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# Anterior Cruciate Ligament Injury Is Rarely the Last Dance for Professional Basketball Players: High Return to Play with Longer Recovery Times. A Systematic Review and Meta-analysis

Riccardo D’Ambrosi, MD, Derya Akbaba, MD, Alessandro Carrozzo, MD, Lorenzo Tagliabue, MD, Prof Luca Maria Sconfienza, MD, Prof Elmar Herbst, MD PhD, Elisabeth Abermann, MD, Prof Christian Fink, MD

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# Anterior Cruciate Ligament Injury Is Rarely the Last Dance for Professional Basketball Players: High Return to Play with Longer Recovery Times. A Systematic Review and Meta-analysis

Running title: **The Last Dance? ACLR in Pro Basketball Players**

Riccardo D'Ambrosi[1,2] MD, Derya Akbaba[3] MD, Alessandro Carrozzo[4] MD
Lorenzo Tagliabue[1] MD, Prof. Luca Maria Sconfienza[1,2] MD, Prof. Elmar Herbst[5] MD PhD,
Elisabeth Abermann[6] MD, Prof. Christian Fink[6,7] MD

1. IRCCS Ospedale Galeazzi – Sant'Ambrogio, Milan, Italy
2. University of Milan, Department of Biomedical Sciences for Health, Milan, Italy
3. Cerrahpasa Medical Faculty, Department of Orthopaedics and Traumatology, Istanbul, Turkey
4. Università degli Studi "Link Campus University", Dipartimento di Scienze della Vita, della Salute e delle Professioni Sanitarie, Città di Castello, Italy
5. Department of Trauma, Hand and Reconstructive Surgery University of Muenster, Muenster Germany
6. Gelenkpunkt-Sports and Joint Surgery FIFA Medical Centre of Excellence Innsbruck Austria.
7. Research Unit for Orthopaedic Sports Medicine and Injury Prevention (OSMI), Private University for Health Sciences Medical Informatics and Technology Innsbruck Austria.

**Authors Contact**

Riccardo D’Ambrosi: riccardo.dambrosi@hotmail.it

Derya Akbaba: drakbaba1@gmail.com

Alessandro Carrozzo: alessandrocarrozzo27@gmail.com

Lorenzo Tagliabue: lorenzotagliabue@hotmail.com

Luca Maria Sconfienza: io@lucasconfienza.it

Elmar Herbst: elmar.herbst@gmail.com

Elisabeth Abermann: e.abermann@gelenkpunkt.com

Christian Fink: c.fink@gelenkpunkt.com

**Corresponding Author:**

Riccardo D’Ambrosi, MD

IRCCS Ospedale Galeazzi – Sant’Ambrogio, Milan, Italy

Università degli Studi di Milano, Dipartimento di Scienze Biomediche per la Salute, Milan, Italy

Tel: +393397066151

Mail: riccardo.dambrosi@hotmail.it



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# Anterior Cruciate Ligament Injury Is Rarely the Last Dance for Professional Basketball Players: High Return to Play with Longer Recovery Times. A Systematic Review and Meta-analysis

**Importance:** Anterior cruciate ligament (ACL) injuries are considered one of the most serious setbacks for professional basketball players. While return to play (RTP) is commonly achieved in other sports, the impact of ACL reconstruction (ACLR) on RTP rate, timing, and re-rupture in elite basketball remains unclear.

**Aim:** To evaluate the rate, timing, and level of return to play, as well as re-rupture rates, in professional basketball players following ACL reconstruction, and to assess whether these outcomes have changed over time. We hypothesized that while overall RTP rates would remain high, time to RTP may have increased over the past decade, reflecting evolving rehabilitation protocols and return-to-sport criteria.

**Evidence Review:** A comprehensive search of PubMed, Embase, and Cochrane Library was performed (last updated July 2025) following PRISMA guidelines. Studies were included if they reported RTP outcomes in skeletally mature professional basketball players after primary ACLR. Four distinct outcome measures were extracted and documented: RTP; time to RTP: level of RTP: ACL re-rupture. Meta-regression was performed based on publication period (pre-2016, 2016–2020, post-2020).

**Findings:** Eight studies were included. The pooled RTP rate was 86.8% (95% Confidence Interval [CI], 79.5–92.8%), with 97.2% (95% CI, 86.9–100.0%) of players returning to their pre-injury level. The mean time to RTP was 367 days (95% CI, 357–376), increasing significantly in recent years (p=0.012). The overall ACL re-rupture rate was 1.8% (95% CI, 0.2–4.6%). No significant differences were observed in RTP or re-rupture rates across time periods, but a progressive increase in time to RTP was noted.

**Conclusion:** Professional basketball players achieve high rates of RTP after ACLR, with most returning to their pre-injury level. Re-rupture rates are low; however, time to RTP has increased in recent years, likely reflecting more conservative, criteria-based rehabilitation strategies. ACL injury is no longer a career-ending event in elite basketball, but a longer and more complex recovery may be required.

**Level of Evidence:** Level IV

**Keywords:** Anterior cruciate ligament, Return to play, Basketball, Reinjury, Elite athletes

**What is already known:**

• Anterior cruciate ligament injury is considered a potentially career-threatening event for professional basketball players.

• Return to play rates after anterior cruciate ligament reconstruction have been extensively studied in sports such as soccer and American football, but evidence specific to elite basketball remains limited.

• Previous studies have reported variable return to play rates and inconsistent data on re-rupture and career outcomes in National Basketball Association and other professional basketball cohorts.

**What are the new findings:**

• Professional basketball players achieve high rates of return to play (86.8%) after anterior cruciate ligament reconstruction, with nearly all (97.2%) returning to their pre-injury competitive level.

• Mean time to return to play has significantly increased over the past decade, from approximately 340 days before 2016 to more than 370 days after 2020, reflecting more conservative, criteria-based rehabilitation strategies.

• Re-rupture rates in elite basketball players are low (1.8%), substantially lower than reported in other high-risk athletic populations.

• Anterior cruciate ligament injury is no longer a career-ending event in professional basketball, but recovery timelines have become longer and more complex.

**Registration:** PROSPERO Registry (CRD420251113289

## INTRODUCTION

The anterior cruciate ligament (ACL) injury is one of the most devastating events in the career of a professional basketball player. Due to the sport's high demands in cutting, pivoting, and jumping, basketball players are particularly vulnerable to ACL tears. While advances in surgical techniques and rehabilitation protocols have improved clinical outcomes in the general population, the implications of ACL reconstruction (ACLR) on elite athletes' ability to return to play (RTP) and sustain their careers remain uncertain [1-4].

In contrast to sports such as American football or soccer, where ACL outcomes have been extensively investigated, fewer studies have focused specifically on professional basketball. Moreover, variability in RTP rates, recovery time, and performance sustainability raises questions about whether an ACL injury represents a temporary setback—or the beginning of the end—for a professional basketball career. The cultural legacy of high-profile cases, most notably within the National Basketball Association (NBA), has even led to the popular notion of ACL injury as "the last dance" for elite players [5-11].

Therefore, the purpose of this systematic review and meta-analysis is to (1) quantify the rate of RTP, time to RTP, level of RTP, and incidence of ACL re-rupture in professional basketball players undergoing ACLR; and (2) assess whether these outcomes have changed over time. We hypothesized that while overall RTP rates would remain high, time to RTP may have increased over the past decade, reflecting evolving rehabilitation protocols and return-to-sport criteria.

## METHODS

## SEARCH STRATEGY

A systematic searching strategy had been developed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and it is registered in the PROSPERO Registry (CRD420251113289) [12,13]. The A Measurement Tool to Assess Systematic Reviews 2 (AMSTAR-2) checklist was used to confirm the quality of the systematic review [14], and the Transparency In the Reporting of Artificial Intelligence (TITAN) checklist was completed to transparently report the use of artificial intelligence [15].

