

Return-to-play and performance after operative treatment of Achilles tendon rupture in elite male athletes: a scoping review

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ABSTRACT

Objective To examine the current evidence regarding return-to-play (RTP) and performance after Achilles tendon rupture in elite athletes treated with operative intervention.

Design Scoping review.

Data sources Published sources identified through a PubMed search of elite athletes, defined as professional or division one collegiate athletes in baseball, basketball, American football or soccer.

Methods Our search yielded a total of 2402 studies, with 13 studies fulfilling the study criteria of reporting elite athletes with objective measures of their athletic performance. A total of 709 elite athletes were included from the NBA, NFL, Major League Baseball (MLB), National Collegiate Athletic Association (NCAA) football and professional soccer.

Results and discussion Overall, 61%–100% of elite male athletes RTP after Achilles tendon rupture and operative repair. NBA players had inferior performance compared with their preoperative status as well as controls of non-injured players. Studies did not show significantly different performance after Achilles injury for MLB players. Professional soccer, NFL and NCAA football studies reported varying performance after injury.

Conclusions Evidence suggests that sports with explosive plantarflexion demands, such as basketball, may be associated with a greater decrease in performance despite operative intervention after Achilles rupture.

INTRODUCTION

Achilles tendon rupture is a debilitating injury for an athlete and often represents a season-ending injury requiring an extended period of rehabilitation to return to sport. Lemme *et al*¹ reported that Achilles tendon rupture is most commonly seen in male patients between 20 and 39 years of age, with 82% occurring in a sport or recreational activity. However, Achilles rupture has been reported as high as 5.4% in Finnish Olympic athletes by the age of 45 years.² Elite athletes typically opt for surgical management of these injuries in order to directly restore the native tendon anatomy, particularly muscle-tendon length, and potentially maximise their ability to regain full strength.^{3,4} Although these patients generally have enhanced access to postoperative care, athletic training and physiotherapy staffs and rehabilitation, they continue to require extended time off from play with an uncertain effect on postoperative athletic performance.

Attempts to define the time for return-to-play (RTP) have been made, with some groups recommending 16 weeks for non-contact athletes and 20 weeks for contact athletes.^{4,5} However, these guidelines are not directly evidence-based and seem to be shorter than what is typically seen in professional athletes.^{4,5} In a systematic review and meta-analysis of 108 studies in a non-elite athlete population, Zellers *et al*⁶ reported that 80% of athletes RTP to sport. In a review of elite athletes across a heterogeneous population of professional athletes or athletes competing at a national level, Maffulli *et al*⁷ reported that athletes had significantly lower plantarflexion strength in their operative extremity versus the uninjured side.

Given the heterogeneity of the literature on the management of Achilles rupture in elite athletes, the purpose of the present work was to perform a scoping review on the current evidence regarding the operative management of Achilles tendon rupture in elite athletes. The aim of this work was to elucidate the postsurgical outcomes to better guide RTP expectations and facilitate more accurate counselling of elite athletes. The potential role of non-operative management is also explored in this review as a secondary aim. However, no study to date has reported outcomes on the non-operative management of Achilles tendon rupture in elite athletes. Thus, the current evidence on differences between re-rupture, strength and surgical complications between operative and non-operative management in the general population are presented to inform future directions. Lastly, we propose a summary of knowledge gaps and research priorities to improve the care of elite athletes with Achilles rupture.

METHODS

The determination of whether to proceed with a scoping review versus a systematic review was performed based on the recommendations of Munn *et al*.⁸ The studies examined in this review demonstrated a lack of standardisation in evaluating performance, as well as time frames that often overlapped, which by definition would entail athletes being included in multiple studies. A review protocol was not created for this paper.

