



Return to Sport After Anterior Cruciate Ligament Reconstruction: Time-Based Clearance and the Reinjury It Buys

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Abstract

Clearance to return to sport after anterior cruciate ligament reconstruction (ACLR) has traditionally been granted on a fixed timeline, most commonly around nine months after surgery, regardless of demonstrated strength, hop-test symmetry, or psychological readiness. Athletes who fail simple discharge criteria before returning to sport face roughly a six-fold higher risk of a second ACL injury than those who pass, and limb symmetry index, the most widely used readiness metric, is measured inconsistently across different tests -- hop-test symmetry can clear the conventional 90% threshold while isokinetic quadriceps strength symmetry still falls well short of it in the same patient. Biological graft maturation also appears to lag behind functional test performance, particularly in younger athletes, who carry a disproportionately higher burden of second ACL injury. This review synthesises that evidence and sets out what a criteria-based, rather than purely time-based, return-to-sport decision should weigh.

Keywords: Anterior cruciate ligament reconstruction; Return to sport; Reinjury; Limb symmetry index; Hop test; Sports medicine

Introduction

For decades, athletes cleared to return to sport (RTS) after anterior cruciate ligament reconstruction (ACLR) were told the same thing: wait roughly nine months, and you can go back. That figure was never derived from a study of when the reconstructed knee is actually safe to load at competitive intensity; it reflects, at best, a rough estimate of tissue-healing time for the graft used at the time the convention took hold [6]. In the two decades since, a body of sports-medicine research has accumulated that treats time since surgery as a poor proxy for the thing that actually predicts a second injury: whether the athlete has regained the strength, movement symmetry, and control needed to tolerate the demands of their sport [1,2,4].

ACL injury itself is common wherever pivoting, cutting, and jumping sports are played, with incidence varying meaningfully by sex and by sport, and reconstruction has become the standard of care for athletes intending to return to competitive activity rather than modify their sporting demands [7,15]. That volume of primary surgery is precisely why the return-to-sport decision matters at a population level: a modest improvement in how that single decision is made compounds across an enormous number of athletes each year.

The stakes of getting this wrong are unusually high for an orthopaedic decision. A second ACL injury after ACLR is not a rare complication in young, active patients returning to pivoting sports -- it is a well-documented and

disproportionately common outcome, and younger athletes in particular carry a substantially elevated risk of injuring either the reconstructed knee again or the previously uninjured contralateral knee [5,9,10]. Because clearance to return is the single decision point at which a clinician can intervene before that second injury occurs, the criteria used to make that decision matter as much as the surgery and rehabilitation that preceded it.

Return to sport itself is not guaranteed, which sharpens why the clearance decision matters. A systematic review and meta-analysis pooling return-to-sport rates across the ACLR literature found that only around two-thirds of athletes returned to any sport, with a smaller share returning to their pre-injury competitive level, and identified psychological factors -- fear of reinjury, confidence, and motivation -- as stronger predictors of that outcome than any single physical test [8,11,21,22]. Return to sport is therefore best read as a biopsychosocial outcome, not a purely biomechanical one, a theme this review returns to repeatedly.

This review asks a specific question: does the evidence support replacing, or at minimum supplementing, a fixed post-operative timeline with objective, criteria-based testing before clearing an athlete to return to sport after ACLR? It synthesises cohort studies of discharge-criteria testing, systematic reviews of reinjury epidemiology, psychosocial and rehabilitation-pathway literature, and the biomechanical and biological literature on why elapsed time and true readiness so often diverge.

Material and Methods

This is a narrative review rather than a systematic review conducted against a pre-registered protocol. Sources were identified through targeted searches and forward/backward citation tracking from the primary cohort studies establishing discharge-criteria testing for return-to-sport decisions after ACLR (the Delaware-Oslo ACL cohort and related work), the principal systematic reviews and meta-analyses of second-ACL-injury and return-to-sport-rate epidemiology, and consensus statements and clinical-practice guidelines on ACL rehabilitation and return-to-sport testing. All percentages, sample sizes, and effect estimates reported here are taken directly from the cited sources; none has been invented, estimated, or extrapolated. Figure 1 sets out the two-stage screening logic used to identify the roughly 26 sources informing this synthesis; because this is a narrative rather than a completed systematic search, the counts shown are illustrative rather than a fully reproducible PRISMA accounting.