Databases were systematically searched to identify relevant studies assessing time to RTP, level of RTP and re-rupture rates in professional basketball players following ACL reconstruction. The MEDLINE (PubMed), Embase (Elsevier), and Cochrane Library databases were screened on July 10, 2025, and the process was repeated two weeks later. Following Boolean search terms have been used: "ACL reconstruction" OR "anterior cruciate ligament reconstruction" OR "ACL" AND "professional" OR "elite" OR "competitive" AND "basketball" OR "NBA" OR "National Basket Association".

## STUDY ELIGIBILITY

The inclusion of studies was determined according to the following selection criteria.

### *Study Design*

Studies were selected based on predefined eligibility criteria. Randomized controlled trials, controlled clinical trials, prospective and retrospective cohort studies, case-control studies and case series which report RTP outcomes after ACLR were included. Case reports and series were excluded in the absence of reported outcomes related to RTP. In cases that multiple studies analyzed the same cohort with identical outcomes, only the most methodologically robust or up-to-date publication was selected to minimize redundancy.

*Participants and Interventions*

Eligible studies targeted skeletally mature elite basketball players who underwent primary ACLR. Players were evaluated on return to sport parameters, including time to return, level of return and incidence of graft re-rupture. Concomitant procedures didn't serve as exclusion criteria, which provided that ACLR remained principal intervention. In studies where revision ACLR was performed without providing disaggregated data, outcomes were analyzed under the assumption of primary surgery. An elite or professional athlete was defined as one who participates in national- or international-level competitions in professional or amateur sports—including academy players aged 15 or over [16]. Minimum follow-up included studies that analyzed athletes for at least one full season after the intervention.

*Type of Outcome Measures*

Four distinct outcome measures were extracted and documented:

- Return to play: defined as participation in at least one official game following ACLR
- Time to return to play: defined as the duration between operation and the first postoperative official game
- Level of return to play: defined as resuming competition at the same or a higher level than prior to injury (% calculated only among those patients who returned to sports)
- ACL re-rupture: defined as ipsilateral graft failure which requires revision surgery (% calculated on patients who returned to sports)

The including studies were categorized according to their publication period as follows:

- Studies published before 2016 (2016 excluded);
- Studies published between 2016 (2016 included) and 2021 (2021 excluded):
- Studies published after 2021 (included).

## SCREENING

*Study Selection*

All retrieved articles were initially screened by title and those deemed potentially relevant underwent abstract screening. Articles that did not meet the predefined eligibility criteria were excluded. Full texts of the remaining studies were subsequently reviewed to determine final eligibility.

For minimizing the risk of bias; all included and excluded studies, as well as their reference lists, were independently reviewed and discussed by authors. In cases of disagreement, the final decision was made by senior investigator. In addition, to ensure comprehensive coverage, reference lists of all included studies articles and relevant systematic reviews were manually screened for identifying any potentially eligible studies which are not captured by the initial search strategy.

Inter-reviewer agreement was assessed using Cohen's kappa coefficient to evaluate consistency during the title, abstract, and full-text screening. Any disagreement was resolved by consensus with a senior author (CF).

## DATA ABSTRACTION

*Data Collection Process*

Data were extracted from selected articles by the first two authors (RD and DA) using a custom electronic tool which is developed in Microsoft Access (Version 2010, Microsoft Corp., Redmond, WA, USA). Each article was subsequently revalidated by the first author prior to data analysis. For each inclusive study, following variables were collected: patient demographics, RTP status, time to RTP, postoperative activity level and ACL re-rupture rate.

*Level of Evidence*

The Oxford Levels of Evidence set by the Oxford Centre for Evidence-Based Medicine were used to categorize the level of evidence [17].

*Evaluation of The Quality of Studies*

The quality of selected studies was evaluated using the Methodological Index for Non-randomized Studies (MINORS) Score. The checklist comprises 12 items, with the final four which are specific to comparative studies. Each item was assigned a score ranging from 0 to 2, resulting in a maximum total score of 16 for non-comparative studies and 24 for comparative studies [18].

## STATISTICAL ANALYSIS

Descriptive data are reported as mean and standard deviation (SD) when normally distributed, or as median with interquartile range (IQR) and/or full range when data did not follow a normal distribution.

Normality of continuous data was assessed using the Shapiro–Wilk test and visual inspection of histograms. Variables with a normal distribution are presented as mean and SD and were compared using parametric tests. Variables not normally distributed are presented as median with interquartile range (IQR) and/or full range and were compared using appropriate non-parametric tests.

Meta-analyses were conducted overall and by group on i) mean age; ii) frequency of patients who returned to sport, iii) average time to return to sport, iv) frequency of patients who returned to the pre-injury level; v) frequency of patient with a re-rupture.

For continuous outcomes, ie age and time to return to sport, we performed a random-effect model on log transformed means using the restricted maximum-likelihood (REML) estimator for variance estimation. The pooled estimates were presented as pooled means with 95% confidence intervals (CI). The meta-analysis included primary studies with available standard deviation (SD) or range, from which we estimated the SD [19]. Time to return to sport was available on the subset of patients who returned to sport. Categorical outcomes were analysed with a random-effects model using the Der Simonian-Laird estimator for the variance. The raw proportions were stabilized using the Freeman–Tukey double arcsine transformation. The pooled estimates were presented as pooled proportions with corresponding 95% CI.

Differences among groups were explored with mixed-effects meta-regression models with common between-study variance component across groups, using variance estimators and transformations previously described. For each outcome, we tested within and between group heterogeneity with a Cochran's Q test. Group comparisons were performed with the group "before 2016" as reference category.

Between-study variations were assessed for each model with the Cochran's Q test of heterogeneity and the Higgins $I^2$ statistic. Statistical heterogeneity was defined as substantial if $I^2 > 50\%$ [20]. Publication bias and small-study effect were assessed through the funnel plot and doi plot. Funnel plot symmetry was tested with rank correlation test and the regression test while the LKF index was calculated with the doi plot. A sensitivity analysis with Trim-and-fill method was performed and the fail-safe N was calculated using the Rosenthal approach. For outcomes with primary studies in both groups, we checked robustness of findings combining "before 2016" and "2016-2020" in a single group and testing this new combined group with the group "after 2020".

Two tailed tests were performed. A p-value of <0.05 was considered to indicate statistical significance. The analysis was carried out using R (version 4.3.0, R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/) specifically with meta (version 8.0.1) and metafor packages (version 4.2.0).

## RESULTS

Initially, comprehensive search of three electronic databases yielded 678 records. After removal of 402 duplicates; titles and abstracts of 276 studies were screened. Following this stage, 151 studies were excluded and 125 full text articles were assessed for eligibility. Of these, 117 were excluded based on full-text review, resulting in 8 studies being included in the final analysis (Figure 1) [21-28]. The inter-reviewer agreement was almost perfect at each stage of the selection process, with kappa values of $\kappa = 0.91$ for title screening, $\kappa = 0.93$ for abstract screening, and $\kappa = 0.92$ for full-text eligibility assessment. Among the included studies, three were published before 2016, three between 2017 and 2020, and two in 2021 (Table S1).

***Age***

The pooled meta-analysis showed no statistically significant difference in terms of age at surgery between the different groups (25.6 years [95% confidence interval (CI), 25.0–26.3]; $p > 0.05$) (Figure 2).

***Return to Sport***

A total of 86.8% [95% CI, 79.5–92.8] of elite basketball players returned to sport. No statistically significant difference was found between the three time periods ($p > 0.05$) (Figure 3).

***Level of Return to Play***

Overall, 97.2% [95% CI, 86.9–100.0] of elite basketball players returned to their pre-injury competitive level. Meta-analysis showed no statistically significant difference ($p > 0.05$) in level of return-to-play rates among the different time periods, ranging from 92.9% (2016–2020) to 100% (after 2020) (Figure 4).