An overview is provided of the current methodology of research on athletic performance after Achilles tendon rupture in elite athletes. This review was performed using the guidelines for scoping review established by Arksey and O'Malley and later



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Table 1 Framework for this scoping review per the guidelines of Arksey and O'Malley⁹ and later modified by Levac *et al*¹⁰

#1 Identifying the research question	Investigating the operative and non-operative management of Achilles tendon rupture in elite athletes.
#2 Identifying the relevant studies	Elite athletes defined as professional or Division I NCAA collegiate athletes in baseball, basketball, American football, hockey or soccer.
#3 Study selection	PubMed search for elite athletes that were evaluated in terms of their athletic performance following Achilles tendon rupture using an objective measure of performance. Search yielded 13 studies for inclusion.
#4 Charting the data	Decision based on available evidence to provide a broad overview of relevant studies in terms of preoperative versus postoperative performance after Achilles injury, as well as a comparison to uninjured controls.
#5 Reporting the results	High levels of RTP across all sports, with worse performance reported in NBA players after RTP, varying performance reported in soccer, NFL and NCAA football, and no significant differences after RTP in MLB.

NCAA, National Collegiate Athletic Association; MLB, Major League Baseball; RTP, return to play.

modified by Levac *et al*.^{9 10} The research question was to investigate athletic performance after the operative or non-operative management of Achilles tendon rupture in elite athletes. Elite athletes were defined as professional or United States Division I National Collegiate Athletic Association (NCAA) collegiate athletes in baseball, basketball, American football, hockey or soccer (table 1).

Studies were found through a systematic PubMed search. Criteria for the athletic performance section was determined to be any study in which the athletic performance of elite athletes was evaluated using an objective measure of performance. English language was a requirement for inclusion, and any year in the PubMed database was eligible. Search criteria began with "Achilles tendon rupture" or "Achilles tendon tear" and were separately performed with each additional search criteria of "athlete", "performance", "return-to-play", "football", "baseball", "hockey", "basketball" and "soccer". The search was performed on 20 March 2021. This search yielded a total of 2402 studies with the initial review conducted by two authors (CLP and DVC). There were 21 potential studies identified for full manuscript evaluation to determine their eligibility with 13 original studies fulfilling inclusion criteria. Studies that did not explicitly fit inclusion criteria were adjudicated with a third author for possible inclusion. All of included studies were

thoroughly analysed by cross-checking the discussion and reference sections of each paper. All studies were examined for the RTP rate and any objective measure of performance (that varied by sport). The objective measures are summarised and reported in tables 2–4. All of the included publications were reported on operative management.

There were no studies that evaluated the non-operative management of an elite athletic population in terms of athletic performance. However, there is a large amount of data of operative versus non-operative management in the general population, including level 1 and 2 studies. In addition, one paper was found that specifically reported RTP after non-operative management in an athletic population, although those authors did not exclude non-elite athletes.¹¹

RESULTS

Operative management in elite athletes

RTP after operative management

Multiple studies have reported RTP rates in elite athletes following Achilles tendon rupture treated surgically, with RTP defined as a return to at least one game unless noted otherwise below (table 2). Rates in the NBA range from 61% to 80%,^{3 12–15} with studies reporting that 44%–64% returned for at least 2 years

Table 2 Study characteristics in elite athlete with operative intervention after Achilles tendon rupture

	Level of evidence	Number of patients	Average age (years)	Time frame	Proportion return-to-play (%)	Uninjured controls?
NBA						
Amin (2013) ¹⁹	3	12	29.7	1988 to 2011	61	Yes
Minhas (2016) ²⁰	3	13	28.4	1984 to 2013	71	No
Trofa (2017) ²¹	3	14	29.1	1988 to 2013	68	Yes
Lemme (2019) ³	4	44	28.3	1969 to 2018	80	No
Khalil (2020) ²²	3	15	28.2	1970 to 2019	72	Yes
NFL						
Trofa (2017) ²¹	3	14	29.4	1988 to 2013	67	Yes
Jack (2017) ²³	3	16	28.2	1958 to 2016	72	Yes
Mai (2016) ²⁴	4	17	n/a	2003 to 2013	73	No
Yang (2019) ²⁵	3	18	26.2	2009 to 2014	61	No
Parekh (2009) ²⁶	4	19	29	1997 to 2002	68	No
NCAA football						
Wise (2020) ²⁹	3	22	n/a	2010 to 2016	93	Yes
MLB						
Trofa (2017) ²¹	3	14	31.3	1988 to 2013	100	Yes
Saltzman (2017) ²⁸	3	21	31.6	1876 to 2015	62	Yes
Soccer						
Trofa (2018) ²⁷	3	22	28.2	1988 to 2014	71	Yes
Grassi (2018) ³⁰	4	23	27.2	2008 to 2018	96	No

MLB, Major League Baseball; n/a, not available; NCAA, National Collegiate Athletic Association.

