

Baseline Musculoskeletal Imaging Abnormalities and Subsequent Injury in Asymptomatic Athletes: A Systematic Review and Exploratory Meta-Analysis

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Systematic Review

Keywords: asymptomatic athletes, magnetic resonance imaging, musculoskeletal ultrasound, prognosis, sports injury

Posted Date: September 28th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11155333/v1>

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Additional Declarations: No competing interests reported.

Abstract

Purpose

To determine whether abnormal baseline magnetic resonance imaging (MRI) or diagnostic ultrasound in athletes asymptomatic in the imaged region predicts subsequent same-region symptomatic injury.

Methods

A multi-database literature search was screened against prespecified criteria. Eligible studies imaged asymptomatic athletes before longitudinal clinical follow-up and reported an abnormal-imaging denominator. Risk of bias used the Quality In Prognosis Studies framework. Achilles and patellar tendon risk ratios (RRs) were pooled separately using exploratory DerSimonian–Laird random-effects models.

Results

Of 979 screened records, 78 reports were sought, 61 were assessed, and 16 reports representing 11 cohorts were included; four reports contributed six structure-specific estimates. In collegiate athletes, abnormal imaging predicted time-loss injury of the patellar tendon (adjusted RR 10.7, 95% confidence interval [CI] 4.1–27.8), Achilles tendon (adjusted RR 19.2, 95% CI 6.6–55.7), and plantar fascia (adjusted RR 13.3, 95% CI 1.4–104.8). Pooled RRs were 5.43 (95% CI 1.28–23.13; $I^2=81.1\%$) for Achilles outcomes and 3.15 (95% CI 1.11–8.94; $I^2=83.4\%$) for patellar outcomes. Youth medial-elbow abnormality also predicted injury (17/59 vs 18/151; crude RR 2.42, 95% CI 1.36–4.31). MRI findings were less consistent.

Conclusion

Baseline imaging abnormalities identify higher-risk groups, most consistently on Achilles and patellar tendon ultrasound, but prediction is heterogeneous and many abnormal structures remain asymptomatic. Imaging should inform monitoring and contextual load management, not serve alone as an indication for restriction or invasive treatment.

Introduction

Baseline MRI and diagnostic ultrasound are increasingly used in elite sport, preseason evaluation, research surveillance, and clinical decision-making. These tests frequently reveal structural findings in athletes who report no pain or functional limitation. Tendon thickening, hypoechogenicity, neovascularity, ligament heterogeneity, partial tearing, labral abnormalities, cartilage changes, and bone marrow signal may reflect adaptation to loading, previous subclinical injury, early pathology, or normal variation. The clinical question is therefore prognostic: does an abnormal image identify an athlete who is more likely to develop a subsequent same-region symptomatic injury? This distinction matters because a risk

marker is not necessarily a treatment target. Sports-injury prognosis depends on athlete exposure, training load, age, prior symptoms, sport demands, outcome surveillance, and the unit of analysis as well as the imaging finding itself [1–3]. Current consensus also distinguishes structural change from clinical tendinopathy, which requires symptoms and functional consequences [4]. An imaging-only interpretation can therefore overmedicalize normal adaptation, while an evidence-based prognostic interpretation may support closer monitoring or load modification.

Previous systematic reviews have concentrated mainly on Achilles and patellar tendon ultrasound and have reported associations between asymptomatic structural abnormalities and later pain, but substantial heterogeneity and limited event counts remain [5–7]. Longitudinal primary studies have also examined the throwing elbow, shoulder, and foot and ankle, yet these findings have not been consistently compared with the lower-limb tendon literature. A broader synthesis is needed to separate prevalence from prediction, link companion publications, and distinguish self-reported pain from time-loss injury, injured-list placement, and surgery.

The purpose of this systematic review was to determine the incidence and relative risk of subsequent symptomatic musculoskeletal injury among asymptomatic athletes with abnormal baseline MRI or diagnostic ultrasound and to identify imaging, athlete, and study characteristics that modify the association. We hypothesized that baseline tendon ultrasound abnormalities would predict later symptoms, while prognostic findings in other regions would be less consistent because of smaller cohorts, multiple feature-level comparisons, and heterogeneous outcomes.

Methods

Eligibility criteria

The review question was: among athletes who were asymptomatic in the imaged anatomical structure or region at baseline, what was the incidence of subsequent same-region symptomatic injury after an abnormal MRI or diagnostic ultrasound, and what was the risk relative to normal baseline imaging when a comparator was available? Human athletes of any age, sex, sport, competitive level, or geographic location were eligible. MRI, B-mode ultrasound, and Doppler or power Doppler used as part of a diagnostic musculoskeletal examination were eligible modalities.