### *Re-rupture Rates*

Only 1.8% [95% CI, 0.2–4.6] of elite basketball players experienced an ACL re-rupture**.** Meta-analysis showed no statistically significant difference ($p > 0.05$) in re-rupture rate between the time periods, ranging from 1.5% (after 2020) to 3.4% (before 2016) (Figure 5).

### *Time to Return to Play*

The mean time to return to play was 367 days [95% CI, 357–376]**.** Meta-analysis showed a statistically significant difference between the first time period (before 2016; 340 days [95% CI, 318–363]) and the most recent time period (after 2020; 373 days [95% CI, 362–384]) ($p = 0.012$) (Figure 6).

## DISCUSSION

This systematic review and meta-analysis demonstrates that professional basketball players achieve high rates of return to play after anterior cruciate ligament reconstruction, with nearly all athletes regaining their pre-injury competitive level. Re-rupture rates are low, while the time to return to play has significantly increased over recent years, likely reflecting more conservative and criteria-based rehabilitation strategies.

Notably, however, time to RTP has progressively increased over the last decade, with athletes in the post-2020 period returning after a mean of 373 days compared to 340 days in the pre-2016 era. This trend reflects a growing clinical caution, perhaps influenced by evidence advocating for stricter return-to-sport criteria based on functional recovery rather than arbitrary timeframes [29,30].

When comparing these findings to existing literature across sports, several nuances emerge. Previous meta-analyses in professional soccer have reported RTP rates ranging from 77% to 92%, depending on competition level and graft type [31,32]. Lai et al. reported an 83% RTP rate in elite athletes across multiple sports, while Ardern et al. emphasized that fewer than 60% return to pre-injury competitive levels [31,32]. In the National Football League (NFL), RTP after ACLR is highly variable, ranging from 63% to 79%, with significant influence from player position and roster dynamics [33]. In the National Collegiate Athletic Association (NCAA) Division I athletes also demonstrate wide variability, especially when factoring in scholarship status and year of eligibility [34]. Compared to these cohorts, professional basketball players demonstrate relatively favorable outcomes both in RTP rate and return to previous level.

Interestingly, the high percentage of athletes returning to the same level (97.2%) in our analysis exceeds that of most other sports [31]. This may be partially attributed to the structure of professional basketball leagues, where elite players benefit from high-quality surgical care, tailored rehabilitation protocols, and team-based support systems. Similar trends were noted in sport-specific studies in the NBA, where Harris et al. reported RTP rates >90%, although performance metrics such as player efficiency rating and minutes played were often diminished in the first season post-return [24]. Likewise, Mai et al. found that basketball players had among the highest RTP rates when compared to NFL, Major League Baseball (MLB), and National Hockey League (NHL) athletes [26].

Although the concepts of return to play and return to pre-injury competitive level are expected to overlap in professional basketball, subtle discrepancies were observed in the pooled analysis. This likely reflects heterogeneous definitions used across the included studies: some defined return to play as participating in at least one official game, while others required full-season participation or achievement of pre-injury performance indicators such as minutes played, scoring averages, or efficiency metrics. These methodological differences may account for the small but measurable divergence between overall return-to-play rates and return-to-pre-injury-level rates in the present meta-analysis [31,32].

Our findings are also in line with and further specify the results of a recent meta-analysis of elite and professional athletes across different sports. That large review reported that >85% of elite athletes returned to sport and almost 90% returned to their preinjury level after ACL reconstruction, with a mean return to play of 292 days and a 7.0% graft failure rate [35]. While that study encompassed multiple sports and pooled both male and female elite athletes, our current meta-analysis focuses specifically on professional basketball players. This single-sport focus provides a more homogeneous cohort with comparable sport-specific demands (pivoting, jumping, cutting) and competition calendar, which reduces heterogeneity and allows a more precise estimate of sport-specific outcomes. Moreover, in contrast to the general elite population evaluated in the previous meta-analysis, our study demonstrated a slightly longer mean time to return to play (367 days) but a notably lower graft failure rate (1.8%), which may reflect basketball-specific rehabilitation demands, different surgical graft choices, or league-specific return-to-play protocols. These differences highlight the value of sport-specific systematic reviews, as they can capture nuances not evident when different sports are pooled together.

The mean time to RTP approaching 12 months in the most recent era is consistent with emerging recommendations advocating delayed return beyond 9 months to reduce risk of reinjury [29,30]. Biomechanical and neuromuscular recovery often lags behind clinical healing, and shorter RTP timelines have been associated with significantly higher risk of graft failure, particularly in younger athletes. As such, our finding of a prolonged recovery may indicate a shift toward safer, evidence-based decision-making in elite basketball [36].

The re-rupture rate of 1.8% observed in this study is notably low, especially when compared to the general athletic population, where rates range from 3% to 7%, and up to 23% in younger competitive athletes [36]. This favorable outcome likely reflects both surgical expertise and cautious RTP protocols in professional settings. However, it is important to recognize that follow-up durations in most studies were limited, and late graft failure or contralateral ACL injury may be underreported.

While the high RTP and low re-rupture rates are encouraging, it is essential to consider that ACL injury may still impact long-term performance and career trajectory. Studies have reported reductions in player productivity, agility, and confidence in the early seasons following return [24,26]. These outcomes are likely influenced by both physical limitations and psychological readiness, including fear of reinjury and altered movement strategies. Unfortunately, such aspects were not captured in the current meta-analysis but are critical in the elite sports context.

From a clinical standpoint, these findings underscore the importance of setting realistic expectations for RTP after ACLR in professional basketball. Players, teams, and medical staff should anticipate a recovery process that may exceed one calendar year, even in optimal environments. The decision to return should be guided not only by time but by objective testing (e.g., strength symmetry, functional hop tests) and psychological readiness. The shift toward individualized, data-driven rehabilitation strategies may contribute to more sustainable recoveries and prolonged careers.

To reduce graft failure and lower the risk of re-rupture, anterolateral extra-articular procedures have become increasingly popular as an adjunct to anterior cruciate ligament reconstruction (ACLR), particularly in patients at higher risk of graft failure [37]. Hurley et al. demonstrated that ACLR combined with a lateral extra-articular procedure (LEAP) results in high rates of return to play in both primary and revision ACLR cases [38]. These findings were corroborated by Hopper et al., who reported that professional athletes undergoing isolated ACLR at ≤21 years of age have more than a twofold higher risk of graft failure [39]. Similarly, Rosenstiel et al. showed that combined ACL and anterolateral ligament (ALL) reconstruction is associated with excellent outcomes in professional athletes, including lower graft rupture rates, higher return-to-sport rates, improved knee stability, and reduced reoperation rates after injury [40].

Psychological factors play a critical role in an athlete's ability to successfully return to sport following ACL reconstruction. Conditions such as depression, low self-efficacy, and kinesiophobia (fear of reinjury or movement) can significantly impact both adherence to rehabilitation and overall recovery. Notably, clinical depression has been identified in up to 40% of patients prior to ACLR and is considered one of the most detrimental predictors of suboptimal postoperative outcomes. As such, early recognition and targeted management of psychological barriers should be considered an integral part of the rehabilitation process. Although interventions such as guided imagery, relaxation techniques, behavioral therapy, goal setting, and coping strategies have shown mixed results in the literature, they hold promise in supporting psychological readiness for return to play [41].

This meta-analysis has several limitations. First, the number of included studies and the overall sample size were limited, which precluded subgroup analyses based on graft type, surgical technique, or rehabilitation protocol. Second, data on associated injuries, which may significantly influence outcomes and rehabilitation time, were not consistently reported. Third, none of the included studies provided sufficient detail on the use of anterolateral reinforcement procedures such as lateral extra-articular tenodesis or anterolateral ligament reconstruction, which have become widely recommended in elite athletes. These factors should be taken into account when interpreting our findings.