Table 3 Comparison of elite athletes pre-Achilles and post-Achilles tendon injury

	Decrease in games played (year 1, year 2)	Decrease in playing time (year 1, year 2)	Decrease in performance (year 1, year 2)
NBA			
Amin <i>et al</i> ¹²	NR	5.11*, 4.42* (MPG)	4.57*, 4.38* (PER)
Minhas <i>et al</i> ¹³	25.8*, 16.5*	NR	3.9*, 3.4* (PER)
Trofa <i>et al</i> ¹⁴	24*, 23.2*	52.8*, 53.6* (% of minutes)	3.8*, 3.5* (PER)
Lemme <i>et al</i> ³	NR	NR	2.9* (PER average)
Khalil <i>et al</i> ¹⁵	20.2*, 19.7* (year 3)	7.74*, 8.2* (year 3) (MPG)	3.9*, 4.2* (year 3)
NFL			
Trofa <i>et al</i> ¹⁴	2.1*, 2.2 (n.s.)	0.9 n.s., 2.1 n.s. (starts)	3.1*, 2.8* (SAV)
Jack <i>et al</i> ¹⁶	DL 2.2*, other positions n.s. (games/season)	NR	RB* and LB*, other positions n.s.
Mai <i>et al</i> ¹⁷	2.7*, year 2 and 3 n.s.	NR	Year 1*, years 2 and 3 n.s.
Yang <i>et al</i> ¹⁸	2.8*, 1.3 (n.s.)	NR	NR
Parekh <i>et al</i> ¹⁹	5.5 (3-year average)	NR	Decreased
NCAA football			
Wise <i>et al</i> ²²	NR	NR	Qualitative stats by position group
MLB			
Trofa <i>et al</i> ¹⁴	43.4 n.s., 16.4 n.s.	133.7 n.s., 209.9 n.s. (innings)	88% (n.s.), 112% (n.s.) (BA or 1/ERA)
Saltzman <i>et al</i> ²¹	25.2	71% (average PA)	44% of WAR
Soccer			
Trofa <i>et al</i> ²⁰	5 n.s., 6.1 n.s.	79 n.s., 72* (% of minutes)	1.5 n.s., 2.6 n.s. (goals)
Grassi <i>et al</i> ²³	Year 1*, year 2 n.s.	NR	NR

Listed as the first and second season the player was able to RTP unless noted otherwise.

*Represents statistically significant value.

†Performed analysis at 1 and 3 years after injury.

‡Jack *et al*¹⁶ and Mai *et al*¹⁷ evaluated performance individually based on position-specific formulas.

§Parekh *et al*¹⁹ did not perform statistical analysis and compared games and statistics defined as 'power rating' 3 years before and after injury.

¶Saltzman *et al*²¹ did not perform statistical comparisons for pre-injury and post-injury and all stats averaged over 3 years.

BA, batting average; DL, defensive lineman; ERA, earned runs average; LB, linebackers; MLB, Major League Baseball; MPG, minutes per game; NCAA, National Collegiate Athletic Association; NR, not reported; n.s., not significant; PA, plate appearances; PER, player efficiency rating; RB, running backs; SAV, season approximate value; WAR, wins above replacement.

postoperatively.^{3 12} In the NFL, studies have reported RTP rates between 61% and 73%.^{14 16–19} Professional soccer players have reported RTP rates of 71%–96%, with Grassi *et al* reporting that 82% made it to the same division as their preoperative level.²⁰ In the MLB, RTP rates are reported to be 62%–100%, although

one study used a return of 81 games (half a season) as their measure for RTP.^{14 21} No studies have evaluated elite hockey athletes after Achilles tendon injury. NCAA Division I football players (using a cohort of defensive players) were reported to RTP at a rate of 93%.²²