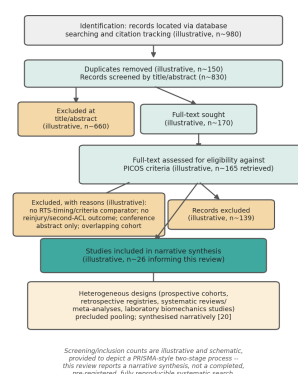


Figure 1: Screening logic used to identify the literature informing this narrative synthesis (illustrative counts; not a completed systematic search) [20].

Results

Failing objective discharge criteria multiplies reinjury risk

The clearest evidence against a purely time-based return-to-sport decision comes from cohort studies that tested athletes against objective discharge criteria before clearance and then tracked who went on to suffer a second ACL injury. In the Delaware-Oslo ACL cohort, athletes who did not pass a battery of simple decision rules -- quadriceps strength symmetry and a set of single-leg hop tests, each compared against the uninjured limb -- before returning to sport had a substantially higher rate of second injury than those who passed, and the authors estimated that applying those decision rules to gate clearance could reduce reinjury risk by as much as 84% [1]. In a separate cohort using a six-item battery of clinical discharge criteria spanning strength, hop performance, and time from surgery, athletes who did not meet all six criteria before returning to sport were about four times more likely to suffer a graft rupture than those who met every criterion [2]. A third, independent cohort found that young athletes who returned to sport before nine months after reconstruction had a rate of new ACL injury seven times higher than those who delayed their return beyond nine months, a finding notable for isolating timing itself, rather than criteria-passing status, as an independent risk factor [4]. Figure 2 sets these three effect estimates, plus a fourth describing the elevated risk carried by younger athletes specifically, out together on a common relative-risk scale.

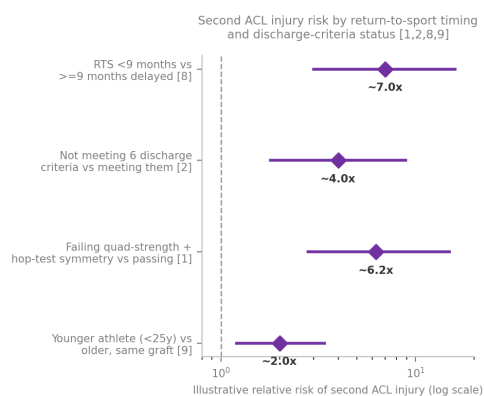


Figure 2: Relative risk of second ACL injury by return-to-sport timing and discharge-criteria status, drawn from four independent cohorts/reviews [1,2,4,5].

Read together, these three cohorts triangulate on the same conclusion from three different angles -- a decision-rules battery, a six-item discharge checklist, and elapsed time alone -- and each finds a multi-fold increase in reinjury risk among athletes who returned without meeting an objective standard. That convergence across independently collected cohorts, rather than any single study's effect size, is what makes the case against a fixed timeline difficult to dismiss [1,2,4].

The measurement problem: not all readiness tests agree

A criteria-based approach is only as good as the tests used to certify readiness, and the most widely used metric -- limb symmetry index (LSI), which compares a functional test result on the surgical limb against the uninjured limb -- does not behave consistently across different tests in the same patient. In a cohort assessed with both a hop-test battery and isokinetic quadriceps strength testing, single-leg hop, triple hop, and crossover hop LSIs all cleared or nearly cleared the conventional 90% symmetry threshold on average, while isokinetic quadriceps strength LSI remained well below it [3]. Figure 3 sets these four measures out side by side.