Eligible designs included prospective and retrospective cohorts, longitudinal surveillance studies, registries, screening cohorts, and case series with more than 10 athletes. Imaging had to precede the outcome period, baseline asymptomatic status had to be established, and the abnormal-imaging denominator had to be reported or calculable. The clinical outcome had to involve the same structure or corresponding region and could include new pain, a clinician-diagnosed injury, time loss, injured-list placement, rehabilitation, a procedure, or surgery. Cross-sectional and prevalence-only studies, symptomatic baseline cohorts, post-injury or postoperative imaging, imaging-only progression, non-MRI

or non-ultrasound studies, reviews, case reports, non-English reports, and records without extractable denominators or temporal linkage were excluded.

Protocol, registration, and reporting

Protocol, registration, and reporting

A protocol was prepared using PRISMA-P and PROSPERO guidance [8, 9], and this report follows PRISMA 2020 and prognostic-factor review guidance [10, 11]. The record was registered in PROSPERO as CRD420261502330 on Sep 22, 2026. Deviations from the registered plan were QUIPS rather than RoB 2/JBI tools, DerSimonian–Laird rather than REML with Hartung–Knapp adjustment, and combined rather than separate pooling of adjusted and crude estimates. These deviations reflected the completed workflow and sparse structure-specific evidence. Sports-injury terminology followed the International Olympic Committee consensus [12].

Information sources, search, and selection

A literature search containing all records identified through PubMed/MEDLINE, CINAHL, and Google Scholar was conducted using a highly sensitive search algorithm. The documented search combined athlete, asymptomatic or preseason screening, MRI or ultrasound, injury or pain, and longitudinal or prognostic concepts, with an animal-only exclusion; the search log returned 994 results on Sep 22, 2026. The consolidated export contained 979 records. Consequently, the PRISMA flow begins with the 979 supplied records. The documented search strategy and all detailed exclusion decisions are provided in Online Resource 1.

Screening and extraction were conducted by multiple reviewers with a process to resolve disagreements through other reviewers. Titles and abstracts were triaged in a structured workbook; potentially relevant records were manually checked before final classification. Full text was sought for every report retained for detailed assessment. Seventeen reports were excluded because complete text could not be retrieved. For multiple publications from the same or likely overlapping cohort, the most complete report contributed to quantitative synthesis and companion reports contributed only nonduplicative information.

Data collection and outcomes

Extracted fields included author, year, country, design, sample, sport and competitive level, baseline asymptomatic definition, anatomical region and structure, modality, imaging protocol and abnormality, unit of analysis, follow-up, surveillance method, clinical outcome, event counts, relative effects, confounders, analytic role, overlap, and limitations. The reviewers extracted the data and checked each retained report against full text. Reports were linked at cohort level to avoid double counting. The athlete

was the preferred unit; tendon-, limb-, joint-, and athlete-season observations were labeled when authors used those units.

Outcomes were grouped by structure and then by clinical severity. New pain, time-loss injury, injured-list placement, and surgery were not treated as interchangeable. An author-reported adjusted estimate was preferred for interpretation. Crude RRs and 95% CIs were calculated from 2 x 2 data when available. Odds ratios were reported but were not converted to RRs or combined with RRs.

Risk of bias and certainty

Reviewers assessed risk of bias using the six-domain Quality In Prognosis Studies (QUIPS) framework: participation, attrition, prognostic-factor measurement, outcome measurement, confounding, and analysis and reporting [13]. Overall judgments were low, moderate, or high rather than numeric scores. Certainty for each major anatomical conclusion was judged qualitatively using an adaptation of GRADE for prognostic-factor research, considering risk of bias, inconsistency, indirectness, imprecision, and possible publication bias [14].

Statistical analysis

Separate exploratory random-effects meta-analyses were performed for Achilles and patellar tendon RRs when at least three independent reports provided estimates with 95% CIs. Effects were analyzed on the log-RR scale with the DerSimonian-Laird estimator [15]. Heterogeneity was described with Cochran Q, tau-squared, and I^2 [16], following general Cochrane guidance for cautious interpretation of sparse heterogeneous evidence [17].