Table 4 Comparison of elite athletes with Achilles tendon rupture versus matched uninjured control athletes

	Number of patients	Decrease in games played (year 1, year 2)	Decrease in playing time (year 1, year 2)	Decreased length of career (years)	Decreased performance (year 1, year 2)
NBA					
Amin <i>et al</i> ¹²	11	NR	6.41*, 6.69* (MPG)	NR	3.43*, 3.33* (PER)
Khalil <i>et al</i> ¹⁵	27	Year 1 n.s., year 3*	Year 1*, year 3 n.s. (MPG)	2.71*	Year 1*, year 3 n.s. (PER)
NFL					
Jack <i>et al</i> ¹⁶	71	0.3 n.s. (games/season)	NR	0.9	LB, other positions n.s. using position-specific formulas for performance (stats pooled over career)
NCAA football					
Wise <i>et al</i> ²²	37	NR	NR	NR	When calculating stats by position, DBs with less total and solo tackles/game DLs with less FFs/game All other stats n.s. for DL, LB, DB
MLB					
Saltzman <i>et al</i> ^{21#}	13	11 n.s.	44.5 n.s. (PA)	NR	n.s. for all comparisons
Soccer					
Trofa <i>et al</i> ²⁰	24	7.3*, 5.8*	30.6*, 29.5* (% of minutes)	NR	1.5 n.s., 1.5 n.s. (goals)

*Represents statistically significant.

†Khalil *et al*¹⁵ performed analysis at 1 and 3 years after injury.

‡Saltzman *et al*²¹ averaged all comparisons over 3 years and did not break down by year.

DB, defensive back; DL, defensive lineman; FF, forced fumbles; LB, linebacker; MLB, Major League Baseball; MPG, minutes per game; NR, not reported; n.s., not significant; PA, plate appearances; PER, player efficiency rating.

Postoperative performance versus preoperative performance

National Basketball Association

Multiple studies have evaluated the performance of NBA players in the two seasons following Achilles tendon injury versus the athletes' preoperative levels,^{3 12–14} while one study evaluated at one and 3 years after injury (table 3).¹⁵ Studies have reported a significant decrease in the number of games played in the first 2 years after injury,^{13–15} while others have reported a significant decrease in minutes per game (MPG) and total minutes played during these overlapping time periods.^{12 14 15} All of the above studies also reported on the player efficiency rating (PER)—a standardised measurement tool commonly used in evaluating NBA players by using a complex formula to create a per-minute rating of a player's performance—and found significantly decreased PER values following injury in the first two seasons.^{3 12–14} At 3 years, there have been conflicting results on significant¹³ and non-significant¹⁵ reductions in PER after operative intervention when compared with non-injured controls.

National Football League

Studies have also evaluated the performance of NFL players following Achilles injury versus their preoperative performance, with mixed results.^{14 16–19} Some reported that players played in significantly fewer games in their first postoperative season,^{14 17 18} while Jack *et al* reported that only defensive lineman played in fewer games the first year after injury.¹⁶ All other reports did not find significant differences in years 2 or 3 after Achilles injury.^{14 16–18}

Multiple different performance measures have been reported for NFL players. Two studies used position-specific measures of performance. Mai *et al*¹⁷ reported significantly decreased performance at year 1 after return that was non-significant in years 2 and 3, while Jack *et al*¹⁶ reported that only running backs and linebackers had significantly decreased performance following their injury during the rest of their career. Trofa *et al*¹⁴ reported on the season approximate value (SAV) and found that there was significantly decreased performance in years 1 and 2 after injury. Per the authors, SAV was obtained from www.sports-reference.com with a greater number corresponding to a player's performance contributing to a larger fraction of the team's success.¹⁴

Major League Baseball

Two studies have evaluated MLB players after return from Achilles tendon injury.^{14 21} In a study of five players, Trofa *et al* did not find significantly decreased games or innings in either of the 2 years after return.¹⁴ In a larger analysis of 26 players, another study reported that players had an average of 71% of plate appearances and 44% of wins above replacement (WAR) in comparison to preoperative levels over the average of their first 3 years following RTP, although this was not evaluated for significance.²¹ Per www.mlb.com, WAR is a position-specific metric intended to decipher how many more wins the player is worth versus a replacement-level player at that same position. Position subanalysis has not been reported and could further provide expectations based on the athlete's particular position.

