THE CURRENT APPROACH TO RESTORING KNEE STABILITY THROUGH THE KNEE SYMMETRY MODEL: LITERATURE REVIEW

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Abstract. *The main objectives of anterior cruciate ligament reconstruction (ACLR) are to maximize stability and functional capacity, while enabling a safe return to sports activity. The aim of this study was to conduct a literature review focused on the objectification of the Knee Symmetry Model (KMS) program in restoring stability and motor control of the knee following ACL surgery, using the Limb Symmetry Index (LSI). The purpose of KMS is to restore symmetry in the affected limb in terms of range of motion (ROM), strength, and function compared to the contralateral limb. The literature review included 200 articles selected based on eligibility criteria, through searches of databases such as PubMed, Medline, Web of Science, Cochrane Library, Embase, etc., encompassing randomized controlled trials and cohort studies. The principal outcome of the review indicated that restoration of hamstring strength symmetry remains suboptimal up to one year following anterior cruciate ligament (ACL) reconstruction, with values frequently falling below the 90% limb symmetry index (LSI) threshold typically used to define successful recovery. Although it is theoretically plausible that achieving an LSI of ≥90% in hamstring strength may confer a protective benefit given the hamstrings' role as synergistic stabilizers of the ACL-only four of the studies included in the review reported disaggregated hamstring strength data for individuals who sustained a subsequent ACL injury. The conclusion of the study is that the use of LSI, in the context of applying the KMS, may allow for effective monitoring of the progression of stability and functional symmetry in the operated ACL knee.*

Keywords: *knee; knee symmetry model; stability; symmetry index.*

Introduction

Injuries to the anterior cruciate ligament (ACL) are prevalent among physically active and athletic individuals, frequently necessitating surgical intervention to re-establish joint stability and functional capacity. While anterior cruciate ligament reconstruction (ACLR) is generally associated with favorable outcomes, the risk of postoperative complications, including reinjury and recurrence, remains a significant concern especially in the context of return-to-sport scenarios. Consequently, the objective assessment of recovery progress is critical to guiding clinical decision-making and ensuring safe rehabilitation.

The Knee Symmetry Model (KSM) proposes a standardized approach for monitoring symmetry between the operated and healthy limb, using the Limb Symmetry Index (LSI). This model aims to balance range of motion, strength, and function as relevant indicators for clinical decision-making regarding the return to demanding activities.

This paper aims to review the scientific literature regarding the application of the KSM in post-ACLR rehabilitation, in order to highlight the role of LSI in objectively tracking functional progress and reducing the risk of recurrence.

The main objective of this critical and comprehensive literature synthesis is to explore the application of the Knee Symmetry Model (KSM) in the postoperative rehabilitation process following anterior cruciate ligament reconstruction. By leveraging the Limb Symmetry Index (LSI), we present various aspects of how this index is used in the recovery process to reestablish

the stability of the ACL-operated knee, and to monitor the degree of functional balance between the operated knee and the contralateral limb. The analysis integrates range of motion, muscle strength with a particular focus on the posterior chain of the thigh and dynamic stability. Additionally, the literature review aims to track the correlation between achieving an LSI threshold ≥ 90% for hamstring strength and the incidence of ligament reinjury, highlighting the potential protective role of muscular symmetry in preventing recurrence.

Materials and Methods

This study employed thematic analysis, a method commonly used in medical synthesis articles, with a focus on high-quality information and a detailed understanding of the subject. One of the search strategies used was the Setting, Perspective, Intervention, Comparison and Evaluation (SPICE) method. Documentation was carried out by consulting specialized journals, starting from the titles and abstracts of articles published in PubMed. We used specific keywords or keyword combinations to ensure relevance and comprehensiveness of the results, selecting the following search terms: knee, knee symmetry model, stability, symmetry index.