Although concepts such as minimal clinically important difference (MCID), patient acceptable symptom state (PASS), and substantial clinical benefit (SCB) are important to determine the clinical relevance of patient-reported outcome measures, these thresholds are not currently validated for objective outcomes such as return to play rates, time to return to sport, or graft re-rupture rates in professional athletes. Consequently, these metrics could not be directly applied to the results of this meta-analysis.

While an ACL injury may pause the rhythm of a player's career, it is rarely the final note. For many, it is not the last dance—but a recalibrated performance marked by resilience, adaptation, and an eventual return to the hardwood.

The results of this meta-analysis support our initial hypothesis that professional basketball players achieve high rates of return to play with low re-rupture rates after anterior cruciate ligament reconstruction, while the time to return to play has increased in recent years, likely reflecting more conservative, criteria-based rehabilitation strategies.



## CONCLUSIONS

Professional basketball players demonstrate a high rate of return to play (RTP) following anterior cruciate ligament reconstruction, with the majority returning to their pre-injury level of competition. The overall risk of graft re-rupture remains low. However, time to RTP has progressively increased over the past decade, possibly reflecting more cautious rehabilitation strategies and stricter return-to-sport criteria. While ACL injury is no longer a career-ending event for elite basketball athletes, it still represents a significant physical and psychological challenge, with longer recovery timelines than previously reported. For most players, an ACL injury is not the "last dance," but rather an extended intermission—one that requires resilience, patience, and the right team around them to return to center stage.

## Figures Legend

**Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram of the literature search and study selection.**

The figure depicts the number of records identified, screened, assessed for eligibility, and included in the final meta-analysis, with reasons for exclusion provided at each stage.

**Figure 2. Forest plot of mean age at surgery among different publication periods.**
This figure summarizes the pooled mean age at the time of anterior cruciate ligament reconstruction across three time periods (before 2016, 2016–2020, and after 2020), with corresponding 95% confidence intervals and between-group comparison.
*Abbreviations: SD, standard deviation; CI, confidence interval.*

**Figure 3. Forest plot of overall return to play after anterior cruciate ligament reconstruction.**
This figure shows the pooled proportion of elite basketball players who successfully returned to competitive sport following anterior cruciate ligament reconstruction, stratified by publication period (before 2016, 2016–2020, and after 2020), with 95% confidence intervals.
*Abbreviations: SD, standard deviation; CI, confidence interval;*

**Figure 4. Forest plot of return to pre-injury competitive level after anterior cruciate ligament reconstruction.**
The figure displays the pooled proportion of professional basketball players who returned to their pre-injury level of competition, with 95% confidence intervals, and compares results across publication periods.
*Abbreviations: SD, standard deviation; CI, confidence interval.*

**Figure 5. Forest plot of anterior cruciate ligament re-rupture rate after reconstruction.**
This figure reports the pooled incidence of graft re-rupture among professional basketball players, with 95% confidence intervals, and compares rates across three publication periods (before 2016, 2016–2020).
*Abbreviations: SD, standard deviation; CI, confidence interval.*

**Figure 6. Forest plot of time to return to sport after anterior cruciate ligament reconstruction.**
The figure presents pooled estimates of the mean time (in days) required to return to competitive basketball after anterior cruciate ligament reconstruction, with 95% confidence intervals, and compares the three publication periods.
*Abbreviations: SD, standard deviation; CI, confidence interval.*

## References

1. Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of literature. *Am J Sports Med.* 1995;23(6):694-701. doi: 10.1177/036354659502300611.
2. Harmer PA. Basketball injuries. *Med Sport Sci.* 2005;49:31-61. doi: 10.1159/000085341.
3. Koga H, Nakamae A, Shima Y, Iwasa J, Myklebust G, Engebretsen L, Bahr R, Krosshaug T. Mechanisms for noncontact anterior cruciate ligament injuries: knee joint kinematics in 10 injury situations from female team handball and basketball. *Am J Sports Med.* 2010;38(11):2218-2225. doi: 10.1177/0363546510373570.
4. Owoeye OBA, Ghali B, Befus K, Stilling C, Hogg A, Choi J, Palacios-Derflingher L, Pasanen K, Emery CA. Epidemiology of all-complaint injuries in youth basketball. *Scand J Med Sci Sports.* 2020;30(12):2466-2476. doi: 10.1111/sms.13813.
5. Benis R, LA Torre A, Bonato M. Anterior cruciate ligament injury profile in female elite Italian basketball league. *J Sports Med Phys Fitness.* 2018;58(3):280-286. doi: 10.23736/S0022-4707.16.06663-9.
6. Bisciotti GN, Chamari K, Cena E, Bisciotti A, Bisciotti A, Corsini A, Volpi P. Anterior cruciate ligament injury risk factors in football. *J Sports Med Phys Fitness.* 2019;59(10):1724-1738. doi: 10.23736/S0022-4707.19.09563-X.
7. Borque KA, Laughlin MS, Hugo Pinheiro V, Ngo D, Kent M, Balendra G, Jones M, Williams A. The Effect of Primary ACL Reconstruction on Career Longevity in English Premier League and Championship Soccer Players Compared With Uninjured Controls: A Matched Cohort Analysis. *Am J Sports Med.* 2024;52(5):1183-1188. doi: 10.1177/03635465241235949.
8. Lian J, Sewani F, Dayan I, Voleti PB, Gonzalez D, Levy IM, Musahl V, Allen A. Systematic Review of Injuries in the Men's and Women's National Basketball Association. *Am J Sports Med.* 2022;50(5):1416-1429. doi: 10.1177/03635465211014506.
9. Manoharan A, Barton D, Khwaja A, Latt LD. Return to Play Rates in NFL Wide Receivers and Running Backs After ACL Reconstruction: An Updated Analysis. *Orthop J Sports Med.* 2021 ;9(1):2325967120974743. doi: 10.1177/2325967120974743.
10. Secrist ES, Bhat SB, Dodson CC. The Financial and Professional Impact of Anterior Cruciate Ligament Injuries in National Football League Athletes. *Orthop J Sports Med.* 2016;4(8):2325967116663921. doi: 10.1177/2325967116663921.
11. Tramer JS, Khalil LS, Jildeh TR, Sattar M, Ziedas A, Abbas MJ, Kolowich PA, Okoroha KR. Association of Prior Anterior Cruciate Ligament Tear With Decreased Career Longevity in Women's National Basketball Association. *Orthop J Sports Med.* 2021;9(6):23259671211009248. doi: 10.1177/23259671211009248.

12. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi: 10.1136/bmj.n71.
13. Page MJ, Shamseer L, Tricco AC. Registration of systematic reviews in PROSPERO: 30,000 records and counting. *Syst Rev.* 2018;7(1):32. doi: 10.1186/s13643-018-0699-4.
14. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, Moher D, Tugwell P, Welch V, Kristjansson E, Henry DA. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ*. 2017;358:j4008. doi: 10.1136/bmj.j4008.
15. Agha RA, Mathew G, Rashid R, Kerwan A, Al-Jabir A, Sohrabi C, Franchi T, Nicola M, Agha M, TITAN Group. Transparency In The reporting of Artificial INtelligence – the TITAN guideline. *Premier Journal of Science* 2025:10;100082
16. Borque KA, Jones M, Laughlin MS, Balendra G, Willinger L, Pinheiro VH, Williams A. Effect of Lateral Extra-articular Tenodesis on the Rate of Revision Anterior Cruciate Ligament Reconstruction in Elite Athletes. *Am J Sports Med.* 2022;50(13):3487-3492. doi: 10.1177/03635465221128828.
17. Burns PB, Rohrich RJ, Chung KC. The levels of evidence and their role in evidence-based medicine. *Plast Reconstr Surg.* 2011;128(1):305-310. doi: 10.1097/PRS.0b013e318219c171.
18. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. *ANZ J Surg.* 2003;73(9):712-716. doi: 10.1046/j.1445-2197.2003.02748.x.
19. Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med Res Methodol.* 2014;14:135. doi: 10.1186/1471-2288-14-135.
20. Cumpston M, Li T, Page MJ, Chandler J, Welch VA, Higgins JP, Thomas J. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev.* 2019;10(10):ED000142. doi: 10.1002/14651858.ED000142.
21. Abbas MJ, Khalil LS, Rahman T, Abbas L, Akioyamen NO, Farley BJ, Bazzi T, Okoroha KR. Anterior Cruciate Ligament Reconstruction Does Not Impact Career Earnings After Return to Play in National Basketball Association Athletes. *Arthrosc Sports Med Rehabil.* 2021;3(5):e1491-e1497. doi: 10.1016/j.asmr.2021.07.010.