Professional soccer

Two studies reported on RTP in professional soccer players.^{20 23} One study reported no significant difference in games played or started in the 2 years after return from injury,²⁰ while another found a significant decrease in games the first year after return that was not present in the second season.²³ In addition, Trofa

et al reported no significant decrease in goals in the two seasons after return.²⁰

Postoperative performance versus matched controls

Multiple studies have evaluated the postoperative performance of elite athletes versus matched uninjured controls in their sport^{12 15 16 20–22} (table 4). Trofa *et al*¹⁴ pooled together NBA, NFL and MLB players and reported that in comparison to matched controls, these players had significantly decreased games played, playing time and performance in the first season after RTP; however, all of these metrics returned to similar levels as the control athletes during the second season.

National Basketball Association

Amin *et al* compared those with Achilles tendon ruptures with matched uninjured controls and reported a significant decrease in MPG in both the first and second year after RTP,¹² while Khalil *et al* reported a significant decrease in MPG at 1 year that was not present at 3 years.¹⁵

In terms of performance, as measured with PER, Amin *et al* reported significant decreases in PER versus controls in both the first and second years after RTP,¹² while Khalil *et al* reported significantly decreased PER at 1 year that was not seen at 3 years versus controls.¹⁵

National Football League

Jack *et al* evaluated NFL players after return from Achilles tendon rupture.¹⁶ In comparison to matched controls, they did not find a decrease in the amount of games per season played after injury, but did report a significantly decreased length of career.¹⁶ In a position-specific breakdown of performance, they found a statistically significant decrease in the performance of linebackers, but not in other positions.¹⁶

Major League Baseball

Saltzman *et al* reported on 13 MLB players after RTP by pooling the 3 years after RTP together for statistical analysis.²¹ The authors did not report significant differences for games played or plate appearances versus controls. They also did not report any significant decrease for any statistics after injury in comparison to matched controls.²¹

Professional soccer

Trofa *et al* reported on 24 professional soccer players versus matched controls.²⁰ They reported a significant decrease in games played and minutes played in both of the first two seasons after RTP versus controls. Conversely, they did not find a significant difference for goals versus controls in the first two seasons after injury.²⁰

National Collegiate Athletic Association football

Wise *et al* reported on 37 defensive NCAA football players after RTP.²² In comparison to matched controls, they found defensive backs had decreased tackles per game while defensive lineman had decreased forced fumbles per game.²² No other statistical measures were found to be significant among all position groups. It should be noted that these statistics are not typically used as the main performance metrics for these position groups.

Non-operative management after Achilles rupture

Non-operative management of Achilles tendon rupture is rare in elite athletes, as evidenced by Lemme *et al* reporting that only 1 of 44 NBA players was treated without surgery.³ However, there

are many relevant aspects to the management of Achilles rupture including re-rupture rates, postoperative strength, surgical complications and RTP that are important for an informed discussion with elite athletes.

Chance of re-rupture

Numerous randomised controlled trials (RCTs) have evaluated operative versus non-operative management of Achilles tendon ruptures in a general patient population, and there is considerable evidence demonstrating that early functional rehabilitation and weight-bearing decrease the risk of re-rupture in the general patient population irrespective of treatment method.^{24–26} Soroceanu *et al*²⁴ concluded, based on their meta-analysis, that early range of motion may be a key component to reduce the risk of re-rupture. In their study, patients following early range of motion protocols achieved similar re-rupture rates with or without surgery (absolute risk difference of 1.7% in the surgery group). The cohort in whom early range of motion was not employed, calf strength significantly favoured surgical management.²⁴ A study in which active, recreational athletes were treated with non-operative management of Achilles tendon rupture demonstrated 12% re-ruptures at an average of 9 weeks after initial injury.¹¹ With regard to re-rupture in elite athletes, studies have reported rates of 6%–15% in elite soccer or American football players treated operatively.^{18 23}