The pools combined author-reported adjusted RRs with crude RRs and combined self-reported pain with time-loss outcomes. They were therefore designated hypothesis-generating rather than confirmatory. A prespecified separation of crude and adjusted estimates was not possible because each category contained too few independent studies. Funnel plots and regression tests for asymmetry were not performed because each structure-specific pool contained only three reports and because the outcomes were not clinically exchangeable [18, 19]. No meta-regression or formal sensitivity analysis was attempted.

Calculations and figure preparation were performed in a reproducible local analysis workflow.

Results

Study selection

The consolidated export contained 979 records; none were marked as duplicate within the supplied data. Title and abstract screening excluded 901 records, leaving 78 reports sought for retrieval. Seventeen could not be retrieved, so 61 reports underwent full-text eligibility assessment. Forty-five retrieved

reports were excluded, leaving 16 reports for qualitative synthesis. These represented 11 independent cohorts after conservative cohort linking. Four reports contributed six structure-specific estimates to the exploratory Achilles and patellar analyses (Fig. 1).

Study characteristics

The 16 reports were published from 2011 through 2026 and included prospective, retrospective, and descriptive longitudinal designs. Athlete populations ranged from youth baseball and junior volleyball to recreational runners, NCAA Division I athletes, professional soccer players, professional baseball pitchers, and professional ballet dancers. Ultrasound studies dominated the evidence and focused on the Achilles tendon, patellar tendon, plantar fascia, or medial elbow. MRI studies evaluated the elbow and shoulder in professional pitchers and the foot and ankle in professional dancers. Follow-up ranged from one season to career-long public-record surveillance.

Table 1

Characteristics and principal findings of the 16 included reports. Companion publications were linked and not double counted. MRI, magnetic resonance imaging; MLB, Major League Baseball; UCL, ulnar collateral ligament; US, ultrasound

Study	Design/population	Imaging	Principal finding
Le Beaumont 2026 [22]	Prospective; 22 collegiate athletes	US: patellar/Achilles/plantar	No baseline abnormality resolved; three new Achilles abnormalities preceded pain/injury; severe attrition
Cushman 2025 [20]	Prospective multicentre; 695 athlete-seasons	US: patellar/Achilles/plantar	Adjusted time-loss RRs 10.7, 19.2, and 13.3, respectively
Cushman 2024 [21]	Prospective; 242 collegiate athletes	US: patellar/Achilles/plantar	Abnormal imaging predicted one-year pain; overlaps 2025 cohort
Katakura 2024 [35]	Prospective case series; 31 dancers	3-T MRI: foot/ankle	14 injuries; two attributable to baseline findings
Mersmann 2023 [27]	Prospective; 37 adolescent athletes analysed	US + inverse dynamics: patellar	Strain $\geq$ 9% predicted symptoms (RR 2.3)
Beletsky 2022 [34]	Retrospective; 29 MLB pitchers	MRI: shoulder	No finding predicted injured-list placement; selected findings associated with surgery
Cushman 2022 [23]	Prospective; 138 runners	US: Achilles/patellar	Achilles pain 34.2% vs 12.8%; patellar 22.9% vs 15.1%
Cushman 2021 [24]	Prospective; 104 runners analysed	US: Achilles/patellar	Approximately two- to threefold pain risk; overlaps 2022 report
Nowak 2024 [25]	Blinded reanalysis; 138 runners	US: Achilles	Three echogenic patterns associated with pain; overlapping cohort
Shitara 2021b [30]	Prospective abnormal-only; 82 youth players	US: medial elbow	22 developed symptoms; no normal comparator
Shitara 2021a [29]	Prospective; 210 youth players	US: medial epicondyle	17/59 vs 18/151 injured (RR 2.42)
Garcia 2019 [32]	Retrospective; 41 MLB pitchers	MRI: elbow/UCL	Selected UCL/posteromedial findings predicted later injury-list placement or surgery
Shanley 2018 [31]	Prospective; 70 professional pitchers	Stress US: UCL	Seven UCL injuries; gapping $\geq$ 5.6 mm associated with sixfold risk

Study	Design/population	Imaging	Principal finding
Gutierrez 2017 [33]	Retrospective; 26 professional pitchers	MRI: elbow	Six injured-list placements; no single MRI feature predictive
Visnes 2015 [26]	Prospective; 141 junior volleyball players	US: patellar	Hypoechoic area predicted jumper's knee (adjusted OR 3.3)
Jhingan 2011 [28]	Prospective; 18 soccer players/36 tendons	US: Achilles	5/23 abnormal vs 1/13 normal developed symptoms (RR 2.83)