22. Busfield BT, Kharrazi FD, Starkey C, Lombardo SJ, Seegmiller J. Performance outcomes of anterior cruciate ligament reconstruction in the National Basketball Association. *Arthroscopy.* 2009;25(8):825-830. doi: 10.1016/j.arthro.2009.02.021.
23. DeFroda SF, Patel DD, Milner J, Yang DS, Owens BD. Performance After Anterior Cruciate Ligament Reconstruction in National Basketball Association Players. *Orthop J Sports Med.* 2021;9(2):2325967120981649. doi: 10.1177/2325967120981649.
24. Harris JD, Abrams GD, Bach BR, Williams D, Heidloff D, Bush-Joseph CA, Verma NN, Forsythe B, Cole BJ. Return to sport after ACL reconstruction. *Orthopedics.* 2014;37(2):e103-108. doi: 10.3928/01477447-20140124-10.
25. Kester BS, Behery OA, Minhas SV, Hsu WK. Athletic performance and career longevity following anterior cruciate ligament reconstruction in the National Basketball Association. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(10):3031-3037. doi: 10.1007/s00167-016-4060-y.
26. Mai HT, Chun DS, Schneider AD, Erickson BJ, Freshman RD, Kester B, Verma NN, Hsu WK. Performance-Based Outcomes After Anterior Cruciate Ligament Reconstruction in Professional Athletes Differ Between Sports. *Am J Sports Med.* 2017;45(10):2226-2232. doi: 10.1177/0363546517704834.
27. Namdari S, Scott K, Milby A, Baldwin K, Lee GC. Athletic performance after ACL reconstruction in the Women's National Basketball Association. *Phys Sportsmed.* 2011;39(1):36-41. doi: 10.3810/psm.2011.02.1860.
28. Nwachukwu BU, Anthony SG, Lin KM, Wang T, Altchek DW, Allen AA. Return to play and performance after anterior cruciate ligament reconstruction in the National Basketball Association: surgeon case series and literature review. *Phys Sportsmed.* 2017;45(3):303-308. doi: 10.1080/00913847.2017.1325313.
29. Beischer S, Gustavsson L, Senorski EH, Karlsson J, Thomeé C, Samuelsson K, Thomeé R. Young Athletes Who Return to Sport Before 9 Months After Anterior Cruciate Ligament Reconstruction Have a Rate of New Injury 7 Times That of Those Who Delay Return. *J Orthop Sports Phys Ther.* 2020;50(2):83-90. doi: 10.2519/jospt.2020.9071.
30. Grindem H, Granan LP, Risberg MA, Engebretsen L, Snyder-Mackler L, Eitzen I. How does a combined preoperative and postoperative rehabilitation programme influence the outcome of ACL reconstruction 2 years after surgery? A comparison between patients in the Delaware-Oslo ACL Cohort and the Norwegian National Knee Ligament Registry. *Br J Sports Med.* 2015;49(6):385-389. doi: 10.1136/bjsports-2014-093891.

31. Ardern CL, Taylor NF, Feller JA, Webster KE. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis including aspects of physical functioning and contextual factors. *Br J Sports Med.* 2014;48(21):1543-52. doi: 10.1136/bjsports-2013-093398.
32. Lai CCH, Ardern CL, Feller JA, Webster KE. Eighty-three per cent of elite athletes return to preinjury sport after anterior cruciate ligament reconstruction: a systematic review with meta-analysis of return to sport rates, graft rupture rates and performance outcomes. *Br J Sports Med.* 2018;52(2):128-138. doi: 10.1136/bjsports-2016-096836.
33. D'Ambrosi R, Marchetti A, Farinelli L, Meena A, Franco P, Sconfienza LM, Cristiani R, Herbst E, Kittl C, Herbort M, Abermann E, Fink C. The majority of elite and professional athletes return to the preinjury level of activity after ACL reconstruction: A systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2025 Aug 31. doi: 10.1002/ksa.70020. Epub ahead of print. PMID: 40886081.
34. Shah VM, Andrews JR, Fleisig GS, McMichael CS, Lemak LJ. Return to play after anterior cruciate ligament reconstruction in National Football League athletes. *Am J Sports Med.* 2010;38(11):2233-2239. doi: 10.1177/0363546510372798.
35. Brown CL, Worts PR, Dewig DR, Rolle GA, Ormsbee MJ. Return to Play After an Anterior Cruciate Ligament Reconstruction in the Collegiate Athlete: A Systematic Review Evaluating Return to Play Proportions and Associated Factors. *J Orthop Sports Phys Ther.* 2024;54(10):625-633. doi: 10.2519/jospt.2024.12483.
36. Wiggins AJ, Grandhi RK, Schneider DK, Stanfield D, Webster KE, Myer GD. Risk of Secondary Injury in Younger Athletes After Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-analysis. *Am J Sports Med.* 2016;44(7):1861-1876. doi: 10.1177/0363546515621554.
37. D'Ambrosi R, Corona K, Cerciello S, Guerra G, Mercurio M, Galasso O, Valli F, Abermann E, Fink C. Combining an Anterolateral Complex Procedure With Anterior Cruciate Ligament Reconstruction Reduces Graft Reinjury Without Increasing the Rate of Complications: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Am J Sports Med.* 2025;53(10):2462-2470. doi: 10.1177/03635465241285887.
38. Hurley ET, Manjunath AK, Strauss EJ, Jazrawi LM, Alaia MJ. Return to Play After Anterior Cruciate Ligament Reconstruction with Extra-Articular Augmentation: A Systematic Review. *Arthroscopy.* 2021;37(1):381-387. doi: 10.1016/j.arthro.2020.06.007.
39. Hopper GP, Pioger C, Philippe C, El Helou A, Campos JP, Gousopoulos L, Carrozzo A, Vieira TD, Sonnery-Cottet B. Risk Factors for Anterior Cruciate Ligament Graft Failure in