Inclusion Criteria

1. Randomized clinical trials (RCTs) and cohort studies evaluating adult patients (≥ 18 years) who underwent anterior cruciate ligament reconstruction (ACLR);
2. Use of the Knee Symmetry Model (KSM) program and reporting of the Limb Symmetry Index (LSI) for joint mobility (range of motion - ROM), muscle strength, and function;
3. Postoperative evaluations in which LSI is calculated separately for quadriceps and hamstrings;
4. Articles published in peer-reviewed journals indexed in PubMed, Medline, Web of Science, Cochrane Library, or Embase;
5. Full-text articles available in English or Romanian, containing complete original data.

Exclusion Criteria

1. Literature reviews, meta-analyses, single case studies, editorial letters, and commentaries;
2. Studies that do not report LSI values for ROM, muscle strength, or function;
3. Pediatric populations (< 18 years) or patients with complex/multiple knee injuries associated with other surgical interventions;
4. Articles without full-text access or with insufficient data for calculating limb symmetry.

The literature search was conducted across multiple databases, including Allied Health Source, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane, EBSCOhost, PubMed, ProQuest Health & Medical Collection, ProQuest Nursing, MEDLINE, ScienceDirect, and SPORTDiscus. Eligible studies were those published in English or French, available in full text, and published in peer-reviewed journals. Inclusion criteria required that studies address the Knee Symmetry Model and anterior cruciate ligament (ACL) injuries. The article selection process is outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram presented in Figure 1.