Lower-limb tendon ultrasound

Lower-limb tendon ultrasound produced the most consistent prospective evidence. In the largest collegiate analysis, 695 athlete-seasons from 538 unique athletes were followed across 18 NCAA Division I sports. Among structures without pain at scanning, any prespecified thickening, hypoechogenicity, or neovascularization was associated with subsequent time-loss injury of the patellar tendon (adjusted RR, 10.7; 95% CI, 4.1–27.8), Achilles tendon (adjusted RR, 19.2; 95% CI, 6.6–55.7), and plantar fascia (adjusted RR, 13.3; 95% CI, 1.4–104.8) [20]. The wide plantar fascia interval reflected sparse events. An earlier report from the overlapping cohort provided exact asymptomatic subgroup counts and similarly large relative effects for patellar and Achilles pain, while the two-year subset was limited by retention of only 22 of 242 original athletes [21, 22].

In 138 recreational distance runners, 14 of 41 abnormal Achilles tendons developed pain compared with 30 of 235 normal tendons (34.2% vs 12.8%; crude RR, 2.67; 95% CI, 1.57–4.57). Patellar pain developed in 16 of 70 abnormal tendons and 31 of 206 normal tendons (22.9% vs 15.1%; crude RR, 1.52; 95% CI, 0.88–2.62) [23]. A companion report showed similar risk elevations, and blinded reanalysis linked three specific Achilles echogenic patterns to later pain [24, 25]. These reports arose from the same runner cohort and were not treated as independent estimates.

Other prospective cohorts supported a prognostic association but remained small. Among 141 asymptomatic elite junior volleyball players, 17 of 46 hypoechoic patellar tendons and 18 of 236 tendons without hypoechogenicity developed jumper's knee; the adjusted OR was 3.3 (95% CI, 1.1–9.2) [26]. In adolescent athletes, patellar tendon strain of at least 9% was associated with symptoms (RR, 2.3; 95% CI, 1.1–4.9) [27]. In 18 professional soccer players, symptoms developed in 5 of 23 abnormal Achilles tendons and 1 of 13 normal tendons (crude RR, 2.83; 95% CI, 0.37–21.60), with imprecision, paired-tendon nonindependence, attrition, and retrospective symptom recall [28].

Table 2

Selected structure-specific prognostic estimates. Estimates are not directly interchangeable because outcome definitions, analysis units, imaging thresholds, and adjustment differ. CI, confidence interval; OR, odds ratio; RR, risk ratio; UCL, ulnar collateral ligament

Study	Structure	Outcome	Effect estimate (95% CI)
Cushman 2025 [20]	Patellar tendon	Time-loss injury	Adjusted RR 10.7 (4.1–27.8)
Cushman 2025 [20]	Achilles tendon	Time-loss injury	Adjusted RR 19.2 (6.6–55.7)
Cushman 2025 [20]	Plantar fascia	Time-loss injury	Adjusted RR 13.3 (1.4–104.8)
Cushman 2022 [23]	Achilles tendon	New pain	Crude RR 2.67 (1.57–4.57)
Cushman 2022 [23]	Patellar tendon	New pain	Crude RR 1.52 (0.88–2.62)
Mersmann 2023 [27]	Patellar tendon	New pain	RR 2.3 (1.1–4.9)
Visnes 2015 [26]	Patellar tendon	Jumper's knee	Adjusted OR 3.3 (1.1–9.2)
Jhingan 2011 [28]	Achilles tendon	Tendinopathy symptoms	Crude RR 2.83 (0.37–21.60)
Shitara 2021a [29]	Medial elbow	Throwing-related injury	Crude RR 2.42 (1.36–4.31)
Shanley 2018 [31]	Elbow UCL	UCL reconstruction	RR 6.0 (CI not reported)

Exploratory quantitative synthesis

Three independent Achilles reports yielded a random-effects pooled RR of 5.43 (95% CI, 1.28–23.13), with substantial heterogeneity ($Q = 10.61$; $I^2 = 81.1\%$; $\tau^2 = 1.25$). Three independent patellar reports yielded a pooled RR of 3.15 (95% CI, 1.11–8.94), again with substantial heterogeneity ($Q = 12.08$; $I^2 = 83.4\%$; $\tau^2 = 0.70$). The results were sensitive in principle to the large collegiate adjusted estimates, but the small number of studies did not support a stable leave-one-out or subgroup analysis. The pooled values should be read as a compact display of direction and uncertainty, not as screening thresholds or transportable treatment effects.

