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Isokinetic Effectiveness in Athletes After ACL Reconstruction Surgery: A Scope Review

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Abstract

Background: Anterior cruciate ligament (ACL) injuries are a significant concern among athletes, often necessitating reconstructive surgery (ACLR) to restore knee function and enable return to sport.
Objectives: This scope review aimed to evaluate the effectiveness of isokinetic exercise in the rehabilitation of athletes following ACLR, focusing on the optimal timing, training methods, and their impact on muscle strength and functional recovery.
Methods: Articles published between 2016 and 2025 were systematically reviewed, with inclusion criteria emphasizing isokinetic interventions post-ACLR.
Results: The analysis revealed that isokinetic training administered between 3 and 6 months post-ACLR significantly improves quadriceps and hamstring strength, enhances limb symmetry, and expedites knee function recovery. Isokinetic dynamometry at various angular velocities, combined with functional tests such as the Single-Leg Hop Test, was found to be effective in monitoring rehabilitation progress and determining readiness for return to sport.
Conclusion: The findings underscore that well-timed and appropriately structured isokinetic exercise is an effective rehabilitation strategy for optimizing post-ACLR recovery in athletes, reducing muscle strength deficits, and minimizing the risk of re-injury..

Keywords: ACL reconstruction, isokinetic exercise, athlete rehabilitation, muscle strength, return to sport

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are one of the most serious problems in sports, especially in athletes who focus on lower extremity sports. This ligament plays an important role in maintaining the dynamic stability of the knee, and its rupture often results from sudden movements such as explosive changes in direction, improper landing after jumping, or sudden deceleration of movement. Not only do these ACL injuries cause joint instability, but they can also trigger muscle weakness, impaired balance and proprioception and increase the risk of future cartilage damage (Picinini et al., 2025).

In competitive athletes, the management of ACL injuries requires reconstructive surgery. (ACL Reconstruction/ACLR) to restore normal knee function. ACL Reconstruction is a common surgical procedure performed on athletes and active individuals after sustaining an ACL injury, which often occurs in sports that involve sudden stopping, pivoting, or jumping movements. According to Grassi et al., (2021) in an epidemiological study in Europe showed that the incidence of ACLR ranged from 21.7 to 33.6 per 100,000 population in each year during the period 2001-2015, with a peak incidence in 2011 of 37.11 per 100,000 population. Meanwhile, according to WHO (World Health Organization) data about 42.2% of ACL injuries occur in children and young adults. In Indonesia, the prevalence of knee injuries reaches about 9% or equivalent to 48 cases per 1000 patients with ACL injuries (Choirunisa et al., 2023). The success of ACLR is often assessed based on the recovery of knee stability, muscle strength and functional performance with the ultimate goal of enabling safe return to sport (RT). Among the key factors affecting post-ACLR outcomes, the recovery of muscle strength, especially in the quadriceps and hamstring muscles, plays an important role in ensuring the dynamic stability of the knee and reducing the risk of re-injury.

Isokinetic strength training and testing has become an important tool in rehabilitation and evaluation post ACLR. Isokinetic devices allow for controlled dynamic resistance training, thereby strengthening specific knee extensor and flexor muscles while minimizing stress on the joint. Several studies have shown that preoperative muscle strength, which is often assessed isokinetically, has a strong correlation withpost-ACLRstrength recovery and functional performance (Riesterer et al., 2020). In addition, the timing of ACLR implementation (early versus delayed) was shown to influence muscle strength recovery, where early reconstruction was associated with better outcomes in terms of limb symmetry and force generation ability (Wenning et al., 2023).

A post-ACLRrehabilitation program incorporating isokinetic exercise for 4 weeks has been shown to improve muscle strength, proprioception (joint position awareness), and balance which are among the important factors to determine the readiness for RTS. Compared to regular resistance training, isokinetic exercise yields better results in some aspects (Wang et al., 2023). However, there are differences of opinion in the literature regarding the optimal rehabilitation protocol, the effect of fraft type, and the relationship between isokinetic strength and functional performance tests such as the hop test (Sueyoshi et al., 2017). In addition, the role of prehabilitation in optimizing post-ACLR outcomes is gaining increasing attention, emphasizing the importance of evidence-based strategies to address muscle strength deficits before surgery.

This review synthesizes findings from recent studies to explore the relationship between ACLR, isokinetic exercise and functional recovery, focusing on three aspects between ACLR, isokinetic exercise and functional recovery, focusing on three aspects namely the impact of surgery time, the effectiveness of isokinetic interventions, as well as the importance of symmetrical muscle strength in RTS decision-making. Selection of ACLR as a research topic was based on its high clinical

significance, complexity in case management, as well as the the urgent need for a synthesis of current evidence to optimize rehabilitation outcomes. Through a thorough analysis of these factors, this review aims to provide a thorough understanding of how isokinetic training can be be utilized to improve rehabilitation outcomes in athletes undergoing ACLR.

METHODS

Design Study

This study was conducted as a scope review. The included studies were analyzed based on the following domains: (1) participant characteristics and gender, (2) rehabilitation procedures and duration, (3) measurement methods, (4) follow-up evaluation, and (5) principal findings.

Inclusion criteria were as follows: (1) original research articles involving athletes or physically active individuals who had undergone anterior cruciate ligament reconstruction (ACLR); (2) studies that included isokinetic exercise and/or isokinetic strength assessment as part of post-ACLRrehabilitation; (3) studies reporting outcomes related to quadriceps and/or hamstring strength, limb symmetry, functional performance, or return-to-sport indicators; (4) studies published between 2016 and 2025; and (5) full-text articles written in English or Indonesian, with preference given to English-language publications. Both male and female participants were included.

Exclusion criteria included: (1) studies involving non-surgical ACL management or preoperative interventions only; (2) studies that did not include isokinetic exercise or isokinetic strength assessment; (3) case reports, conference abstracts, editorials, narrative reviews, or opinion papers; and (4) studies with insufficient methodological detail or incomplete outcome data relevant to post-ACLR rehabilitation.

Study selection was based on relevance to the research focus on ACLR and isokinetic rehabilitation. The screening and selection process

followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparent identification, screening, eligibility assessment, and inclusion of studies. Only studies involving post-ACLR patients receiving isokinetic interventions were included to ensure consistency and accuracy in the scope review conclusions.

Seacrh Strategy

A comprehensive literature search was conducted using the following electronic databases: PubMed, Scopus, Springer Nature, BMJ Group, Frontiers, MDPI, Elsevier, and Google Scholar. The search strategy was developed based on the PICOS framework to ensure relevance and consistency with the research objectives. Keywords and Boolean operators were applied as follows: *Anterior Cruciate Ligament* OR *ACL*, *reconstruction*, *Anterior Cruciate Ligament Reconstruction* OR *ACLR*, *isokinetic*, and combinations such as *ACLR and isokinetic*.

The screening process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, including identification of records, removal of duplicates, title and abstract screening, full-text eligibility assessment, and final study inclusion. This process ensured transparent and systematic selection of relevant studies. The PRISMA flowchart is presented in Figure 1

Data analysis

To evaluate the role and effectiveness of isokinetic interventions in athletes after ACL reconstruction, a scope review approach was applied, with comparative analysis across included studies. Data extraction and comparison were guided by predefined domains: (1) author and year of publication, (2) participant characteristics and gender, (3) rehabilitation procedures and duration, (4) measurement methods, (5) follow-up evaluation, and (6) principal findings.

Comparative analysis was performed by examining similarities and differences across studies within each domain to identify patterns influencing rehabilitation outcomes. Variations in isokinetic training duration, angular velocity, postoperative timing, and participant characteristics were analyzed to explain differences in reported outcomes. Particular emphasis was placed on the post-ACLR rehabilitation time frame, as most studies evaluated isokinetic interventions during different postoperative phases. In addition, participant age and characteristics of the isokinetic exercise protocols were considered to better understand their relationship with muscle strength recovery and functional outcomes. Findings from this comparative analysis were synthesized to draw conclusions regarding the effectiveness of isokinetic rehabilitation following ACL reconstruction.

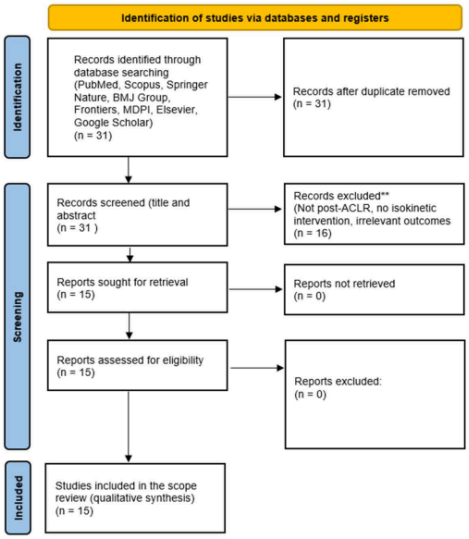

Figure 1. PRISMA flowchart

RESULTS

Based on the search strategy, we got 31 continuous articles with the topic of ACLR and Isokinetic and the year of publication in the range of 2016-2025. We set aside 16 articles as supporting articles and 15 other articles as the main articles used as data in the table, 16 articles were classified as upporting articles because some articles were considered not meeting the criteria to be added to the table. Some of the main articles were selected with the title criteria of post-OP ACLR given isokinetic exercise after Op in the span of several weeks or months. Our result can be seen in Table 1.

Table 1. Summarize main findings based on studies

Author (Year)	Participants & Gender	Rehabilitation Procedures	How to Measure	Follow-up Evaluation	Principal Findings
Wenning et al. (2023)	444 patients (72% men, 28% women)	EARLY group (<42 days), DELAYED (42-180 days). CHRONIC (>180 days). Standard rehabilitation post-ACLR (6 months).	Isokinetic dynamometer (60°/s) for strength extension / flexion .	5-7 months post-operative .	Early reconstruction (<12 weeks) results in better recovery of muscle strength. decreased in cases chronic .
Sueyoshi et al. (2017)	29 athletes (12 men, 17 women).	1. Standard training post - ACLR (26.4±6weeks).	1. Test jump single (single/triple/6-m/crossover hop). 2. Isokinetic dynamometer (180°/s and 300°/s).	When returning to sports (average 6 months).	Significant flexion strength deficit ($p<0.05$). Strong correlation between jump test and flexion strength ($r=0.69$).
Gerdijan et al. (2022)	144 patients (50% men, 50% women).	1. Group Isokinetic : 30 minutes / day ,5×/week (6 weeks). 2. Group classic : isotonic exercise .	Test isokinetic (60°/s) for flexor torque deficit (FLDEF%).	3 and 6 weeks rehabilitation .	Group isokinetic more effective reduce hams-tring deficit (65.3% ofsubjects deficit ≤10% vs. 18.1% in the control group classic).

Author (Year)	Participants & Gender	Rehabilitation Procedures	How to Measure	Follow-up Evaluation	Principal Findings
Wang et al. (2023)	41 athletes (14 men, 27 women).	1. Group isokinetic : training 60°/s and 240°/s (4 weeks,5×/week) 2. Group control: pneumatic resistance.	1. Isokinetic dynamometer. 2. Propriocepti on test (kinaesthesia, 30°/60° position). 3. Test balance (displacement AP/ML).	4 weeks post-interventi on .	Improvement strength extensor (40.3%) and flexor (31.7%), as well as proprioception ($p<0.05$). There was no improvement power stand flexion .
Cobian et al. (2025).	35 athletes (57% female).	8.9 ± 2.5 months post -ACLR.	Isometric and isokinetic (60°/s), CMJ, running .	Not mentioned .	Strength symmetry isometric more related to kinetics functional knees , while isokinetic more related to results report patient .
Riesterer et al. (2020)	80 patients (26 women).	6 months post -ACLR.	Isokinetic (60°/s).	6 months post-operative .	Preoperative strength correlates strongly with postoperative strength. H/Q ratio remains constant. stable.
Wang et al. (2025).	40 patients (gender not specified) specific).	6 weeks .	Isokinetic + PNF.	24 weeks .	The combination of isokinetics and PNF improves proprioception and function knee .
Cicchella & Zhang (2024).	Player Women's Football .	Not Applicable any rehabilitation (study normative).	Isokinetic (60°/s).	n't any	Optimal H/Q ratio 50%, D/NDratio <10% on players Healthy.
Kaeding et al (2016).	2683 subjects (56% male , 44% female).	Not specific, but focuses on risk factors after ACL reconstruction	Data from MOON cohort , analysis multivariable .	Follow-up 2 years (92.7% follow-up rate).	Age young , activity high , and the use of allografts increases risk injury repeat . - None difference significant based on type sex .

Author (Year)	Participants & Gender	Rehabilitation Procedures	How to Measure	Follow-up Evaluation	Principal Findings
Rawung et al (2024).	16 patients (81.25% male, 18.75% female).	ACL reconstructio n with Hamstring or peroneal graft . No rehabilitation details .	Record data medical and evaluation telephone .	Follow-up not specific , evaluation functional .	Majority patient own results functional moderate (43.75%). - ACL injuries are common accompanied by injury meniscus (56.25%).
Ong et al (2024).	36 patients (83% male , 17% female).	1. Intervention: Eccentric vs. isokinetic exercise concentric for 6 weeks (1x/week). 2. Duration : 6 weeks .	1. Strength Muscles : Measurement of peak torque of the quadriceps and hamstrings using Cybex Humac - Norm. 2. Function Knee : Single-leg hop test. 3. Return-to-sport: Interview patient .	Evaluatio n was conducted before and after 6 weeks of interventi on.	1. Eccentric training is more effective in increasing quadriceps (+43.61 Nm) and hamstrings (+31.22 Nm) strength than concentric training. 2. LSI (Limb Symmetry Index): Increased significant on hamstrings (ECC: 88.28% → 101.00%). 3. Return-to-sport: 55.6% of patients group eccentric return to sports vs. 27.8% group concentric .
Culiver . A et al (2025)	20 ACLR participants (10 female, 10 male) and 20 controls (12 female, 8 male)	Rehabilitatio n starts 12 weeks post-operative , duration up to 4 months .	Isokinetic dynamometer (20, 60, 120, 240, 400 °/s) for APT and ATW.	months evaluation post-operative .	1. APT and ATW deficits in ACLR in all speed . 2. speed slow more discriminatory . 3. There is none difference between uninvolved and control.
Genç & Güzel, (2022).	29 athletes men (age 18- 35 years)	Standard post-operative rehabilitation program,	Isokinetic dynamometer (60, 180, 240 °/s) for	months evaluation post-operative	1. Improvement significant Lysholm, Tegner, IKDC.

Author (Year)	Participants & Gender	Rehabilitation Procedures	How to Measure	Follow-up Evaluation	Principal Findings
		duration 6 months.	PT, H/Q ratio, JAPT, TPT, RD.	.	2. Deficit strength in ACLR vs. HK. 3. H/Q ratio is sufficient for RTS.
Adam et al. (2025)	552 patients teenagers (55% female).	Post- ACLR rehabilitation lasts 6 to 12 months .	1. Quadriceps and hamstring measurements using an isokinetic dynamometer (human norm, biodex system 3 or 4) 2. Do 90 degree hip flexion 3. Filling questionnaire For evaluation .	Evaluatio n is conducted at 6 to 12 months post ACLR operation .	1. BPTB produces more quadriceps strength 10.8% lower than quadriceps tendon (QT) graft and 20.4% higher low compared to the hamstring tendon (HT). 2. HT graft produced 9.6% higher quadriceps strength than QT. 3. BPTB graft produced 3.1% higher hamstring strength than QT and 7.0% higher than HT.
Huijuan Shi et al (2024).	23 patients post primary unilateral ACL and 25 controls healthy (gender not specific) and non-athletes.	Strength training beginning , practice coordination and balance progressive , closed chain exercises , and lunge progressions.	CON-TREX MJ (60°/sec) with knee range of motion 20°–90°.	6 and 12 months postoperat ively, with strength testing of both legs at each evaluation time.	Quadriceps and hamstring strength deficits in the reconstructed leg were still found up to 12 months after ACLR, especially at certain knee flexion angles. Symmetry power (LSI) no get better in a way significant during follow-up period .

DISCUSSION

The provision of isokinetic time is very influential on the results, because this is influenced by the athlete's post-ACLRe recovery period. in month 1 (Inflammatory phase and early proliferation) isokinetic exercise is not recommended. in month 2 is recommended for eccentric isokinetics with small intensity, weeks 3-4 increase strength without jeopardizing the graft, with small intensity. in month 3 the potential LSI >90% at return to play. in the 4th to 6th month of effective isokinetic exercise can significantly increase the Peak torque quadrisep and hamstring, LSI (>90%), Functional hop test and reduce the risk of injury, because the graft is sufficiently stable and the muscles are ready for heavy work. based on a comprehensive analysis of the articles in the table, the researchers who have maximum and significant results are carried out in months 3-6, such as in the research of Genç & Güzel, (2022), Culiver. A et al (2025), Adam et al. (2025), Riesterer et al. (2020), Cobian et al. (2025), but still have differences in training results that are influenced by the type of exercise, exercise intensity, participant and training method used.

Based on a comprehensive analysis of the studies in the table, the isokinetic dynamometer is the most effective and comprehensive measurement tool for assessing muscle strength, as it provides precise and objective measurements of quadriceps and hamstring performance across various angular velocities. The studies by Wenning et al. (2023) and Gerdijan et al. (2022) demonstrated that assessments at 60°/s are effective for evaluating muscle endurance and maximal strength capacity, while higher velocities (180–300°/s) are more suitable for assessing functional and sport-specific strength. Importantly, low angular velocity testing is more sensitive in detecting residual post-ACLR strength deficits, as it requires near-maximal voluntary torque production and better reveals neuromuscular inhibition and limb asymmetry that may be masked at higher speeds. These measurements are therefore crucial for accurately

determining rehabilitation progress, particularly given that cases treated early (<12 weeks) show superior strength recovery compared to delayed or chronic cases (>180 days).

To assess the functional ability of patients more holistically, the Single-Leg Hop Test is a very appropriate complementary tool. Research by Sueyoshi et al. (2017) found a strong correlation (r=0.69) between the results of this hop test and flexion strength measured isokinetically, while identifying significant flexion deficits ($p<0.05$). The combination of isokinetic measurement and proprioceptive neuromuscular facilitation (PNF) as performed by Wang et al. (2025) provided even more optimal results, with 65.3% of subjects achieving ≤10% deficit after 6 weeks of intervention.

Another important aspect of rehabilitation evaluation is determining the patient's readiness to return-to-sport (RTS). The study by Ong et al. (2024) showed that the eccentric approach with measurements at 60°/s and 240°/s resulted in a higher RTS success rate (55.6%) than the conventional approach (27.8%). Meanwhile, the multi-speed evaluation by Culiver et al. (2025) revealed that slow speed (60°/s) is more sensitive in detecting specific post-ACLR deficits. In clinical practice, it is recommended to use an approach that combines these various measurement tools. The early phase of rehabilitation should focus on basic isokinetic measurements (60°/s), followed by functional and proprioceptive tests in the intermediate phase, and multi-speed evaluation in the late phase. The combination of objective data from measurement tools with subjective patient reports (PROs) will provide the most comprehensive picture of rehabilitation progress and readiness to return to full activity.

Based on our analysis of the tables and journals reviewed, isokinetic exercises used in patients after anterior cruciate ligament (ACL) reconstruction are generally knee flexion and extension exercises using an isokinetic dynamometer at various angular velocities, such as 60°/s, 120°/s,

180°/s, up to 300°/s. These exercises are given either in the form of concentric or eccentric exercises, with varying frequency and duration, for example 30 minutes per day for 5 times a week for 6 weeks (Gerdijan et al., 2022), or exercises with a combination of low and high speeds (Wang et al., 2023; Genç & Güzel, 2022). In addition, some studies also combined isokinetic exercises with other methods such as proprioceptive neuromuscular facilitation (Wang et al., 2025) or compared with conventional exercises such as pneumatic resistance (Wang et al., 2023) and isotonic exercises (Gerdijan et al., 2022). Evaluation of exercise effectiveness is done by measuring muscle strength using an isokinetic dynamometer, which is considered the gold standard in objectively assessing quadriceps and hamstring strength (Sueyoshi et al., 2017; Culiver et al., 2025; Shi et al., 2024; Adam et al., 2025). This isokinetic exercise approach has been shown to be effective in improving muscle strength, accelerating recovery of knee function, and minimizing post-ACLR strength deficits in ACLR patients.

CONCLUSION

Analysis of various studies and practices of isokinetic training after ACL reconstruction shows that the most ideal period to perform isokinetic training is at 3 to 6 months postoperatively. This is done when the condition is stable enough and the muscles located around the knee are ready to receive a more intense training load without causing a high risk of injury. Isokinetic exercises given during this time have been shown to be effective in improving quadriceps and hamstring muscle strength and preparing patients to return to normal physical activity. In the process of evaluating the progress of rehabilitation, the isokinetic dynamometer is the most appropriate and comprehensive measurement tool for objective assessment of muscle strength. Measurements at various angular velocities, when combined with functional tests such as the Single-Leg Hop Test can

provide a complete picture of the patient's functional ability. This approach helps identify specific muscle deficits and determine patient readiness, so that the rehabilitation program can be tailored to the needs and conditions at each phase of recovery. The combination of well-timed isokinetic exercise and the use of appropriate measurement methods has been shown to improve the effectiveness of rehabilitation and the success of patients returning to sport after ACLR. Therefore, clinical evaluation standards that integrate isokinetic exercise with multi-method objective measurements are highly recommended to support a safe, fast, and maximized recovery process for athletes and general patients undergoing ACL reconstruction.

CONFLICT OF INTEREST

The author hereby declares that this research is free from conflicts of interest with any party.

AUTHOR'S CONTRIBUTION

Andara Gita Cahyani determines the theme and writes the introduction, results and discussion, Tyas Zahro Amalia1, Alya Zalfathia Kinanti1, Nudya Fani Zahra1 writes the method and looks for references according to Muchammad Yahya's method, writes the results and discussion.

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