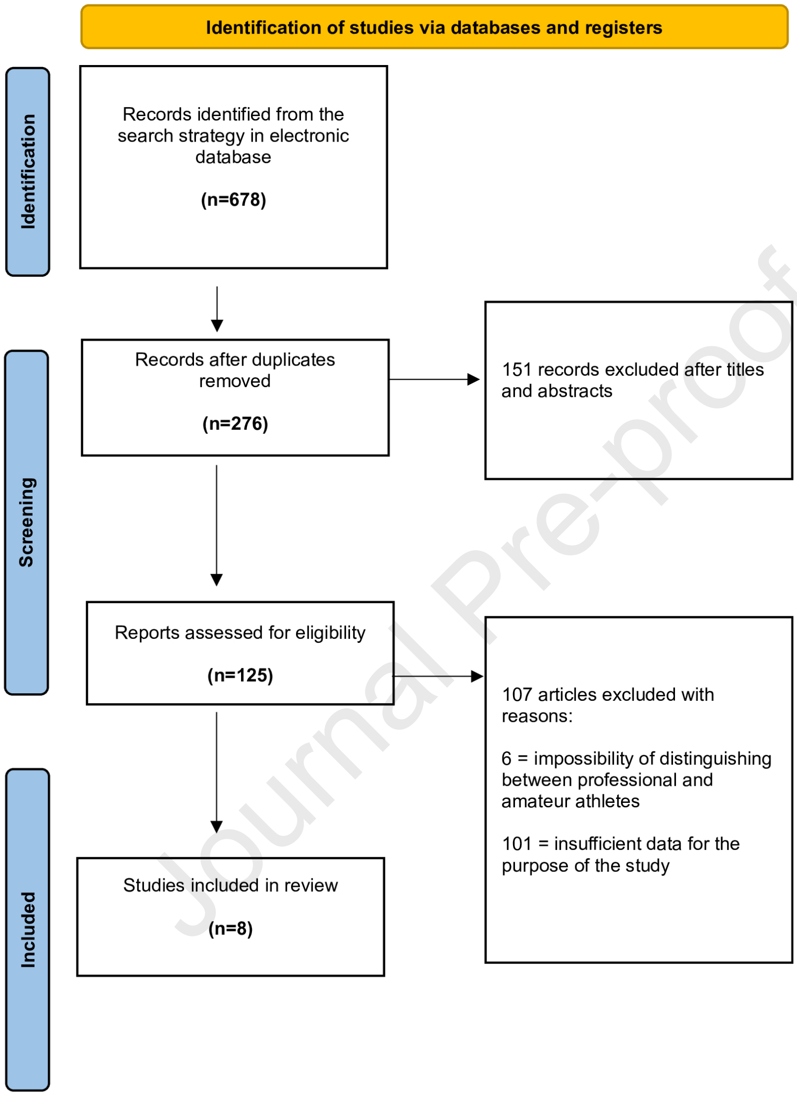
Professional Athletes: An Analysis of 342 Patients With a Mean Follow-up of 100 Months From the SANTI Study Group. *Am J Sports Med.* 2022 ;50(12):3218-3227. doi: 10.1177/03635465221119186. PMID: 36177758.

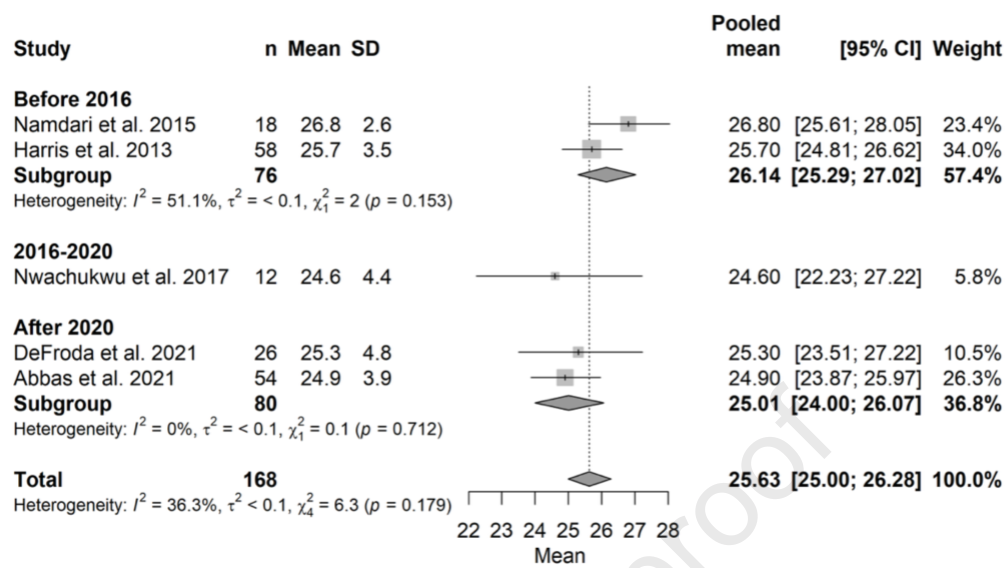
40. Rosenstiel N, Praz C, Ouanezar H, Saithna A, Fournier Y, Hager JP, Thaunat M, Sonnery-Cottet B. Combined Anterior Cruciate and Anterolateral Ligament Reconstruction in the Professional Athlete: Clinical Outcomes From the Scientific Anterior Cruciate Ligament Network International Study Group in a Series of 70 Patients With a Minimum Follow-Up of 2 Years. *Arthroscopy*. 2019;35(3):885-892. doi: 10.1016/j.arthro.2018.09.020.
41. Piussi R, Berghdal T, Sundemo D, Grassi A, Zaffagnini S, Sansone M, Samuelsson K, Senorski EH. Self-Reported Symptoms of Depression and Anxiety After ACL Injury: A Systematic Review. *Orthop J Sports Med.* 2022;10(1):23259671211066493. doi: 10.1177/23259671211066493.

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review. | 1 |
| **ABSTRACT** | | | |
| Abstract | 2 | See the PRISMA 2020 for Abstracts checklist. | 1-2 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of existing knowledge. | 3 |
| Objectives | 4 | Provide an explicit statement of the objective(s) or question(s) the review addresses. | 3 |
| **METHODS** | | | |
| Eligibility criteria | 5 | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses. | 4-8 |
| Information sources | 6 | Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. | 4-8 |
| Search strategy | 7 | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | 4-8 |
| Selection process | 8 | Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. | 4-8 |
| Data collection process | 9 | Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process. | 4-8 |
| Data items | 10a | List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. | 4-8 |
| | 10b | List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. | 4-8 |
| Study risk of bias assessment | 11 | Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. | 4-8 |
| Effect measures | 12 | Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. | 4-8 |
| Synthesis methods | 13a | Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). | 4-8 |
| | 13b | Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. | 4-8 |
| | 13c | Describe any methods used to tabulate or visually display results of individual studies and syntheses. | 4-8 |
| | 13d | Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. | 4-8 |
| | 13e | Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). | 4-8 |
| | 13f | Describe any sensitivity analyses conducted to assess robustness of the synthesized results. | 4-8 |