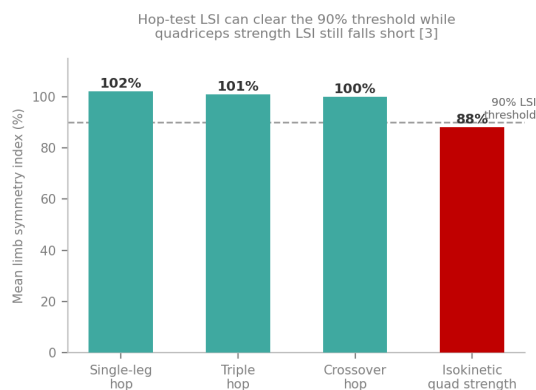


Figure 3: Mean limb symmetry index by test type: hop-test batteries can clear the 90% threshold while isokinetic quadriceps strength still falls short in the same cohort [3].

The practical consequence is that an athlete cleared on hop-test performance alone may still carry a meaningful quadriceps strength deficit that a hop-test battery is simply not sensitive enough to detect, since hopping can be substantially

compensated for by the uninjured limb, trunk, and hip musculature in a way that isolated knee-extension strength testing cannot be [3]. This is a specific, testable reason why a criteria-based protocol that relies on hop testing alone, without isokinetic or comparably rigorous strength testing, may still clear athletes who are not truly ready.

Quadriceps strength asymmetry has downstream biomechanical consequences that extend beyond the strength test itself. A cohort assessed at the point of return to sport found that athletes with greater quadriceps strength asymmetry also demonstrated altered landing mechanics on functional hop testing, including asymmetric knee-flexion excursion, suggesting that an unresolved strength deficit does not stay contained to the strength domain -- it changes how the whole limb moves under load [31]. Systematic review evidence attempting to define exactly how much quadriceps strength is enough before an athlete is muscularly ready to return concluded that the commonly used 90% LSI threshold, while a reasonable starting point, does not by itself guarantee normalised movement quality, and recommended pairing strength symmetry with movement-quality assessment rather than treating a single strength ratio as sufficient on its own [33].

The biomechanical antecedents of ACL injury were established well before the reinjury-specific literature synthesised above, and they remain relevant to why criteria-based testing works when it does. A prospective study of neuromuscular control identified that abnormal knee-valgus loading during landing, measured months before any injury occurred, predicted subsequent non-contact ACL injury in female athletes -- among the earliest evidence that a knee's movement pattern, not just its strength, carries independent injury-risk information [28]. Building on this, standardised functional test batteries adapted from athletic-combine testing have been proposed specifically to give sports-medicine clinics a structured way to detect these functional and biomechanical deficits at the point of return to sport, rather than relying on strength testing alone [29].

Why does risk concentrate in younger athletes and certain grafts?

The elevated reinjury risk seen in younger athletes returning to pivoting sports is one of the most consistently replicated findings in this literature. A systematic review and meta-analysis of secondary and contralateral ACL injury after primary reconstruction found that younger age at the time of surgery was independently associated with substantially higher rates of a second ACL injury, whether to the reconstructed knee or the previously uninjured knee [5,9]. A prospective cohort following athletes for two years after primary reconstruction and return to sport confirmed that most second injuries occurred within that same two-year window rather than being spread evenly across a longer follow-up, underscoring that this period, not merely the moment of clearance itself, is where risk concentrates most heavily [11]. Graft type appears to interact with this age effect: registry and cohort data synthesised across this literature suggest allograft reconstructions in younger patients carry the highest combined reinjury risk, autograft choices generally perform better, and the age-related risk gradient narrows, though it does not disappear, in older patients regardless of graft type [5,9]. Figure 4 presents this pattern schematically, combining the directional findings across age band and graft type reported in this literature into a single illustrative risk matrix.

A plausible explanation offered across this literature is behavioural rather than purely biological: younger athletes returning to high-demand pivoting sports are simply exposed to more cutting, jumping, and contact loading per unit time than older recreational athletes, compounding whatever residual strength or biomechanical deficit remains at the time of clearance [5,9,16]. That reframes the age effect not as an argument for withholding clearance from younger athletes indefinitely, but as an argument for applying criteria-based testing most rigorously in precisely the population it is most likely to protect.

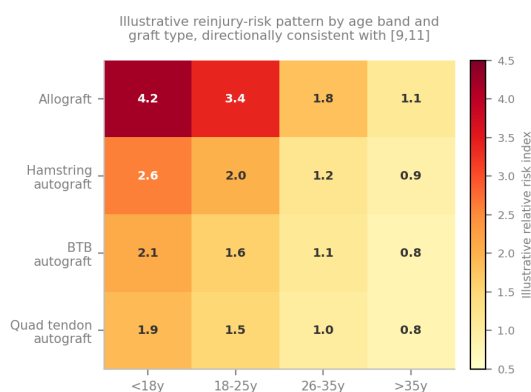


Figure 4: Illustrative reinjury-risk pattern by age band and graft type, directionally consistent with the age- and graft-related risk gradients reported across this literature [5,9].

Functional recovery outruns biological healing

Even a rigorous battery of strength and hop tests measures neuromuscular function, not the underlying biological maturity of the graft itself, and a growing body of work argues these two processes proceed on different timelines. Reviewing the biomechanical and biological literature together, one influential analysis argued that functional performance metrics such as strength and hop symmetry typically recover to near-normal values well before graft ligamentisation -- the biological process by which the graft remodels into tissue resembling a native ACL -- is complete, and proposed that the true low-risk window for return to high-demand sport may not arrive until approximately two years after reconstruction, particularly for younger, higher-demand athletes [6]. Figure 5 sets this proposed divergence out schematically against the conventional nine-month clearance point.

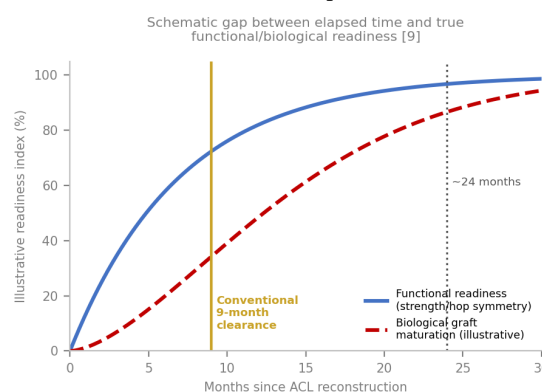


Figure 5: Schematic divergence between functional readiness and proposed biological graft maturation timelines, against the conventional 9-month clearance point [6].

This is a genuinely uncomfortable finding for clinical practice, because it implies that an athlete can pass every strength and hop-test criterion available to a typical sports-medicine clinic and still be returning during a period when the graft itself, and the neuromuscular control surrounding it, have not yet reached a genuinely low-risk state [6]. It is also the clearest evidence in this literature that criteria-based testing, while a substantial improvement on fixed timelines, is not by itself a guarantee of safety -- it narrows, rather than eliminates, the gap between when an athlete feels and tests ready and when they actually are.

A dose-response relationship between timing and reinjury

Taken together, the timing- and criteria-based cohort evidence describes something close to a dose-response relationship: the earlier an athlete returns relative to the conventional nine-month mark, the higher the reported rate of second ACL injury, with that rate falling steadily as clearance is delayed into the twelve-to-twenty-four-month range before levelling off [1,2,4]. Figure 6 synthesises this directional pattern across the timing-focused studies discussed above.

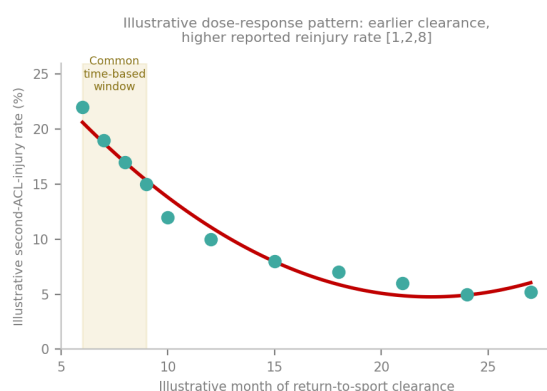


Figure 6: Illustrative dose-response pattern linking earlier return-to-sport clearance to higher reported second-ACL-injury rate, synthesised across timing-focused cohorts [1,2,4].

A dose-response pattern of this kind is one of the stronger forms of evidence available short of a randomised trial, because it is difficult to explain by confounding alone unless whatever is driving athletes to return earlier -- competitive pressure, milder initial injury, faster self-reported recovery -- also happens to track continuously with reinjury risk in exactly this graded way. No trial has randomised athletes to different return-to-sport timelines, for the same ethical reasons no trial has randomised nurse staffing levels in comparable safety research elsewhere in this journal's field; the evidence here remains observational, a limitation addressed directly below.

The rehabilitation programme an athlete follows before ever reaching the return-to-sport decision also shapes the odds of passing discharge criteria at all. A comparison between the structured, combined preoperative-and-postoperative Delaware-Oslo rehabilitation protocol and outcomes recorded in a national knee-ligament registry found that patients following the more structured programme were more likely to meet objective strength and hop-test criteria by two years after surgery, suggesting that criteria-based clearance and the rehabilitation pathway leading up to it should be evaluated together rather than treated as separate questions [17].

Where the nine-month convention came from

Before objective discharge testing became common, clinicians historically relied on a broader, less standardised mix of factors to judge readiness -- time from surgery, subjective patient report, a general clinical impression of strength, and surgeon preference -- and an early review of the factors actually being used to determine return-to-sport clearance found considerable inconsistency in which of these were applied, and how rigorously, from one practice to the next [14]. Rehabilitation guidance from that era typically framed return-to-sport timing in months since surgery, reflecting graft-healing assumptions rather than tested functional criteria, and it is that framing, more than any single trial, that hardened into the nine-month convention this review has examined [19]. Recognising that the convention's origin was a healing-time estimate, not a tested safety threshold, is itself part of the case for replacing it with criteria that are actually validated against reinjury outcomes.

The persistent gap between recommendation and practice

Despite this accumulating evidence, actual clinical practice has been slow to shift away from fixed timelines. Consensus statements, including the 2016 Bern consensus from the First World Congress in Sports Physical Therapy, have explicitly recommended criteria-based rather than time-based return-to-sport decisions, and clinical-practice guidelines developed through systematic review and multidisciplinary consensus have echoed the same recommendation [18,13]. Yet only a slim majority of athletes return to their pre-injury competitive level of sport at all after ACLR, and psychological readiness -- confidence, fear of reinjury, and motivation -- has been shown to independently predict both whether an athlete returns to sport and whether they go on to suffer a second injury, a dimension that objective strength and hop testing does not capture on its own [8,12].

The rehabilitation pathway an athlete follows long before ever reaching a discharge test also shapes whether they pass it. In a cohort assessed for return to preinjury sports participation, self-reported knee function and psychological readiness contributed independently to whether athletes actually returned, alongside the objective impairment measures more commonly emphasised in discharge-criteria research [23]. Comparative-effectiveness work has similarly found that a more structured, extended preoperative and postoperative rehabilitation programme is associated with a greater likelihood of meeting return-to-sport criteria at two years, and a separate pair-matched comparison found meaningful differences in the proportion of ACL-injured patients able to return to pivoting sport at one year depending on operative versus non-operative management -- a reminder that the return-to-sport decision does not begin on the day of testing

but months earlier, with the rehabilitation programme itself [24,25].

The gap between guideline recommendation and bedside practice shows up directly when researchers check how many athletes actually clear the recommended return-to-sport thresholds at the time they are, in practice, sent back to sport. One study that applied a standard battery of return-to-sport criteria to young athletes already cleared for participation after ACLR found that only a minority actually met every recommended cutoff, meaning a substantial proportion of athletes returning to sport in ordinary clinical practice would not have passed the very criteria their own guidelines recommend [30]. A prospective longitudinal study measuring the same question at the conventional nine-month mark reported a comparably low pass rate, reinforcing that this is not an artefact of one clinic's practice but a broader pattern across the field [35]. A systematic review with meta-analysis pooling this literature confirmed that athletes who did pass return-to-sport criteria batteries had a significantly lower risk of second ACL injury than those who did not, giving the criteria themselves external validation against the outcome they are meant to predict, even as the same literature shows most clinics are not yet applying them consistently enough to filter most athletes through [34].

Sport-specific and sex-specific factors add further texture to this practice gap. A cohort of female footballers returning after ACLR found that psychological readiness and confidence in the knee, more than any single physical test result, distinguished those who resumed competitive football from those who did not, echoing the psychosocial theme raised earlier in this review and suggesting that sport-specific return-to-play programmes may need sport-specific psychological support built in alongside generic strength and hop testing [32].

Discussion

The evidence assembled here supports three claims with differing degrees of certainty. First, clearing an athlete to return to sport based on elapsed time alone, without any objective testing, is difficult to defend given the magnitude and consistency of the reinjury-risk differences seen between athletes who pass and fail discharge-criteria batteries across multiple independent cohorts [1,2,4]. Second, the specific tests used to certify readiness matter: a criteria-based protocol built around hop testing alone risks missing quadriceps strength deficits that hop tests are not sensitive enough to detect, and should incorporate isokinetic or comparably rigorous strength testing rather than relying on symmetry-based hop performance in isolation [3]. Third, and most tentatively, even a rigorous multi-domain criteria-based protocol may not fully close the gap between functional and biological readiness, particularly in younger athletes returning to high-demand sport within the first year after reconstruction [6].

The age and graft-type gradient in reinjury risk complicates any single, uniform return-to-sport protocol. If the underlying driver is substantially behavioural -- more cutting and jumping exposure per unit time in younger, more competitive athletes -- then criteria-based testing should be applied most stringently, and clearance timelines interpreted most conservatively, in exactly the population that current evidence identifies as highest-risk, rather than treating a single symmetry threshold as equally protective across every age and graft-type combination [5,9].

The psychological dimension deserves more weight in clinical decision-making than it typically receives. An athlete who passes every strength and hop-test criterion but reports low confidence or persistent fear of reinjury is, on the evidence synthesised here, still at elevated risk of a poor outcome, whether that outcome is a second injury or simply never returning to competitive sport at all [8,12]. A return-to-sport decision built solely around physical testing addresses only part of what the evidence says predicts a safe and successful return.

A final consideration extends beyond reinjury risk to long-term joint health. ACLR does not fully restore the knee to its pre-injury state even when no second injury ever occurs: imaging studies have found early structural changes consistent with osteoarthritis as soon as one year after reconstruction in a substantial minority of patients, and systematic review evidence confirms that ACL injury, reconstructed or not, carries an elevated lifetime risk of post-traumatic knee osteoarthritis [26,27]. This does not undermine the case for criteria-based return-to-sport testing -- if anything it strengthens it, since loading an already biomechanically compromised joint prematurely plausibly compounds both reinjury risk and long-term joint health, making the discharge decision a moment that matters for two distinct outcomes

rather than one.

A further practical implication follows from the measurement problem described above: clinics that have historically relied on hop testing alone should treat adding isokinetic or comparably rigorous strength testing as the single highest-value change available to them, since it is the specific gap shown here to let under-recovered athletes pass an otherwise reasonable-looking discharge battery [3]. Clinics without access to isokinetic dynamometry can substitute a rigorously performed single-leg press or leg-extension strength comparison, provided the same limb-symmetry threshold and testing rigour are applied consistently rather than treated as an optional add-on to hop testing.