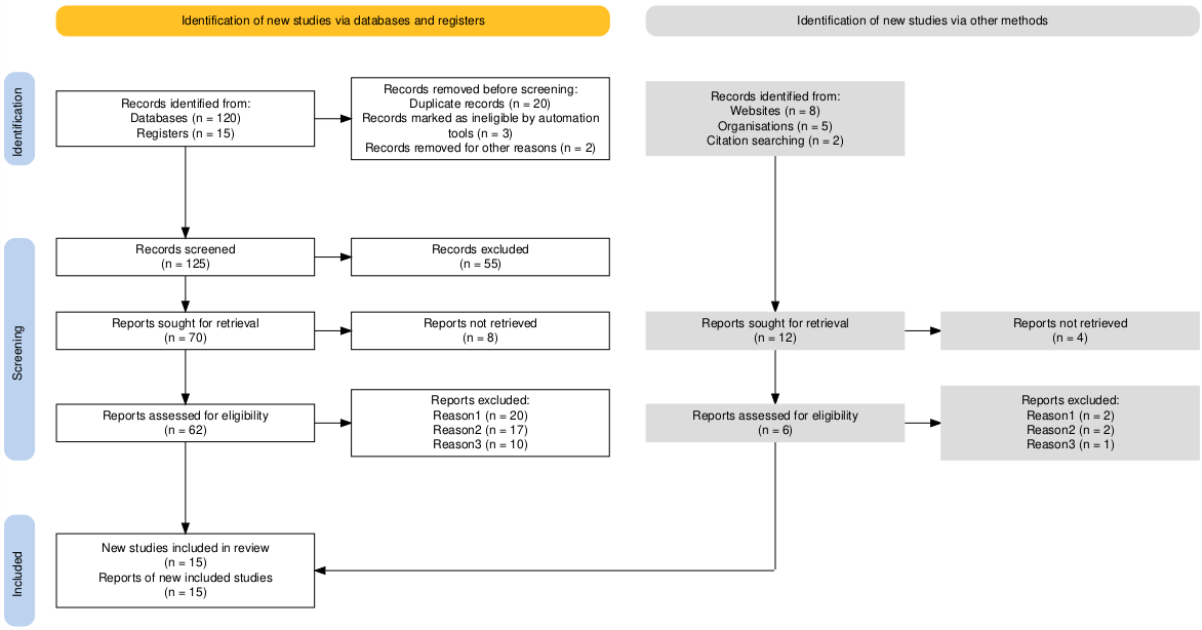

Figure 1. PRISMA flow diagram illustrating the study selection process

Results

A. Critical Analysis of Therapeutic Intervention in Surgically Treated ACL Injuries

Anterior cruciate ligament (ACL) injury is the most common and disabling knee injury associated with athletic activities. ACL rupture leads to decreased joint stability, muscle weakness, meniscal injuries, and pain, and accelerates the development of osteoarthritis. In an attempt to prevent deficits in joint function, surgical reconstruction of the torn ligament is a common orthopedic procedure at the knee level and is usually followed by six months of therapy. Strength deficits in the quadriceps and hamstring muscles represent a major challenge for both clinicians and patients after ACL reconstruction (ACLR). Therefore, strength assessments are widely performed after surgery to better understand patients' strength recovery over time and to plan a strength training program tailored to the patient's strength level. Most studies investigating muscle strength after ACLR have focused on testing concentric and/or eccentric strength of the stabilizing muscles of both the operated and contralateral knees. This is particularly important at the six-month time point, as this is when patients typically return to sports.

Analyzing the selected articles, we observed that in the study by Zore et al. (2021), ACL injuries are common, with an estimated incidence of approximately 81 ACL ruptures per 100,000 inhabitants aged between 10 and 64 years. After ACL reconstruction (ACLR), numerous short- and long-term issues can affect the health of the knee joint. Despite advances in surgical and rehabilitation techniques, the risk of a secondary ACL injury remains high.

According to Keays et al. (2022), return to sport following primary ACL reconstruction is associated with a markedly elevated risk of reinjury, estimated at 15- to 25-fold. Within five years post-surgery, reinjury rates have been reported at up to 22% for the reconstructed knee and up to 24% for the contralateral limb.

Regarding anterior cruciate ligament reconstruction (ACLR), it is a common intervention among physically active individuals who have suffered an ACL injury, as emphasized by Bodkin et al. (2017). Unfortunately, a large proportion of patients experience chronic knee symptoms that affect their daily activities and limit their ability to exercise. These patients may experience episodes of instability, muscle weakness, and joint pain and may perceive a heightened level of disability, which overall influences their return to the previous level of activity and potentially affects their ability to maintain a healthy and active lifestyle.

B. Muscle Function in Surgically Treated ACL Injuries

The function of skeletal muscles plays a crucial role in ensuring knee joint stability, maintaining postural control, and absorbing forces acting on the joint. ACL reconstruction (ACLR) is associated with diminished muscle function and abnormal functional movement patterns which can persist long after the initial injury or surgical reconstruction. Muscle function impairment following ACLR, reflected by a decrease in quadriceps strength, has been shown to predict unfavorable subjective knee function outcomes.

Current studies aiming to highlight relationships between subjective function and other factors have mainly recruited large cohorts with varying time intervals since the ACLR procedure. These relationships may vary as patients move further away from the postoperative period, since activity levels and physical demands may change.

Developing clinical guidelines to improve function in ACLR patients after returning to normal activity can be facilitated by a better understanding of the link between skeletal muscle dysfunction and subjective knee disability. Many current predictors of outcomes post-ACLR focus on preventing ACL injury recurrence and ensuring safe reintegration into previous activity levels. Traditional clinical tests such as measuring quadriceps and hamstring strength and symmetry and assessing single-leg hop performance and symmetry are often used to identify muscular deficits following ACLR, support return-to-sport decisions, and monitor long-term joint health.

Among ACLR patients who have completed postoperative rehabilitation, authors refer to clinical recommendations involving measures of muscular performance designed to improve perceived function. One limitation of these studies is the examination of a highly heterogeneous population in terms of time since surgery. The relationships between muscular and subjective function may not remain consistent over such a broad timeframe, during which ACLR knee demands and activity levels can change. Therefore, it is important to establish these relationships in order to provide individualized clinical recommendations tailored to the time elapsed since surgery.

Anterior cruciate ligament (ACL) reconstruction is frequently performed to restore knee stability after an ACL rupture. However, recovery of sport-related function following ACLR varies significantly, and some athletes never return to their previous level of performance. Criteria-based rehabilitation aims to restore sports function; nonetheless, deficits such as reduced range of motion, quadriceps and hamstring weakness, gait abnormalities and altered neuromuscular activation patterns persist, with some lasting up to two years. Muscle deficits, in particular, are associated with altered knee biomechanics and function and thus are key areas of focus in rehabilitation.