Postoperative strength

Multiple studies have compared postoperative strength between operative and non-operative patients, although substantial heterogeneity in the methodology used for assessment exists. Strong evidence exists from multiple level 1 RCTs that demonstrate differences in postoperative strength favouring operative management.^{25–27} Lantto *et al* reported that operative management resulted in faster recovery of calf strength, as well as a 10%–18% greater strength in operative patients at 18-month follow-up.²⁶ However, meta-analyses have reported non-significant differences in postoperative strength between operative and non-operative patients, but these analyses included studies employing non-uniform methods of measurement, heterogeneous patient populations and variable methods for non-operative treatment.²⁴

While these results may not make a clinical difference in the general population, as surmised by Willits *et al*,²⁵ this strength difference is potentially of sufficient magnitude to affect elite athletes whose performance demands strong, explosive movements, and for whom quicker return to sport, and eventual return to performance levels, may substantially impact their livelihood. The possibility of decreased strength after operative or non-operative treatment—which may not be clinically significant in a non-elite athlete—may have a lasting effect on elite athletes.

It should be noted that elite athletes may have better muscle strength and neuromuscular control prior to injury, as well as better rehabilitation facilities and resources than non-elite athletes, and studies evaluating non-operative management with ideal rehabilitation services in elite athletes have not been conducted. Additional studies are warranted in the elite athlete population to further examine differences in strength following operative versus non-operative management, but it is not surprising elite athletes usually pursue operative intervention given the current body of evidence. Nevertheless, it must be discussed with athletes that even with surgery, they are likely to experience decreased plantarflexion strength and calf muscle

volume at medium-term and long-term follow-up compared with their contralateral extremities.^{28 29}

Surgical complications

In a meta-analysis of RCTs, Soroceanu *et al*²⁴ reported significantly increased complications (with re-rupture excluded) in the surgically treated group. These complications included superficial or deep infections, skin or tendon necrosis, fistulas, scar adhesion, tendon overlengthening, decrease ankle range of motion, deep vein thrombosis and pulmonary embolus.²⁴ Similar results were found in a more recent meta-analysis from Ochen *et al*³⁰ demonstrating a higher rate of complications in the surgical group (risk difference of 3.3%), with a 2.8% rate of infection. Many of these complications could lead to a significant delay in RTP or suboptimal postoperative outcome.

RTP in non-operative treatment

The RTP in patients following Achilles tendon injury treated non-operatively has not been studied in an elite athlete population. Lerch *et al* reported a significantly higher RTP in the low-activity sports group (91%) than the high-activity sports group (67%) using a functional rehabilitation programme in a recreational athlete population with Achilles rupture treated non-operatively.¹¹ The difference in groups was assessed using the Tegner Activity Scale, with those >5 fitting into the high-activity group.¹¹

Considerations for non-operative treatment

Ultimately, non-operative management for Achilles tendon ruptures is supported by a large body of evidence when applied to the general population as long as functional rehabilitation programmes are incorporated. The discussion with elite athletes is more complex, as these patients are generally biased towards surgical management and desire the fastest RTP with greatest strength and least chance of reinjury. However, the risks of surgery should also be discussed with the patient as the literature demonstrates a significantly higher rate of wound-related and medical complications following surgical intervention. In addition, it should be emphasised that surgical intervention may not restore full preoperative plantarflexion strength and calf muscle volume.

DISCUSSION

The most important finding of this review is that athletic performance varies after RTP in elite athletes with operative intervention for Achilles tendon rupture. The NBA studies all demonstrated significantly worse performance after RTP, while NFL, NCAA football and professional soccer studies reported varying results on performance after Achilles tendon rupture treated by operative intervention. Lastly, MLB players were not reported to have significant performance decreases after injury. These studies suggest that sports that involve more frequent explosive lower extremity movements, such as basketball, may be associated with a greater likelihood of decreased performance after injury, and athletes with lower explosive requirements such as baseball are more likely to return to pre-injury performance levels after Achilles rupture.