Throwing-elbow ultrasound and MRI

Youth baseball provided the clearest non-tendon comparator. In 210 asymptomatic players, a preseason medial epicondyle apophyseal abnormality was followed by throwing-related elbow injury in 17 of 59 players compared with 18 of 151 players without the finding (28.8% vs 11.9%; crude RR, 2.42; 95% CI, 1.36–4.31) [29]. Daily parent and player diaries strengthened outcome surveillance, but applicability is limited to youth baseball. In a separate abnormal-only cohort, 22 of 82 players with asymptomatic medial-elbow abnormalities developed symptoms during one season; the absence of a normal-imaging comparator limited comparative inference [30].

Professional baseball studies reported potentially important but less stable findings. In 70 asymptomatic pitchers, seven sustained a UCL injury requiring reconstruction; valgus-stress joint

gapping of at least 5.6 mm was associated with an approximately sixfold risk, although the threshold-group denominator and confidence interval were not reported [31]. Among 41 Major League Baseball pitchers, UCL heterogeneity, humeral-sided partial tearing, and posteromedial impingement were associated with later elbow injured-list placement or surgery [32]. An earlier overlapping 26-pitcher report found that no single MRI feature predicted injured-list placement [33]. Small samples, multiple comparisons, feature-specific denominators, public-record outcome ascertainment, and likely cohort overlap reduce certainty.

Shoulder and foot/ankle MRI

MRI findings outside the elbow were common but not consistently prognostic. In 29 asymptomatic Major League Baseball pitchers with analyzable shoulder imaging, no individual MRI feature predicted future injured-list placement. Partial articular-sided rotator cuff tearing and biceps hyperintensity were associated with surgery, but only seven pitchers entered the injured group and many imaging features were tested [34]. In 31 asymptomatic professional ballet dancers, 51 of 62 feet and ankles had at least one baseline MRI finding. Fourteen foot or ankle injuries occurred during follow-up, and only two were attributed to a baseline MRI abnormality [35]. These studies show that a high prevalence of imaging findings does not by itself establish useful predictive performance.

Risk of bias and certainty

Overall risk of bias was low in six reports, moderate in four, and high in six. Imaging measurement was generally well described, while confounding was the most persistent concern. Other limitations included incomplete or selective follow-up, self-reported pain, multiple unadjusted imaging-feature comparisons, structure-level observations without full allowance for within-athlete correlation, and retrospective use of public injury records. Companion publications were retained to describe nonduplicative findings but were linked to their parent cohorts for synthesis.

Certainty was rated low for the conclusion that abnormal Achilles or patellar tendon ultrasound predicts later symptoms or time-loss injury. Prospective temporal sequence and repeated directionally consistent findings supported the association, but high heterogeneity, mixed outcomes, sparse events, mixed adjusted and crude estimates, and correlated structure-level data limited confidence. Certainty was low for youth medial-elbow ultrasound because the comparative estimate came from one prospective cohort. Certainty was very low for professional-baseball elbow imaging and for shoulder and foot/ankle MRI because of small samples, multiple testing, incomplete denominators, cohort overlap, and inconsistent results. Publication bias could not be evaluated reliably.

Discussion

This review found that baseline musculoskeletal imaging abnormalities in asymptomatic athletes can identify groups at higher risk of later same-region symptoms or injury, but the signal was concentrated in specific anatomical and methodological settings. Prospective Achilles and patellar tendon ultrasound studies produced the most consistent associations. A well-surveilled youth-baseball cohort also linked

medial-elbow abnormality to subsequent throwing-related injury. In contrast, MRI abnormalities in professional pitchers and dancers were common but showed limited or feature-specific prognostic value.

The tendon findings agree with earlier reviews, which concluded that abnormal Achilles or patellar ultrasound increases future symptom risk while leaving substantial overlap between athletes who do and do not develop pain [5–7]. The current collegiate time-loss study strengthens clinical relevance because its outcome required missed participation and physician or athletic-trainer surveillance rather than pain alone [20]. Even so, the adjusted RRs were accompanied by wide confidence intervals, and the underlying event counts in the asymptomatic subgroup were not separately reported. A large RR in a sparse setting does not establish high positive predictive value.

The pooled Achilles and patellar estimates reinforce the direction of association but not its magnitude. Each pool contained only three reports and combined adjusted with crude estimates, different athlete populations, and pain with time-loss outcomes. I^2 exceeded 80% in both pools. Those features violate the assumptions needed to treat a summary RR as a stable clinical threshold. The more defensible conclusion is that an abnormal tendon image increases risk on average, while absolute risk and actionability depend on sport exposure, age, the abnormality definition, baseline symptom ascertainment, and outcome severity.

The elbow evidence illustrates the importance of age and sport-specific load. Medial epicondyle apophyseal abnormality in youth baseball may mark a tissue-load mismatch during growth, whereas UCL morphology and dynamic gapping in professional pitchers may reflect cumulative valgus stress. These are biologically distinct exposures and should not be pooled. The conflicting professional-baseball MRI results also demonstrate the risk of multiple testing in small cohorts. A feature may appear prognostic in one analysis and fail in an overlapping or smaller sample because of sparse events, different outcomes, or model instability.

Shoulder and foot/ankle MRI findings further separate prevalence from prediction. Most dancers had at least one MRI abnormality, yet only two subsequent injuries were attributed to baseline findings. In pitchers, some shoulder features were associated with surgery but not with injured-list placement. Surgery is influenced by clinical judgment, athlete career context, access to care, and treatment preference; it is not equivalent to incident symptoms. Future studies should prespecify one or a small number of prognostic features, report normal and abnormal denominators, and use blinded clinical surveillance rather than relying only on public records.

Clinical implications

Baseline imaging should be interpreted as one component of a broader risk assessment. For an asymptomatic athlete with an abnormal Achilles or patellar tendon ultrasound, reasonable responses include documenting prior symptoms, reviewing recent workload, identifying rapid load increases, monitoring sport-specific pain and function, and setting a low threshold for reassessment. The evidence

does not justify removing an athlete from participation solely because an image is abnormal, nor does it support injection, surgery, or other invasive treatment without a clinical indication.

The same principle applies to throwing athletes. Medial-elbow ultrasound or UCL imaging may justify closer surveillance and attention to workload, mechanics, recovery, age, and growth-stage factors. Imaging cannot replace examination or exposure data, and normal imaging does not eliminate risk. Shared decisions should account for the athlete's sport, competitive context, preferences, and the consequences of both false reassurance and overdiagnosis.

Research implications

Future prognostic studies should enroll sufficiently large asymptomatic cohorts, define symptoms and previous injury before imaging, prespecify imaging thresholds, and report athlete-level as well as structure-level denominators. Surveillance should distinguish any pain from medical-attention, time-loss, and surgery outcomes using current sport-injury reporting standards [12]. Models should account for repeated seasons and paired structures, adjust for plausible confounders, and report calibration and discrimination in addition to relative association. Independent validation is needed before an imaging feature is used for screening policy or participation decisions.

Limitations

This review has important limitations. First, 17 otherwise plausible reports were excluded because complete text could not be retrieved. This rule improved extraction verifiability but may have introduced availability bias. Second, the included literature used mixed units, imaging definitions, sports, age groups, follow-up periods, and outcomes. Several reports arose from overlapping cohorts, and the true extent of overlap in professional baseball data could not always be confirmed. Third, the exploratory meta-analyses combined adjusted and crude RRs and combined self-reported pain with time-loss outcomes. With only three reports per pool, sensitivity analysis, meta-regression, and publication-bias assessment were not credible. Finally, several estimates were imprecise or based on very few events, and high relative risks should not be interpreted as high predictive accuracy.

Conclusion

Pre-existing musculoskeletal imaging abnormalities in asymptomatic athletes are associated with subsequent same-region symptoms or injury in several settings, most consistently for Achilles and patellar tendon ultrasound. Youth medial-elbow ultrasound also identified a higher-risk group, while MRI findings in professional pitchers and dancers were less consistent. The evidence supports risk stratification and targeted monitoring, not deterministic screening or imaging-only participation decisions.

Declarations

Author Contribution

A.K. : conceptualization, investigation, data curation, writing - original draft, project administration. M.G. : investigation, data curation, writing - review and editing. R.V. : methodology, formal analysis, visualization, writing - review and editing. R.B. : supervision, clinical interpretation, writing - review and editing. C.A. : supervision, clinical interpretation, writing - review and editing. L.V. : supervision, clinical interpretation, writing - review and editing.

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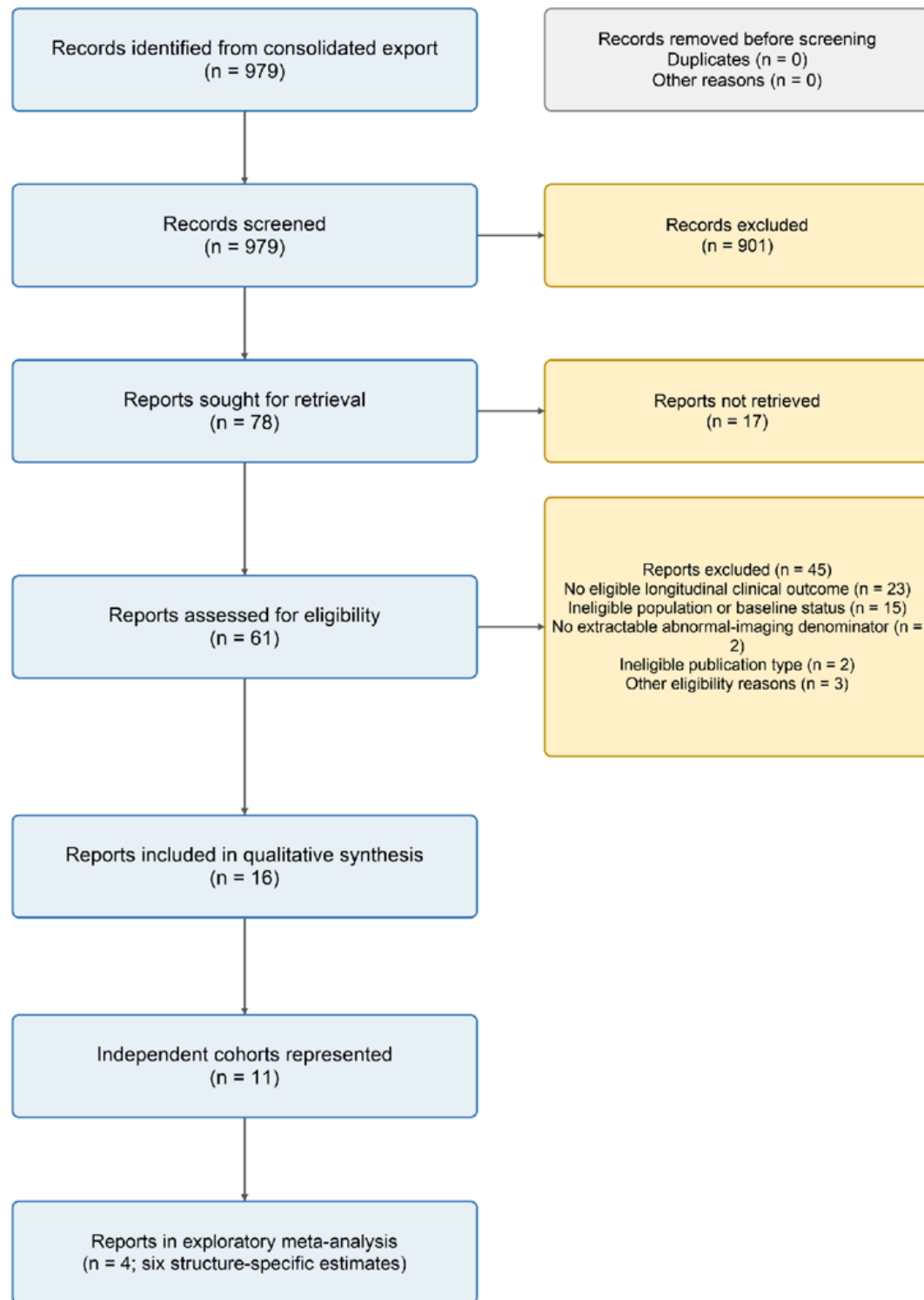
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Figures



Source-specific database counts were unavailable; the flow begins with the 979 supplied records.

