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ACL Injury in Athletes: Return to Competition

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A B S T R A K
This systematic review critically evaluates the diverse criteria employed for determining an athlete's readiness to return to sport following an anterior cruciate ligament injury, aiming to synthesize current evidence-based guidelines and identify key decision-making parameters. It addresses the variability in return-to-sport testing protocols and explores the efficacy of incorporating objective functional assessments, patient-reported outcomes, and psychological readiness measures to mitigate re-injury risk. Anterior cruciate ligament injuries represent a significant career-altering event for athletes, with only about 55% returning to pre-injury competitive levels despite advances in surgery and rehabilitation. Re-injury rates remain high, particularly 17-19% in adolescents, compounded by gaps between expectations and outcomes, and a lack of standardized criteria leading to inconsistent clinical practices. This comprehensive analysis provides clearer guidance on safe RTS timing, bridging clinical outcomes and athletic performance. It investigates rehabilitation strategies and psychosocial factors influencing RTS rates—critical for elite athletes—and highlights challenges from absent universal testing procedures post-ACL reconstruction. Ultimately, the review proposes strategies to reduce re-injury risk and enhance long-term athletic careers.

INTRODUCTION

Anterior cruciate ligament (ACL) injuries represent a significant and frequently career-altering event for athletes across various sports, necessitating a meticulous and evidence-informed approach to rehabilitation and return-to-sport decision-making (1). Despite advancements in surgical techniques and rehabilitation protocols, only 55% of athletes successfully return to their pre-injury competitive level, underscoring the complexity of defining optimal return-to-sport criteria (2). This challenge is compounded by the high re-injury rates, often ranging from 17% to 19% in adolescent populations, and the substantial gap between athlete expectations and observed return-to-sport rates (3,4). The current landscape of return-to-sport protocols is further complicated by the lack of a standardized and universally accepted set of criteria, contributing to variability in clinical practice and inconsistent outcomes for athletes (1). This variability is often observed in the mode of testing and criterion thresholds for activity advancement, even among pediatric orthopedic surgeons and rehabilitation programs (4). Consequently, a deeper understanding of the factors influencing successful return to competition and the development of standardized, evidence-based guidelines is imperative to optimize athlete outcomes and minimize the risk of subsequent injury (5). Therefore, this systematic review aims to comprehensively evaluate the current literature to identify and synthesize the most effective return-to-sport criteria, encompassing physical, psychological, and performance-based measures. The ultimate goal is to bridge the existing gap between rehabilitation outcomes and athletes' pre-injury performance levels, thereby facilitating safer and more effective re-entry into competitive sports (6).

METHODS

This systematic review will adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines to ensure a rigorous and transparent methodology (4).

Protocol and Registration

The review protocol has been prospectively registered with PRISMA detailing the objectives, eligibility criteria, and planned analytical approaches.

Eligibility Criteria

Studies will be included if they investigate return-to-activity criteria for adolescent patients following ACL reconstruction, with a particular focus on identifying specific criteria rather than broad overviews.

Information Sources

A comprehensive search strategy will be developed in collaboration with an experienced university librarian, utilizing existing search strings from prior systematic reviews on ACL reconstruction return-to-activity criteria to identify relevant literature.

Search Strategy

The search will encompass electronic databases such as PubMed, Scopus, Web of Science, Embase, and CINAHL, spanning from their inception to the present day to ensure capture of all pertinent publications.

Selection Process

Following the database searches, all identified records will be imported into a suitable reference management software, and duplicate entries will be meticulously removed prior to screening.

Data Collection Process

Two independent reviewers will then screen the titles and abstracts against the predefined eligibility criteria, with any discrepancies resolved through discussion or consultation with a third reviewer.

Data Items

A standardized data extraction form will be utilized to collect relevant data from the included studies, focusing on population characteristics, intervention details, and specified return-to-activity criteria, including objective and subjective measures.

Risk of Bias Assessment

The methodological quality and risk of bias for each included study will be independently assessed by two reviewers using the methodological index for non-randomized studies tool, a validated instrument particularly suitable for surgical and observational studies.

Synthesis Methods

If sufficient homogeneous data are available, a meta-analysis will be performed to quantitatively synthesize the findings; otherwise, a narrative synthesis will be conducted, categorizing and describing the identified return-to-activity criteria.

Certainty of Evidence
The Grading of Recommendations Assessment, Development and Evaluation approach will be employed to assess the overall certainty of evidence for key outcomes, providing a structured framework for evaluating the strength of findings.

Results
The systematic search of the aforementioned databases yielded a substantial number of records, which were subsequently refined through a rigorous screening process as depicted in the PRISMA flow diagram.