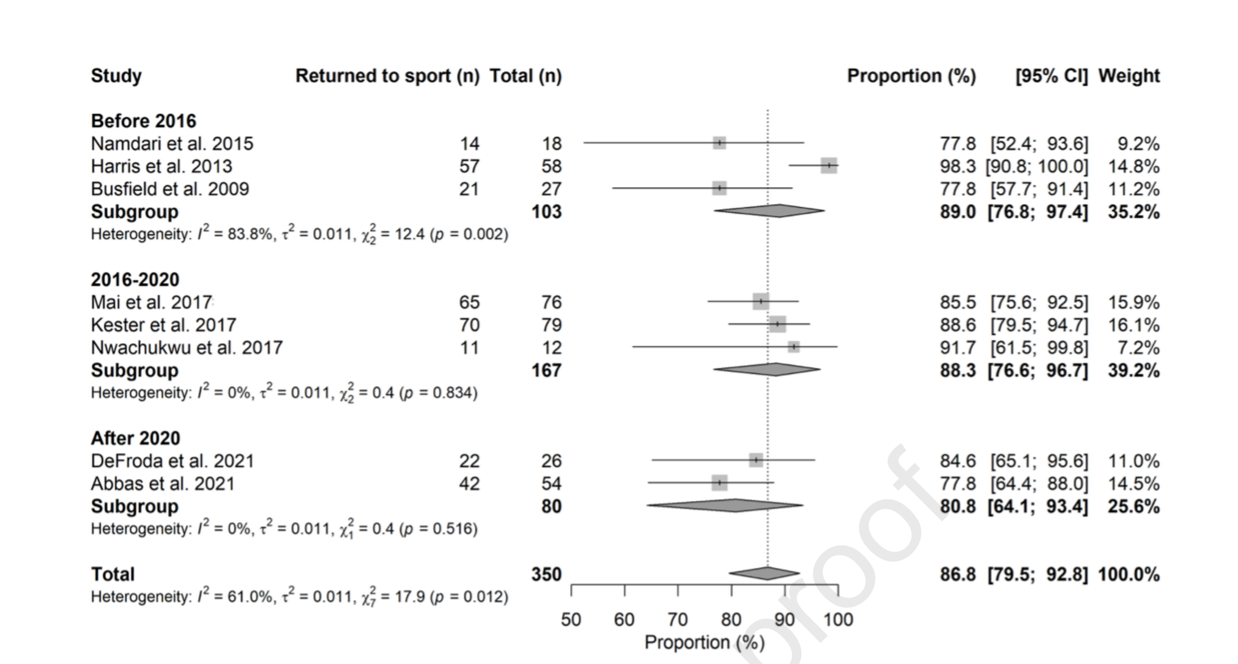
| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| Reporting bias assessment | 14 | Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). | 4-8 |
| Certainty assessment | 15 | Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. | 4-8 |
| **RESULTS** | | | |
| Study selection | 16a | Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. | 8-10 |
| | 16b | Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. | 8-10 |
| Study characteristics | 17 | Cite each included study and present its characteristics. | 8-10 |
| Risk of bias in studies | 18 | Present assessments of risk of bias for each included study. | 8-10 |
| Results of individual studies | 19 | For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots. | 8-10 |
| Results of syntheses | 20a | For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies. | 8-10 |
| | 20b | Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect. | 8-10 |
| | 20c | Present results of all investigations of possible causes of heterogeneity among study results. | 8-10 |
| | 20d | Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results. | 8-10 |
| Reporting biases | 21 | Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. | 8-10 |
| Certainty of evidence | 22 | Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed. | 8-10 |
| **DISCUSSION** | | | |
| Discussion | 23a | Provide a general interpretation of the results in the context of other evidence. | 10-13 |
| | 23b | Discuss any limitations of the evidence included in the review. | 10-13 |
| | 23c | Discuss any limitations of the review processes used. | 10-13 |
| | 23d | Discuss implications of the results for practice, policy, and future research. | 10-13 |
| **OTHER INFORMATION** | | | |
| Registration and protocol | 24a | Provide registration information for the review, including register name and registration number, or state that the review was not registered. | 3 blinded |
| | 24b | Indicate where the review protocol can be accessed, or state that a protocol was not prepared. | 3 blinded |
| | 24c | Describe and explain any amendments to information provided at registration or in the protocol. | n.a. |
| Support | 25 | Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review. | Title page |
| Competing | 26 | Declare any competing interests of review authors. | Title page |

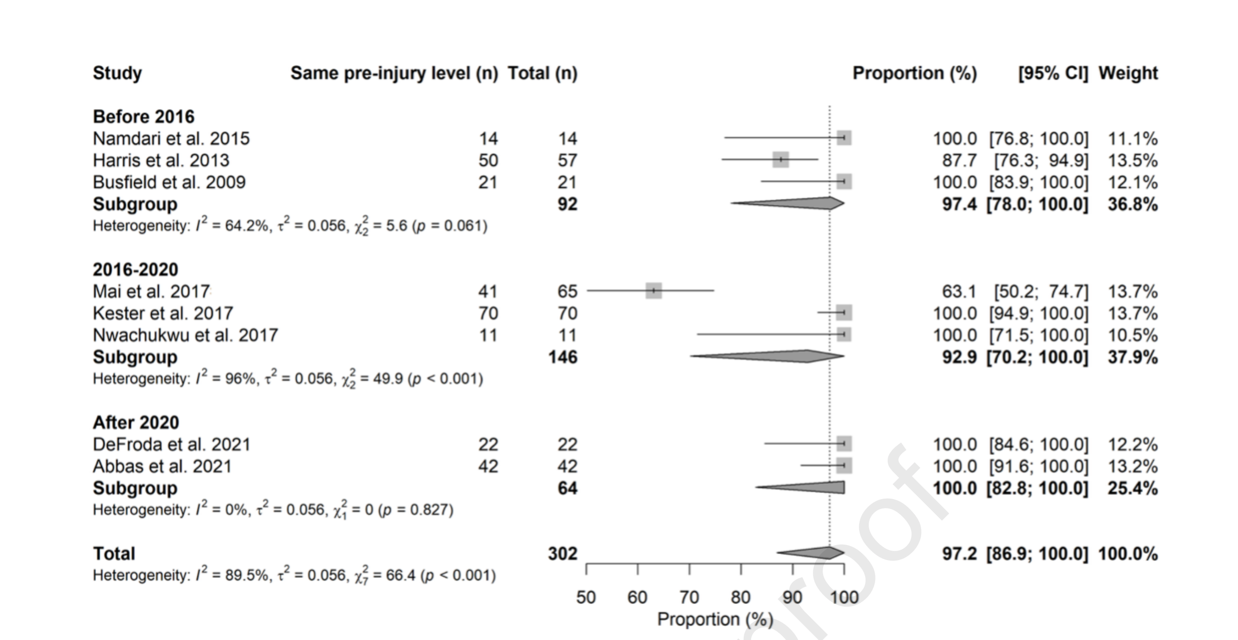
| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| interests | | | |
| Availability of data, code and other materials | 27 | Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review. | Title page |

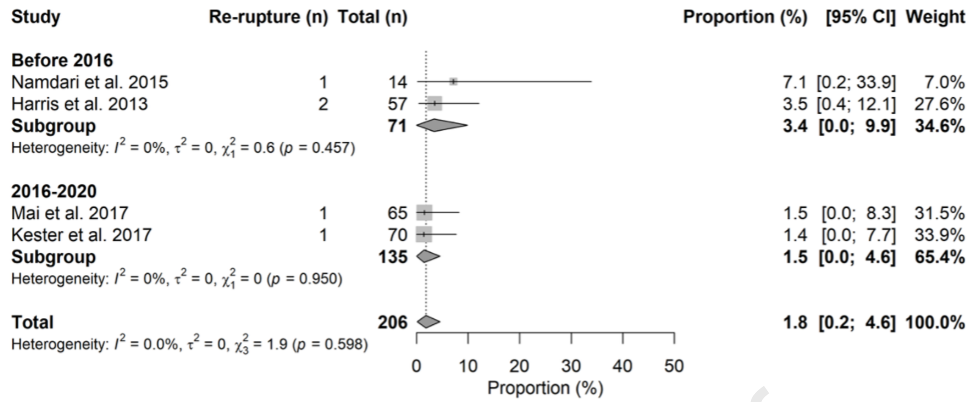

Identification of studies via databases and registers
Identification
Screening
Included
Records identified from the search strategy in electronic database
(n=678)
Records after duplicates removed
(n=276)
151 records excluded after titles and abstracts
Reports assessed for eligibility
(n=125)
107 articles excluded with reasons:
6 = impossibility of distinguishing between professional and amateur athletes
101 = insufficient data for the purpose of the study
Studies included in review
(n=8)