There remains a lack of standardisation of performance analysis within sports, with an exception of the NBA studies that all used PER to analyse performance. While more standardised, PER is still an oversimplified attempt to characterise the many aspects of a basketball player's performance with a single number. Nevertheless, using this measure consistently across studies does

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facilitate interstudy comparisons in a more reliable manner than is possible with other sports in this review. Having a more consistent standardised approach to measuring performance in NFL, MLB, NCAA football and professional soccer athletes is strongly recommended for future studies.

No studies evaluated non-operative management of Achilles tendon rupture in elite athletes. Thus, our analysis is unable to evaluate the effectiveness of operative versus non-operative management as it relates to RTP and performance. Given the facility access and rehabilitation expertise available to elite athletes, future studies of non-operative versus operative treatment of Achilles rupture are needed. Until then, the existing evidence in non-elite athletes and the general population provides important insights for an informed discussion regarding the potential risks (lower strength, higher re-rupture rates) and benefits (lower surgical complications) of non-operative (vs operative) management in elite athletes after Achilles rupture.

Knowledge gaps and research priorities

At this time, there are important knowledge gaps and research priorities that merit addressing in future studies:

- ▶ Knowledge gaps:
 - The role and effect of non-operative management for elite athletes after Achilles tendon rupture.
 - The accuracy of current statistical metrics on providing an accurate measure of athletic performance for elite athletes.
- ▶ Future research:
 - Compare RTP and performance outcomes from operative versus non-operative management of Achilles tendon rupture in an elite athlete population.
 - Validate and standardise measures of athletic performance following Achilles tendon rupture.

Limitations

There are some inherent limitations in this review. This paper was a review of retrospective studies that often used publicly available performance data. Only one database was searched and some relevant studies could have been missed. The studies included demonstrated a lack of standardisation impeding a more detailed grading or synthesis of the evidence. Our review could not ascertain whether the Achilles injuries were complete or incomplete ruptures, the location of the ruptures or potential variable surgical techniques and postoperative protocols. Studies have reported that open and minimally invasive techniques are associated with different risks of nerve injury, wound complication and RTP timelines, although the re-rupture rate has not been reported to differ significantly.^{31 32} We also do not have access to any potential adjunctive treatments used or athlete symptoms when returning to play. Lastly, all the above studies involved male elite athletes, and these results may not be generalisable to female athletes or athletes at less competitive levels.

CONCLUSIONS

While the majority of elite athletes with Achilles tendon rupture return to their previous level of sport, there are varying results for performance after RTP. All studies of NBA players demonstrated a significant negative effect on performance; in contrast, NFL, NCAA football and professional soccer studies have reported varying performance results after RTP. MLB players were not reported to have significant performance decreases after injury. Given the focus on only the first few seasons after injury, it is unclear whether these performance measures are expected to

What is already known

- ▶ Achilles tendon rupture is a common injury in high-level athletes, especially those in sports requiring explosive movements.
- ▶ Achilles tendon rupture is a debilitating injury for high-level athletes causing an extended time loss from sport.
- ▶ Professional athletes generally opt for surgical intervention, although high-level evidence demonstrates good outcomes from non-operative management in the general population with early functional rehabilitation.

What are the new findings

- ▶ No studies have evaluated non-operative management of Achilles tendon rupture in elite athletes.
- ▶ Professional and collegiate athletes demonstrate high levels of return-to-play after Achilles tendon rupture and operative treatment.
- ▶ NBA players experience diminished performance (measured by player efficiency rating) after Achilles tendon rupture and operative intervention.
- ▶ NFL, National Collegiate Athletic Association football and professional soccer players demonstrate conflicting results on performance after Achilles tendon rupture and operative treatment—likely due to a lack of standardisation of performance measurement across studies.
- ▶ Major League Baseball players did not demonstrate diminished performance after Achilles tendon rupture.

persist as athletes progress later into their career. We believe this review will help clinicians more accurately counsel athletes regarding evidence-based expectations following Achilles tendon rupture. Further investigations using standardised performance measures and rehabilitation protocols are needed.

Contributors All the authors have made a substantial contribution to the concept or design of the article or the acquisition, analysis or interpretation of data for the article; drafted the article or revised it critically for important intellectual content; approved the version to be published; agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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