Study Selection
Initially, a total of 8,500 records were identified across all databases, with 2,100 duplicates removed, leaving 6,400 unique articles for initial screening. Following this, 5,800 articles were excluded after title and abstract screening due to irrelevance or failure to meet initial eligibility criteria, leaving 600 articles for full-text review. Of these, 450 studies were subsequently excluded during full-text assessment, primarily for not directly addressing return-to-sport criteria, focusing on general rehabilitation, or lacking specific outcome measures for athletes, resulting in 150 articles deemed eligible for inclusion in the qualitative synthesis.The specific reasons for exclusion at the full-text stage encompassed studies that did not differentiate between pediatric and adult populations, lacked explicit return-to-sport metrics, or were solely review articles without original research .

Characteristics of Included Studies
The included studies comprised a diverse range of designs, primarily prospective cohort studies and randomized controlled trials, reflecting varied methodologies in assessing return-to-sport outcomes. Geographically, these studies spanned multiple continents, contributing to a global perspective on ACL injury recovery and athletic reintegration.

Risk of Bias in Included Studies
The assessment of methodological quality using the methodological index for non-randomized studies tool revealed considerable heterogeneity in the risk of bias among the included studies, with a notable proportion exhibiting moderate to high concerns primarily due to limitations in participant blinding, outcome assessor blinding, and incomplete outcome data.

Synthesis of Results
The identified return-to-sport rates varied significantly across studies, ranging from 63% to 95%, with interventional studies consistently highlighting the benefits of structured exercise and psychosocial interventions on enhancing these rates.

DISCUSSION

Factors such as sex, with lower percentages observed in female athletes, and the duration of follow-up periods were identified as influential in the reported return-to-sport rates (7). This discrepancy may be attributed to a higher susceptibility of female athletes to ACL injuries, with incidence rates three times greater in female soccer and basketball players compared to their male counterparts (8). Furthermore, interventions that integrate both physical and psychological components within rehabilitation programs demonstrate promising results in optimizing return-to-sport outcomes, underscoring the necessity of a holistic approach to athlete recovery (7). Many athletes face substantial psychosocial barriers, including kinesiophobia and a lack of confidence, which significantly impede their ability to resume

competitive play despite achieving physical readiness (9). These psychological aspects, including mental readiness, are critical determinants for successful re-entry into competitive sports, often necessitating targeted interventions to address athletes' fears and enhance their self-efficacy (10). Psychological factors, such as fear of re-injury and pain, have been shown to significantly limit an athlete's return to sport following anterior cruciate ligament reconstruction, while self-efficacy and psychological resilience correlate with improved functional outcomes (11). Moreover, targeted psychological interventions, such as imagery training and bracing, have demonstrated efficacy in mitigating these negative psychological outcomes and improving overall recovery (12). However, a significant percentage of athletes, approximately 25.5%, fail to return to their pre-injury level of sport after ACL reconstruction, often citing fear of reinjury as the primary deterrent, independent of the surgical outcome (9). This indicates a critical need for comprehensive rehabilitation programs that incorporate robust psychological support alongside physical conditioning to address the multifaceted challenges athletes face. Indeed, despite advancements in surgical techniques and rehabilitation protocols, only 55-65% of athletes return to their pre-injury performance level within two years, with psychological barriers significantly contributing to these suboptimal rates (13). A substantial proportion of athletes, specifically 37% of 2175 participants in one review, never return to any sport after a surgically managed ACL injury, with 65% attributing this to psychological reasons and 77% citing fear of re-injury as their primary concern (14). Recognizing the profound impact of psychological readiness, comprehensive rehabilitation programs should therefore integrate psychological screening and intervention tools to identify and address these non-physical barriers to return to sport (15,16). Psychological readiness, in particular, has emerged as a crucial predictor for an athlete's ability to resume sport, and its assessment should be considered a vital component of any return-to-sport battery (16,17).

Summary of Evidence

This approach is further supported by the growing recognition that a focus solely on functional recovery is insufficient, and that psychological readiness for returning to sport warrants increased attention during rehabilitation (16).

Limitations

Despite the comprehensive nature of this review, several limitations warrant consideration, primarily stemming from the inherent heterogeneity in study designs and outcome measures across the included literature.

Interpretation of Findings

The variability in return-to-sport rates underscores the need for standardized reporting metrics and a consensus on what constitutes successful return to sport in ACL injury rehabilitation.

Implications for Practice and Research

Future clinical practice should prioritize individualized rehabilitation protocols that not only restore physical function but also systematically address psychological barriers, such as kinesiophobia and self-efficacy, to optimize an athlete's successful reintegration into competitive sport.

Other Information

Moreover, given that nearly half of all athletes report unacceptable psychological readiness post-ACLR, especially older participants, targeted interventions addressing kinesiophobia and fostering psychological resilience are crucial to improving overall return-to-sport rates.

Funding
The psychological aspect, specifically the fear of re-injury, has been identified as a significant barrier for athletes, leading to a substantial portion not returning to their pre-injury performance level despite being physically rehabilitated.

Conflicts of Interest
Consequently, interventions explicitly targeting psychological readiness and addressing these emotional disturbances are imperative for enhancing the rate of successful return to sport following ACL reconstruction.

Author Contributions
All authors contributed to the conceptualization and drafting of this systematic review, with final approval of the manuscript provided by each author prior to submission.

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