Figure 1

PRISMA flow from the consolidated export through screening, retrieval, full-text eligibility assessment, cohort linking, and exploratory pooling

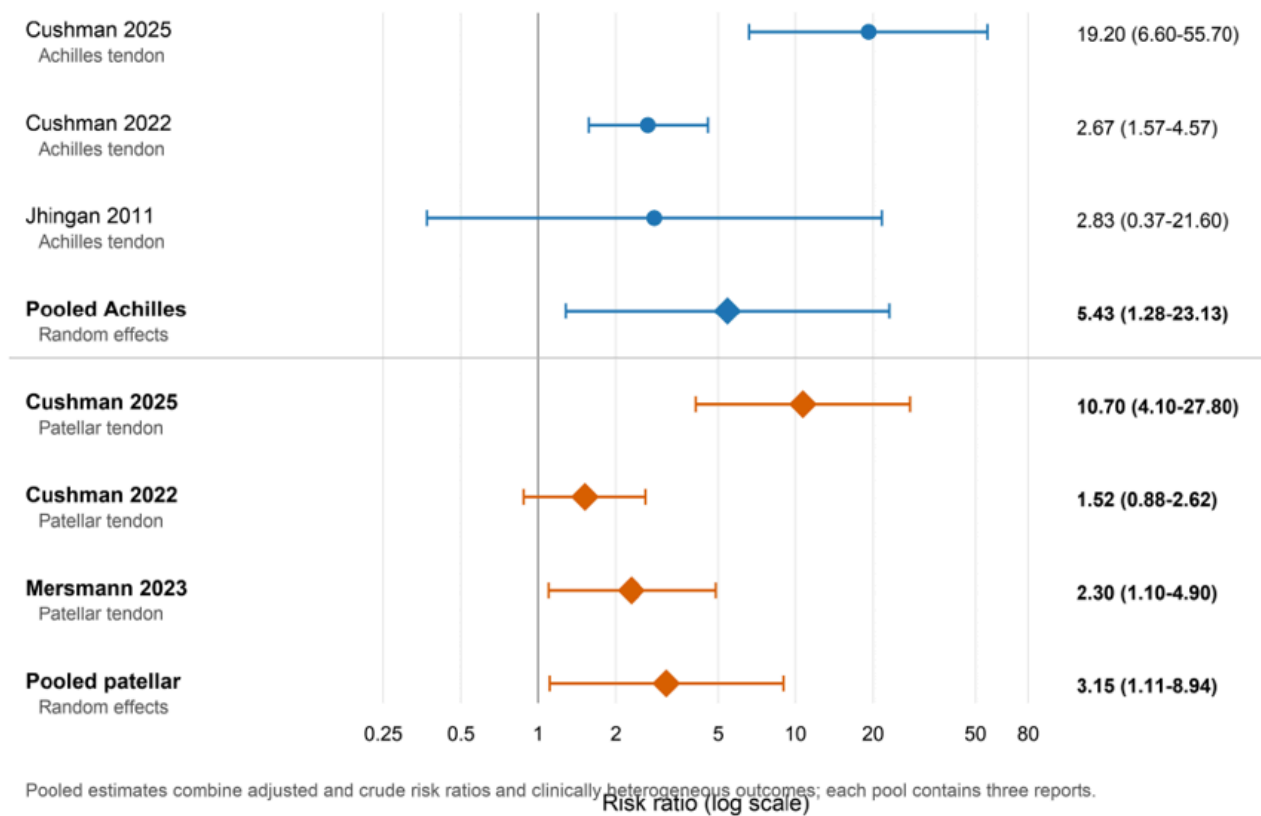


Figure 2

Exploratory random-effects synthesis of Achilles and patellar tendon risk ratios. Each pool combines differing outcomes and adjusted and crude estimates; both contain three reports and have high heterogeneity

	Participation	Attrition	Imaging	Outcome	Confounding	Analysis	Overall
Le Beaumont 2026	M	M	L	M	H	M	H
Cushman 2025	L	L	L	L	M	L	L
Cushman 2024	L	L	L	L	M	L	L
Katakura 2024	M	M	L	M	H	M	H
Mersmann 2023	M	M	L	M	M	M	M
Beletsky 2022	M	M	L	M	H	M	H
Cushman 2022	L	L	L	L	M	L	L
Cushman 2021	M	M	L	M	M	M	M
Nowak 2024	M	M	L	M	H	M	H
Shitara 2021b	L	L	L	L	M	L	L
Shitara 2021a	L	L	L	L	M	L	L
Garcia 2019	M	M	L	M	H	M	H
Shanley 2018	M	M	L	M	M	M	M
Gutierrez 2017	M	M	L	M	H	M	H
Visnes 2015	L	L	L	L	M	L	L
Jhingan 2011	M	M	L	M	M	M	M

● Low
 ● Moderate
 ● High

L, low risk; M, moderate risk; H, high risk. Judgments are provisional pending independent verification.

Figure 3

QUIPS risk-of-bias judgments for the 16 included reports. L, low risk; M, moderate risk; H, high risk. Judgments were made by one reviewer and require independent verification

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