Most studies have assessed muscle strength recovery starting from 6 months post-ACLR. However, studies examining the relationship between quadriceps and hamstring strength and knee function in the first 6 months after ACL reconstruction are limited. During this time, rehabilitation progression includes initiating high-impact activities such as running and plyometrics. It is well documented that performing high-impact activities with insufficient quadriceps strength can lead to abnormal joint loading and asymmetrical dynamic knee function. However, the relationship between hamstring strength and knee function is not as clearly defined.

The primary goals of anterior cruciate ligament reconstruction (ACLR) are to restore joint stability and functional performance, thereby facilitating a safe return to sport (RTS). Despite these objectives, research indicates a notably high incidence of recurrent ACL injuries, with the highest risk occurring within the first 12 months postoperatively. During this period, the likelihood of reinjury is at least twice as high as that observed in uninjured knees. Patients are frequently advised that RTS may be possible within 12 months, contingent upon meeting specific clinical and functional benchmarks; however, some studies suggest that return as early as six months may be permissible under certain conditions.

Several factors can affect both a patient's likelihood of returning to sport and their susceptibility to reinjury. These include preoperative variables such as age, neuromuscular control, knee extension, and participation in prehabilitation as well as intraoperative considerations like graft selection. Postoperative elements, including the quality of rehabilitation and psychological readiness, also play a critical role. One of the primary contributors to reinjury risk may be the insufficient recovery of muscular strength and function, which are considered fundamental prerequisites for a safe and effective return to sport.

Single-leg hop tests and maximal muscle strength assessments are commonly used to determine physical capacity, with results typically reported using the Limb Symmetry Index (LSI). LSI measures the strength or function of the operated limb relative to the non-operated limb. Research has shown an increased risk of reinjury if patients fail to achieve an LSI of at least 90% on strength and hop tests.

Although many factors can influence strength and function after ACLR, the role of pre- and postoperative rehabilitation is well-documented. Studies on the benefits of rehabilitation typically include patients enrolled in clinical trials, who are closely monitored and follow predetermined rehabilitation protocols. This may not reflect the situation of community-level patients, who consult local therapists for rehabilitation guidance after ACLR and for determining the appropriate time to return to sport (RTS). Rehabilitation can help restore neuromuscular deficits; therefore, investigating lower limb symmetry and its connection to rehabilitation among community-level ACLR patients is critically important, especially as this is the period when patients believe and are often informed that they can return to sport (or may already have done so).

Thus, the study by Ebert et al. (2018) aimed to investigate lower limb strength and functional symmetry using common clinical assessments in community-level ACLR patients (as opposed to elite athletes or patients undergoing rigorous rehabilitation in controlled studies), at a time when many believe (and are told) they can return to their chosen sport. It also aimed to explore the association between limb symmetry and various components of postoperative rehabilitation - an area not previously examined.

The study highlights a critical issue in the postoperative management of ACLR patients: the discrepancy between objective criteria for safe return to sport (RTS) and current clinical practice. The high proportion of patients who fail to reach the recommended threshold of ≥90% LSI despite returning to sport underscores a significant problem regarding compliance with rehabilitation programs and the objective evaluation of functional recovery.

This article draws attention to a concerning trend: patients are either prematurely cleared to resume physical activity or choose to return on their own, without rigorous clinical validation. Such practices can increase the risk of reinjury and compromise the long-term outcomes of surgical intervention.

The added value of this study lies in the fact that it is the first to clearly demonstrate the strong link between rehabilitation and the achievement of appropriate functional symmetry. This finding supports the need for standardized rehabilitation protocols and continuous monitoring based on objective criteria before permitting full return to sport.

The study provides an important contribution to the literature, suggesting an urgent need to improve post-ACLR rehabilitation strategies and to strengthen the criteria for RTS evaluation especially in the context of community-treated patients.

