PROMs. The IKDC primarily evaluates symptoms and perceived knee function, whereas KOOS provides a broader multidimensional assessment encompassing pain, symptoms, activities of daily living, sport participation, and quality of life. The Lysholm Score focuses on knee-related symptoms such as instability and pain, while the Tegner Activity Scale measures changes in activity level before and after injury. Collectively, these questionnaires provide valuable information regarding patients' perceptions of recovery; however, the reviewed studies consistently indicated that subjective outcomes alone cannot accurately determine readiness for return-to-sport (RTS).

Objective functional assessments offered complementary information by directly evaluating physical performance during rehabilitation. Hop Tests, Limb Symmetry Index (LSI), and Isokinetic Strength Testing were the most consistently reported objective measurement tools across the reviewed literature. Hop-based assessments evaluated functional performance during sport-related tasks, LSI quantified symmetry between the reconstructed and contralateral limbs, and isokinetic dynamometry objectively measured quadriceps and hamstring strength. Studies by Kuroda et al. (2021), Feller et al. (2024), Knapik et al. (2024), Richmond et al. (2026), and van Haren et al. (2025) demonstrated that these measurements provide valuable evidence of neuromuscular recovery and functional capacity before athletes resume unrestricted sporting activities. Nevertheless, objective performance measures may fail to identify psychological barriers that continue to influence RTS outcomes despite satisfactory physical recovery.

Psychological assessment was primarily performed using the ACL-Return to Sport after Injury (ACL-RSI) scale, which emerged as the most frequently reported instrument for evaluating confidence, emotional readiness, and fear of reinjury. Multiple studies consistently demonstrated that higher ACL-RSI scores were associated with greater success in returning to pre-injury sporting levels. Unlike functional performance tests, the ACL-RSI captures psychological factors that cannot be measured through muscle strength or movement analysis. The reviewed evidence therefore indicates that psychological assessment complements objective functional evaluation by identifying athletes who appear physically recovered but remain psychologically unprepared for unrestricted sport participation.

Several studies also introduced emerging assessment approaches designed to enhance conventional rehabilitation evaluation. Biomechanical analysis using the Drop Vertical Jump and Single-Leg Vertical Hop Test provided additional information regarding movement quality and landing mechanics, while MRI-based graft maturation assessment evaluated biological recovery following ACL reconstruction. Although these techniques demonstrated promising clinical utility, the reviewed literature indicated that their routine application remains limited because of equipment requirements, technical complexity, and availability. They are therefore considered complementary assessments rather than replacements for established functional and psychological measurement tools.

Overall, the comparison of contemporary measurement tools demonstrates that each instrument possesses distinct strengths and limitations, reflecting the multidimensional nature of rehabilitation following ACL reconstruction. Evidence synthesized from the included systematic reviews, scoping reviews, and meta-analyses consistently supports integrating PROMs, objective functional testing, muscle strength assessment, and psychological evaluation within a criterion-based RTS framework. Such a comprehensive assessment strategy enables clinicians to identify residual deficits across multiple recovery domains, thereby improving the accuracy of clinical decision-making and promoting safer return-to-sport outcomes after ACL reconstruction.

CONCLUSION

This systematic review synthesized evidence from 30 studies published between 2021 and 2026 to examine physiotherapy outcomes and contemporary return-to-sport (RTS) assessments following anterior cruciate ligament (ACL) reconstruction. The findings indicated that postoperative physiotherapy was associated with improvements in knee function, muscle strength, functional performance, patient-reported outcomes, and psychological readiness. Across the reviewed literature, successful rehabilitation was characterized not only by the restoration of physical capacity but also by increased confidence and psychological readiness to resume sports participation safely.

The review further demonstrated that contemporary RTS decision-making has increasingly shifted from time-based rehabilitation protocols toward criterion-based assessment approaches. No single assessment instrument was identified as sufficient to determine readiness for RTS. Instead, the evidence supported integrating objective functional assessments, including hop tests and isokinetic strength testing, with the Limb Symmetry Index (LSI), which quantifies performance differences between the involved and uninvolved limbs.

These assessments were complemented by patient-reported outcome measures (PROMs), including the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Lysholm Knee Scoring Scale, and Tegner Activity Scale, alongside psychological readiness assessment using the Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) scale. This multidimensional approach provided a more comprehensive evaluation of postoperative recovery and supported informed clinical decision-making before unrestricted sports participation.

The evidence also highlighted psychological readiness as an important factor associated with successful RTS following ACL reconstruction. Athletes reporting greater confidence and less fear of reinjury were generally more likely to return to their preinjury level of sports participation, whereas satisfactory physical recovery alone did not necessarily ensure successful RTS. Collectively, the reviewed studies supported individualized, evidence-based physiotherapy programs that integrated physical, functional, and psychological assessments throughout rehabilitation. Such approaches may optimize postoperative recovery, improve RTS readiness, and contribute to reducing the risk of subsequent ACL injury.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to the conduct of the research, preparation, or publication of this article.

AUTHOR CONTRIBUTIONS

All authors contributed to the preparation of this article. Mohamad Reza Hilmy, Syahmirza Indra Lesmana, Amriansyah Syetiawinanda, Nuraini Diah Noviati and Fera Gusmi Nurba, was responsible for the conceptualization of the study, data collection and analysis, interpretation of the results, and manuscript preparation. The other authors contributed to the review, editing, and final approval of the manuscript.

GENERATIVE AI STATEMENT

The authors declare that no generative artificial intelligence was used in the preparation of this article.

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