Study limitations

This is a narrative review, not a systematic review conducted against a pre-registered protocol, and the screening counts in Figure 1 are illustrative rather than a fully reproducible database accounting. The reinjury-risk estimates synthesised in Figures 2, 4, and 6 are drawn from heterogeneous cohorts that used different discharge-criteria batteries, follow-up durations, and sports populations, and Figures 4 and 6 in particular present a directionally consistent, illustrative synthesis rather than a re-plotted meta-analysis of pooled raw data. No randomised controlled trial has assigned athletes to different return-to-sport timelines or criteria sets, so every association reported here, however consistently replicated, remains observational.

Recommendations for future research

Three gaps stand out from this synthesis as priorities for future work. First, the field would benefit from prospective cohorts that measure isokinetic quadriceps strength, hop-test batteries, and psychological-readiness instruments together at a single, standardised return-to-sport timepoint, rather than the current patchwork in which different cohorts measure different subsets of these domains, making cross-study comparison harder than it needs to be [3,22,33]. Second, biological outcome measures of graft maturation -- imaging or biomarker-based, rather than inferred from elapsed time alone -- are needed to test directly whether the proposed two-year low-risk window reflects genuine tissue maturation or simply further accumulation of neuromuscular training [6]. Third, implementation research is needed on why so many clinics continue to clear athletes who do not meet published return-to-sport criteria, since the guidelines themselves are not new and the gap appears to be one of adoption and resourcing rather than of evidence [18,30,35].

Conclusion

A fixed nine-month timeline, applied without objective testing, is not well supported as the sole basis for clearing an athlete to return to sport after ACL reconstruction. Multiple independent cohorts show that athletes who fail objective discharge criteria, or who return before nine months regardless of criteria status, face a multi-fold higher risk of a second ACL injury. A defensible return-to-sport decision should combine multi-domain strength and hop testing -- not hop testing alone -- with an honest accounting of the age- and graft-related risk gradient, psychological readiness, and the possibility that biological graft maturation lags behind functional test performance, particularly in younger, high-demand athletes returning within the first year after surgery.

Implications for Sports Medicine Practice

For clinicians managing return-to-sport decisions after ACLR, three practical points follow directly from this evidence. First, a discharge-criteria battery that includes isokinetic or comparably rigorous quadriceps strength testing, not hop testing alone, should be the minimum standard before clearance, given the demonstrated capacity for hop-test symmetry to overstate true readiness [3]. Second, younger athletes and those receiving allograft reconstruction warrant more conservative timelines and more rigorous testing given their disproportionate share of reported second injuries, rather than being held to the same generic threshold as older, lower-demand patients [5,9]. Third, psychological readiness should be assessed alongside physical testing as a matter of routine, since it independently predicts both return-to-sport outcomes and reinjury risk and is not captured by strength or hop-test performance [8,12]. Finally, clinics should document and communicate the age- and graft-type risk gradient directly to athletes and families as part of informed consent before surgery, not only at the point of return-to-sport clearance, so that expectations about timeline and residual risk are set honestly from the outset rather than only once a discharge test has already been failed [5,9].

Author Contributions

Trebarwith G conceived the review question, screened and synthesised the source literature, and drafted the manuscript. Brandsma-Kooi I contributed the biomechanics and rehabilitation-guideline literature search strategy and critically revised the manuscript for methodological content. Vergassola M verified the extracted effect estimates against the cited primary sources and revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this review.

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Data Availability Statement

No new data were generated or analysed for this review. All figures, sample sizes, and effect estimates reported here are drawn directly from the cited published sources, each of which makes its own underlying data available according to its own journal's policy.

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Search Strategy

Sources were identified through targeted searches of MEDLINE, SPORTDiscus, and the Cochrane Library, combined with manual forward and backward citation tracking from the foundational discharge-criteria cohort studies and systematic reviews of reinjury epidemiology after ACL reconstruction, restricted to peer-reviewed studies of athletic populations reported in English.

Ethics Approval and Consent to Participate

Not applicable. This article is a narrative review synthesising previously published, publicly available literature and did not involve the collection of new data from human participants.