The recovery of knee extensor and flexor muscle strength following anterior cruciate ligament (ACL) reconstruction is considered a critical component in facilitating a return to high-demand activities, as emphasized by Högberg et al. (2024). Knee extensors play a key role in absorbing impact and regulating knee flexion, while the flexor muscles contribute to limiting anterior tibial translation and enhancing rotational stability of the joint. As such, restoring strength in both muscle groups is fundamental to the rehabilitation process after ACL injury. Muscle strength is commonly assessed using the Limb Symmetry Index (LSI), which compares the performance of the injured limb to the uninjured one. A widely accepted benchmark for successful recovery is an LSI of ≥90% for both knee extensors and flexors, according to expert consensus. While achieving this threshold in extensor strength has been associated with a reduced risk of ACL reinjury upon returning to sport, the influence of hamstring (flexor) strength symmetry remains less well understood. Leiter et al. (2014) suggest that standardized knee flexor strength assessment following ACLR is essential for evaluating its role in the prevention of secondary ACL injuries.Interpretation of flexor strength data is complicated by the biarticular nature of the hamstring muscles, which function across both the hip and knee joints. Strength measurements can vary significantly based on joint positioning peak torque tends to be lower at high degrees of knee flexion and when the hip is extended (as in prone or supine testing), compared to the seated position. Harput et al. (2015) highlight that graft selection influences strength recovery, noting that hamstring tendon (HT) autografts are often associated with greater hamstring strength deficits compared to patellar or quadriceps tendon grafts.

C. Restoration of Joint Mobility in Surgically Treated ACL Injuries

Numerous researchers highlight that a primary objective of postoperative rehabilitation following anterior cruciate ligament (ACL) reconstruction is the complete restoration of range of motion (ROM). Rubinstein et al. observed that achieving full knee extension shortly after

surgery in a cohort of 194 patients who underwent ACL reconstruction using an autologous patellar tendon graft did not compromise graft integrity or joint stability. Safeguarding the graft remains a shared concern for both the patient and the surgical team, and adherence to rehabilitation protocols is often enhanced when a foundation of trust exists among the patient, surgeon, and rehabilitation professionals.

The early initiation of quadriceps strengthening exercises has been linked to earlier improvements in ROM, facilitating more rapid gains in mobility. Evidence suggests that regaining symmetrical ROM during the initial phase of ACL rehabilitation is critical for preserving long-term joint function. Prompt restoration of muscle strength and ROM contributes to earlier mobilization and enables more effective progression through advanced rehabilitation stages. Consequently, training interventions aimed at preserving long-term ROM can commence sooner. Prior studies indicate that patients who attain normal ROM, as defined by International Knee Documentation Committee (IKDC) standards, tend to experience superior postoperative outcomes.

The discussion surrounding the speed of ROM recovery has prompted debate on whether rehabilitation protocols should be accelerated. However, the literature offers no clear consensus on this issue. Beynnon et al. (2011) found no significant differences between accelerated and conventional rehabilitation programs in relation to knee joint laxity, clinical assessments, proprioception, functional performance, or thigh muscle strength. Shelbourne advocated for rehabilitation strategies prioritizing immediate and sustained knee extension, warning that persistent ROM limitations following ACL graft remodeling could be linked to radiographic signs of long-term osteoarthritis.

More recently, Christensen et al. (2013) reported no significant distinctions between early aggressive and more conservative rehabilitation approaches in terms of knee laxity or subjective IKDC scores. Secondary outcomes, including ROM and peak isometric strength, were also comparable between groups. A systematic review by Kruse et al. (2012) concluded that additional research is necessary to better understand the potential benefits of accelerated rehabilitation protocols for expediting return to sport.

Based on these studies, the importance of early ROM restoration in ACL postoperative rehabilitation is evident. However, the optimal timing for initiating ROM exercises in the immediate postoperative period remains unclear. It is known that early achievement of knee extension and flexion ROM reduces the risk of arthrofibrosis. Clinically, achieving full ROM within the first 2-3 weeks is seen as an accelerated approach. From our experience, ROM recovery during this window should be encouraged unless patient adherence is problematic.

During the initial phase of rehabilitation, the restoration of a normal gait pattern requires the coordinated and synchronized activation of the quadriceps and their antagonistic counterparts, the hamstring muscles. Gait improvement varies individually, with pain sensitivity, anxiety, and other factors potentially delaying recovery. In nearly all cases during this phase, quadriceps atrophy is observed, caused by joint effusion that inhibits quadriceps activation. Numerous studies have shown that electrical stimulation (ES) helps prevent muscle atrophy.

In a 1991 study, Snyder-Mackler et al. evaluated patients randomized to receive ES with voluntary contraction versus voluntary contraction alone. The study reported a significant positive effect in the group receiving electrical stimulation (ES), with improvements observed in cadence, walking speed, stance duration on the affected limb, and knee flexion excursion

during the stance phase, compared to the group performing voluntary exercises alone. The authors noted that participants in the ES group demonstrated greater quadriceps strength and exhibited a gait pattern more closely resembling normal biomechanics.

D. The Knee Symmetry Model in Post-Operative ACL Rehabilitation

Although less extensively examined in the existing literature, the Knee Symmetry Model (KSM) represents a comprehensive and evolving framework for rehabilitation following anterior cruciate ligament (ACL) reconstruction. As outlined in the work of Biggs et al. (2009), rehabilitation strategies have progressed considerably over the past decade from the "Accelerated Rehabilitation after ACL Reconstruction" approach introduced in 1990 to the more contemporary KSM, which is grounded in evidence-based outcomes. Central to this model is the emphasis on achieving functional symmetry between both knees, reflecting a shift away from rigid, time-dependent postoperative protocols.

The KSM introduces several critical distinctions when compared to earlier rehabilitation paradigms. These include a focus on bilateral knee symmetry, the abandonment of fixed timelines in favor of individualized progression, the allowance of immediate full range of motion (ROM) post-surgery, the implementation of strict bed rest for the initial five days following the procedure, and the provision of targeted rehabilitation for both the ACL-reconstructed knee and the graft-donor site.

The model's development is rooted in long-term clinical observations, which indicate that patients attaining early symmetry in ROM between the operated and non-operated limbs report superior subjective and objective recovery outcomes. Moreover, early achievement of knee symmetry has been associated with a lower incidence and reduced severity of postoperative complications.

The CBPTB (Contralateral Bone-Patellar Tendon-Bone) surgical procedure supported this process by identifying different rehabilitation needs for the ACL-reconstructed and graft-donor knees. Understanding the distinct goals for each knee allowed the creation of a rehabilitation program focused on restoring knee symmetry as quickly and safely as possible.

This clinical work describes a new rehabilitation philosophy and protocol after ACL reconstruction. Data collected indicate that patients who achieve symmetrical knee ROM show improved outcomes both subjectively and objectively. Key principles of the model that facilitate knee symmetry include: eliminating time-based postoperative milestones; granting immediate full knee mobility; initial bed rest during the first postoperative week; specialized rehab for both the donor and reconstructed knees.

The Knee Symmetry Model delivers outcomes that ensure the best short- and long-term functional results, while also reducing postoperative complications after ACL reconstruction.

When statistically analyzing postoperative recovery in a group of athletes undergoing a rehabilitation program based on the KSM, the authors Cristiani et al. (2019), observed the following: only 19.6% of patients achieved symmetrical knee function six months after primary ACL reconstruction (ACLR); factors that reduced the likelihood of achieving functional knee symmetry included: age $\geq$ 30 years; medial meniscus (MM) resection or repair; conversely, the use of hamstring tendon (HT) autografts instead of BPTB grafts increased the chance of achieving functional knee symmetry at six months post-op.

This study demonstrates that most patients do not fully recover symmetrical knee function by six months after ACLR. Moreover, it identifies several factors influencing this recovery in a large patient sample. The results should be used to counsel patients on expected functional recovery and to optimize rehab protocols in order to maximize knee function post-ACLR. Regarding the Limb Symmetry Index (LSI): for functional evaluation, the Limb Symmetry Index (LSI) is an objective indicator, calculated using isokinetic strength parameters: LSI = Affected limb force / Healthy limb force, especially using peak torque for knee extensors or flexors; the LSI is widely used to monitor rehab progress after ACLR and to determine the safe return-to-sport (RTS) timing.

Regarding functional rehabilitation of the ACL-operated knee based on KSM, Drigny et al. (2022) highlighted in that: the main finding of our study is that isokinetic evaluation at 4 months post-op may help identify thresholds associated with the LSI value at 8 months, which is recommended for a successful and safe return to sport (RTS). Thus, for the quadriceps: Q-LSI4m4m4m >59% is recommended if targeting Q-LSI8m8m8m >80%; Q-LSI4m4m4m >67% for Q-LSI8m8m8m >85%; Q-LSI4m4m4m >71% for Q-LSI8m8m8m >90%. For the hamstrings: H-LSI4m4m4m >72% is recommended to reach an optimal H-LSI8m8m8m >90%. Moreover, reaching Q-LSI4m4m4m >59% or H-LSI4m4m4m >72% was associated with higher rates of successful return to sport (RTP) within two years post-surgery.

After ACL reconstruction, using isokinetic strength measurements for LSI at 4 months is closely linked with symmetrical muscle strength at 8 months-a common criterion for determining safe RTS. The study provides clinically relevant thresholds for both practice and research. Achieving a Q-LSI4m4m4m >59% and/or H-LSI4m4m4m >72% was associated with a threefold increase in the likelihood of successful RTP within 2 years.

Early LSI values were negatively affected by tourniquet duration, although this effect was reversible over time. Also, using a BPTB graft was associated with persistently lower Q-LSI.

Discussion and Conclusions

Anterior Cruciate Ligament Reconstruction (ACLR) is a common procedure among the active population; however, postoperative outcomes continue to show considerable variability, especially regarding injury recurrence and full return to sports. In this context, the need for standardized and objective methods of functional evaluation becomes essential. The Knee Symmetry Model (KSM), by utilizing the Limb Symmetry Index (LSI), offers a rigorous conceptual and operational framework for monitoring postoperative progress and guiding the decision-making process regarding return to sport.

Lynch et al. (2015) paper provides a critical analysis of the literature highlights that reaching a threshold of ≥90% LSI for quadriceps and hamstring muscle strength is a strong indicator associated with a reduced risk of re-injury and improved functional performance. In particular, muscle symmetry in the knee flexors appears to have significant predictive value, suggesting a biomechanical protective role in joint stabilization and prevention of recurrent instability. Recent studies support the implementation of isokinetic evaluations as early as the fourth postoperative month, offering pragmatic thresholds that accurately anticipate muscle symmetry levels at eight months - an essential milestone for the clinical decision to resume sports activities.

In addition to strength parameters, early and complete restoration of the range of motion (ROM) remains a fundamental component in post-ACLR rehabilitation. Evidence shows that achieving full extension in the immediate postoperative period is associated with better functional outcomes and reduced risk of complications such as arthrofibrosis. Nevertheless, the literature reflects a lack of consensus on the optimal pace of rehabilitation, although early initiation of quadriceps activation exercises including through electrostimulation has shown significant benefits in preventing atrophy and accelerating recovery.

A major issue identified in the reviewed literature is the gap between objective return-to-sport criteria and current clinical practice, especially in community settings. Many patients resume high-intensity physical activities without meeting the recommended functional symmetry thresholds, thereby exposing the joint to significant re-injury risks and compromising long-term outcomes. In this regard, the Knee Symmetry Model proposes a paradigm shift replacing rigid time-based protocols with an approach focused on objective and individualized functional assessment.

In conclusion, the implementation of the Knee Symmetry Model and the Limb Symmetry Index provides a clear and scientifically justified direction for optimizing post-ACLR rehabilitation. By standardizing evaluations and personalizing interventions, these tools contribute to reducing recurrence rates, maximizing functional performance, and strengthening the clinical decision-making process for a safe return to sports activities.

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