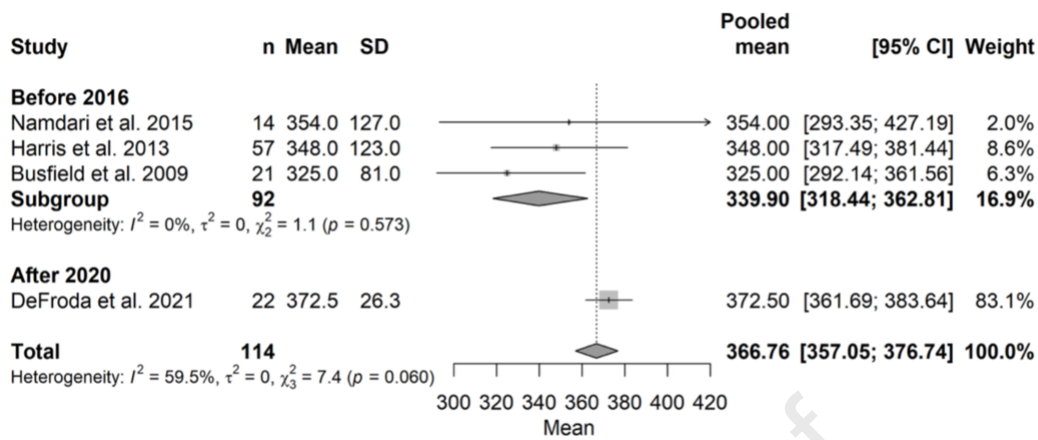


Study n Mean SD
Pooled mean [95% CI] Weight
Before 2016
Namdari et al. 2015 18 26.8 2.6 26.80 [25.61; 28.05] 23.4%
Harris et al. 2013 58 25.7 3.5 25.70 [24.81; 26.62] 34.0%
Subgroup 76 26.14 [25.29; 27.02] 57.4%
Heterogeneity: $I^2$ = 51.1%, $\tau^2$ = < 0.1, $\chi^2_1$ = 2 ($p$ = 0.153)
2016-2020
Nwachukwu et al. 2017 12 24.6 4.4 24.60 [22.23; 27.22] 5.8%
After 2020
DeFroda et al. 2021 26 25.3 4.8 25.30 [23.51; 27.22] 10.5%
Abbas et al. 2021 54 24.9 3.9 24.90 [23.87; 25.97] 26.3%
Subgroup 80 25.01 [24.00; 26.07] 36.8%
Heterogeneity: $I^2$ = 0%, $\tau^2$ = < 0.1, $\chi^2_1$ = 0.1 ($p$ = 0.712)
Total 168 25.63 [25.00; 26.28] 100.0%
Heterogeneity: $I^2$ = 36.3%, $\tau^2$ < 0.1, $\chi^2_4$ = 6.3 ($p$ = 0.179)
22 23 24 25 26 27 28
Mean


Study
Returned to sport (n)
Total (n)
Proportion (%)
[95% CI]
Weight
Before 2016
Namdari et al. 2015 14 18 77.8 [52.4; 93.6] 9.2%
Harris et al. 2013 57 58 98.3 [90.8; 100.0] 14.8%
Busfield et al. 2009 21 27 77.8 [57.7; 91.4] 11.2%
Subgroup 103 89.0 [76.8; 97.4] 35.2%
Heterogeneity: $I^2$ = 83.8%, $\tau^2$ = 0.011, $\chi_2^2$ = 12.4 ($p$ = 0.002)
2016-2020
Mai et al. 2017 65 76 85.5 [75.6; 92.5] 15.9%
Kester et al. 2017 70 79 88.6 [79.5; 94.7] 16.1%
Nwachukwu et al. 2017 11 12 91.7 [61.5; 99.8] 7.2%
Subgroup 167 88.3 [76.6; 96.7] 39.2%
Heterogeneity: $I^2$ = 0%, $\tau^2$ = 0.011, $\chi_2^2$ = 0.4 ($p$ = 0.834)
After 2020
DeFroda et al. 2021 22 26 84.6 [65.1; 95.6] 11.0%
Abbas et al. 2021 42 54 77.8 [64.4; 88.0] 14.5%
Subgroup 80 80.8 [64.1; 93.4] 25.6%
Heterogeneity: $I^2$ = 0%, $\tau^2$ = 0.011, $\chi_1^2$ = 0.4 ($p$ = 0.516)
Total 350 86.8 [79.5; 92.8] 100.0%
Heterogeneity: $I^2$ = 61.0%, $\tau^2$ = 0.011, $\chi_7^2$ = 17.9 ($p$ = 0.012)
50 60 70 80 90 100
Proportion (%)


Study
Same pre-injury level (n)
Total (n)
Proportion (%)
[95% CI]
Weight
Before 2016
Namdari et al. 2015 14 14 100.0 [76.8; 100.0] 11.1%
Harris et al. 2013 50 57 87.7 [76.3; 94.9] 13.5%
Busfield et al. 2009 21 21 100.0 [83.9; 100.0] 12.1%
Subgroup 92 97.4 [78.0; 100.0] 36.8%
Heterogeneity: $I^2$ = 64.2%, $\tau^2$ = 0.056, $\chi_2^2$ = 5.6 ($p$ = 0.061)
2016-2020
Mai et al. 2017 41 65 63.1 [50.2; 74.7] 13.7%
Kester et al. 2017 70 70 100.0 [94.9; 100.0] 13.7%
Nwachukwu et al. 2017 11 11 100.0 [71.5; 100.0] 10.5%
Subgroup 146 92.9 [70.2; 100.0] 37.9%
Heterogeneity: $I^2$ = 96%, $\tau^2$ = 0.056, $\chi_2^2$ = 49.9 ($p$ < 0.001)
After 2020
DeFroda et al. 2021 22 22 100.0 [84.6; 100.0] 12.2%
Abbas et al. 2021 42 42 100.0 [91.6; 100.0] 13.2%
Subgroup 64 100.0 [82.8; 100.0] 25.4%
Heterogeneity: $I^2$ = 0%, $\tau^2$ = 0.056, $\chi_1^2$ = 0 ($p$ = 0.827)
Total 302 97.2 [86.9; 100.0] 100.0%
Heterogeneity: $I^2$ = 89.5%, $\tau^2$ = 0.056, $\chi_7^2$ = 66.4 ($p$ < 0.001)
50 60 70 80 90 100
Proportion (%)


Study
Re-rupture (n)
Total (n)
Proportion (%)
[95% CI]
Weight
Before 2016
Namdari et al. 2015 1 14 7.1 [0.2; 33.9] 7.0%
Harris et al. 2013 2 57 3.5 [0.4; 12.1] 27.6%
Subgroup 71 3.4 [0.0; 9.9] 34.6%
Heterogeneity: $I^2$ = 0%, $\tau^2$ = 0, $\chi^2_1$ = 0.6 ($p$ = 0.457)
2016-2020
Mai et al. 2017 1 65 1.5 [0.0; 8.3] 31.5%
Kester et al. 2017 1 70 1.4 [0.0; 7.7] 33.9%
Subgroup 135 1.5 [0.0; 4.6] 65.4%
Heterogeneity: $I^2$ = 0%, $\tau^2$ = 0, $\chi^2_1$ = 0 ($p$ = 0.950)
Total 206 1.8 [0.2; 4.6] 100.0%
Heterogeneity: $I^2$ = 0.0%, $\tau^2$ = 0, $\chi^2_3$ = 1.9 ($p$ = 0.598)
0
10
20
30
40
50
Proportion (%)


Study
n Mean SD
Pooled mean
[95% CI] Weight
Before 2016
Namdari et al. 2015 14 354.0 127.0 354.00 [293.35; 427.19] 2.0%
Harris et al. 2013 57 348.0 123.0 348.00 [317.49; 381.44] 8.6%
Busfield et al. 2009 21 325.0 81.0 325.00 [292.14; 361.56] 6.3%
Subgroup 92 339.90 [318.44; 362.81] 16.9%
Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $\chi^2_2 = 1.1$ ($p = 0.573$)
After 2020
DeFroda et al. 2021 22 372.5 26.3 372.50 [361.69; 383.64] 83.1%
Total 114 366.76 [357.05; 376.74] 100.0%
Heterogeneity: $I^2 = 59.5\%$, $\tau^2 = 0$, $\chi^2_3 = 7.4$ ($p = 0.060$)
300 320 340 360 380 400 420
Mean

**Declaration of interests**

☒ 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 paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: