

Online Resource 1

Detailed search, eligibility decisions, cohort links, extraction, and risk of bias

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

This supplementary file contains project records available at the time of submission. It does not reproduce copyrighted full-text articles.

Appendix A. Search documentation

Documented PubMed search date: Sep 22, 2026 . The log reported 994 results. The supplied consolidated export contained 979 records and was designated as containing PubMed/MEDLINE, CINAHL, and Google Scholar. Source-specific counts and the exact CINAHL and Google Scholar strategies were not available.

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(
  "Athletes"[Mesh]
  OR athlete*[Title/Abstract]
  OR player*[Title/Abstract]
  OR pitcher*[Title/Abstract]
  OR runner*[Title/Abstract]
  OR sport*[Title/Abstract]
)
AND
(
  asymptomatic[Title/Abstract]
  OR "symptom free"[Title/Abstract]
  OR symptom-free[Title/Abstract]
  OR preseason[Title/Abstract]
  OR "pre-season"[Title/Abstract]
  OR screening[Title/Abstract]
  OR baseline[Title/Abstract]
)
AND
(
  "Magnetic Resonance Imaging"[Mesh]
  OR MRI[Title/Abstract]
  OR "magnetic resonance imaging"[Title/Abstract]
  OR "Ultrasonography"[Mesh]
  OR ultrasound[Title/Abstract]
  OR ultrasonography[Title/Abstract]
  OR sonograph*[Title/Abstract]
)
AND
(
  injur*[Title/Abstract]
  OR symptom*[Title/Abstract]
  OR pain[Title/Abstract]
  OR "time loss"[Title/Abstract]
  OR "time-loss"[Title/Abstract]
)
AND
(
  predict*[Title/Abstract]
  OR subsequent[Title/Abstract]
  OR future[Title/Abstract]
  OR prospective[Title/Abstract]
  OR longitudinal[Title/Abstract]
  OR cohort[Title/Abstract]
  OR follow-up[Title/Abstract]
  OR followup[Title/Abstract]
  OR incidence[Title/Abstract]
  OR risk[Title/Abstract]
)
NOT
(
  animals[Mesh] NOT humans[Mesh]
)
```

Appendix B. Detailed-stage exclusions

Detailed-stage exclusions: 62 records. This set includes 17 reports that could not be retrieved and 45 retrieved reports excluded on eligibility grounds.

PMID	Report	Reason
42122038	Asymptomatic Abnormalities in the Knee, Shoulder, and Ankle Joints of Collegiate Athletes: A Cross-Sectional MRI-Based Comparative Study.	Cross-sectional MRI prevalence study
41778755	Prevalence of Sonographic Achilles Tendon, Patellar Tendon, and Plantar Fascia Abnormalities Among 533 Division I Collegiate Athletes from a Variety of Sports.	Cross-sectional ultrasound prevalence study
41283527	Patellar Tendon Structural Difference Occurs in Female and Male Professional Basketball Players: 8 Months Follow-Up.	Morphology adaptation study without incident clinical injury
41033749	MRI Screening for lumbar bone stress injuries in young male cricket fast bowlers: a 15-year retrospective cohort study.	Screening-detected injury was already present at baseline; no untreated pre-symptomatic clinical follow-up
40100945	Preseason Patellar Tendon Thickness Predicts Symptomatic Patellar Tendinopathy in Male NCAA Division I Basketball Players.	No categorical abnormal-imaging denominator reported
39741483	Longitudinal Assessment of Intersegmental Abnormalities in the Lumbar Spine of Adolescent Competitive Alpine Skiers Over 48 Months.	Imaging progression study without eligible clinical incidence
39565178	3.0-Tesla MRI Observation at Return to Play After Hamstring Injuries.	Post-injury return-to-play imaging
39439271	Long-term Prognosis of Patellar Tendinopathy (Jumper's Knee) in Young, Elite Volleyball Players: Tendon Changes 11 Years After Baseline.	Participants had symptomatic patellar tendinopathy at baseline
39253290	Association Between Longitudinal Changes in Patellar Tendon Abnormality and Land-Jump Biomechanics in Male Collegiate Basketball Players.	Biomechanics/imaging-change outcome rather than incident symptoms
38686323	Association Between Patellar Tendon Abnormality and Land-Jump Biomechanics in Male Collegiate Basketball Players During the Preseason.	Cross-sectional preseason biomechanics association
38406885	The Utility of Stress Ultrasound in Identifying Risk Factors for Elbow Ulnar Collateral Ligament Tear: A Longitudinal Study of 203 Professional Baseball Players.	Full text unavailable for verification
38365902	Superolateral Hoffa fat pad edema in adolescent competitive alpine skiers: temporal evolution over 4 years and risk factors.	Imaging evolution study; no incident clinical outcome by baseline abnormality
37152549	Prevalence of Asymptomatic Talar Bone Marrow Edema in Professional Ballet Dancers: Preliminary Data From a 2-Year Prospective Study.	Prevalence/functional comparison only; subsequent clinical symptoms not reported
36800008	Tendon appearance at imaging may be altered, but it may not indicate pathology.	Narrative/educational article
36682095	Proximal patellar tendon abnormalities on ultrasound can develop in male adolescent basketball players: A longitudinal study.	Imaging evolution study; no baseline abnormal-to-new-symptom incidence
36661480	Risk Factors for Symptomatic Bilateral Lumbar Bone Stress Injury in Adolescent Soccer Players: A Prospective Cohort Study.	Full text unavailable for verification
36438915	On-site Ultrasound Screens out Asymptomatic Knee Lesions in Elite Adolescent Male Basketball Players.	Cross-sectional screening report
36280886	Lumbar spine MRI findings in asymptomatic elite male academy footballers: a case series.	Case series describing prevalence without follow-up symptoms
36003328	No Significant Change in MRI Abnormalities or Back Pain Prevalence in the Thoraco-Lumbar Spine of Young Elite Skiers Over a 2-Year Follow-Up.	Mixed baseline back-pain status; no eligible asymptomatic abnormal subgroup
34961538	Quantitative evaluation of ankle cartilage in asymptomatic adolescent football players after season by T2-mapping magnetic resonance imaging.	Imaging adaptation outcome only
34631145	Clinical relevance of MRI knee abnormalities in Australian rules football players: a longitudinal study.	Mixed baseline knee-symptom and injury history; no eligible asymptomatic subgroup
34435066	Is the Prognosis of Osgood-Schlatter Poorer Than Anticipated? A Prospective Cohort Study With 24-Month Follow-up.	Symptomatic Osgood-Schlatter cohort

PMID	Report	Reason
33888108	A case of an injured calcaneus secundarius in a professional soccer player.	Case report
33237502	Lumbar spine abnormalities and facet joint angles in asymptomatic elite junior tennis players.	Cross-sectional MRI prevalence study
32641518	Longitudinal white-matter abnormalities in sports-related concussion: A diffusion MRI study.	Post-concussion brain-imaging study; not baseline musculoskeletal imaging
32632469	MRI features of and factors related to ankle injuries in asymptomatic amateur marathon runners.	Cross-sectional prevalence and correlates only
32307676	The Effect of Training Experience and Leg Dominance on the Prevalence of Asymptomatic Intraarticular Changes of the Knee Joints in Adult Professional Male Soccer Players.	Cross-sectional prevalence only
31801034	Progressive Elbow Magnetic Resonance Imaging Abnormalities in Little League Baseball Players Are Common: A 3-Year Longitudinal Evaluation.	Primary outcome was imaging progression; baseline abnormal-to-clinical outcome not extractable
31663370	Low prevalence of patellar tendon abnormality and low incidence of patellar tendinopathy in female collegiate volleyball players.	Full text unavailable for verification
31490583	Using Ultrasound Measurement of the Achilles Tendon in Asymptomatic Runners to Assist in Predicting Tendinopathy.	Prevalence/correlation study without clinical follow-up
30994580	The Curse of the All-Star Team: A Single-Season Prospective Shoulder MRI Study of Little League Baseball Players.	Primary outcome was new/worsening MRI findings, not subsequent clinical injury
30959542	Knee Ultrasonography to Determine Risk for Noncontact Injuries in Collegiate American Football Players.	Full text unavailable for verification
30943755	Arthroscopic Treatment of Patellar and Trochlear Cartilage Lesions with Matrix Encapsulated Chondrocyte Implantation versus Microfracture: Quantitative Assessment with MRI T2-Mapping and MOCART at 4-Year Follow-up.	Post-treatment cartilage-repair cohort
30340804	Effectiveness of ultrasonography screening and risk factor analysis of capitellar osteochondritis dissecans in adolescent baseball players.	Cross-sectional screening study
30098975	Quantification of Achilles and patellar tendon structure on imaging does not enhance ability to predict self-reported symptoms beyond grey-scale ultrasound and previous history.	Full text unavailable for verification
29021905	The waterpolo shoulder paradigm: results of ultrasound surveillance at poolside.	Cross-sectional surveillance without longitudinal clinical outcome
27122512	A clinical and ultrasonographic study of risk factors for elbow injury in young baseball players.	Cross-sectional risk-factor analysis
26857473	Incidence of elbow injuries in adolescent baseball players: screening by a low field magnetic resonance imaging system specialized for small joints.	Cross-sectional screening study
26513392	Sonoelastography of the Achilles Tendon: Prevalence and Prognostic Value Among Asymptomatic Elite Australian Rules Football Players.	Full text unavailable for verification
25787114	Prevalence of morphological and mechanical stiffness alterations of mid Achilles tendons in asymptomatic marathon runners before and after a competition.	No categorical abnormal-imaging denominator; acute post-race response
24996873	Asymptomatic hip/groin pathology identified on magnetic resonance imaging of professional hockey players: outcomes and playing status at 4 years' follow-up.	Full text unavailable for verification
24603080	Do MRI and ultrasound of the anterior pelvis correlate with, or predict, young football players' clinical findings? A 4-year prospective study of elite academy soccer players.	Full text unavailable for verification
23841993	Risk factors for lumbar disc degeneration in high school American football players: a prospective 2-year follow-up study.	Primary outcome was MRI disc degeneration; baseline abnormal-to-symptom incidence not extractable
23775245	Glenohumeral findings on magnetic resonance imaging correlate with innings pitched in asymptomatic pitchers.	Full text unavailable for verification
23064082	The prevalence and clinical significance of sonographic tendon abnormalities in asymptomatic ballet dancers: a 24-month longitudinal study.	Full text unavailable for verification

PMID	Report	Reason
22952406	Doppler ultrasound and tibial tuberosity maturation status predicts pain in adolescent male athletes with Osgood-Schlatter's disease: a case series with comparison group and clinical interpretation.	Symptomatic Osgood-Schlatter cohort at baseline
22092963	Asymptomatic Achilles, patellar, and quadriceps tendinopathy: a longitudinal clinical and ultrasonographic study in elite fencers.	Full text unavailable for verification
21720278	Prognostic value of Achilles tendon Doppler sonography in asymptomatic runners.	Full text unavailable for verification
19305975	Back pain and MRI changes in the thoraco-lumbar spine of top athletes in four different sports: a 15-year follow-up study.	Most athletes reported back pain at baseline
18079558	Prophylactic training in asymptomatic soccer players with ultrasonographic abnormalities in Achilles and patellar tendons: the Danish Super League Study.	Randomized preventive intervention confounded natural-history incidence
17016113	Patellar tendons with normal imaging and pain: change in imaging and pain status over a volleyball season.	Baseline population included symptomatic tendons; eligible subgroup not extractable
16416326	Back pain and degenerative abnormalities in the spine of young elite divers: a 5-year follow-up magnetic resonance imaging study.	Most divers had back pain before or at baseline
16251395	Clinical course of knees with asymptomatic meniscal abnormalities: findings at 2-year follow-up after MR imaging-based diagnosis.	Population was not an athlete cohort
15827362	Groin pain in footballers: the association between preseason clinical and pubic bone magnetic resonance imaging findings and athlete outcome.	Mixed symptomatic baseline cohort; asymptomatic subgroup not extractable
15333349	Asymptomatic tibial stress reactions: MRI detection and clinical follow-up in distance runners.	Full text unavailable for verification
12975193	Magnetic resonance imaging of the asymptomatic shoulder of overhead athletes: a 5-year follow-up study.	Full text unavailable for verification
12663358	Are ultrasound and magnetic resonance imaging of value in assessment of Achilles tendon disorders? A two year prospective study.	Symptomatic Achilles disorder cohort
12130402	Significance of ultrasonographically detected asymptomatic tendinosis in the patellar and achilles tendons of elite soccer players: a longitudinal study.	Full text unavailable for verification
11805656	Risk factors for lumbar disc degeneration: a 5-year prospective MRI study in asymptomatic individuals.	Population was not an athlete cohort
11782263	Asymptomatic hypoechoic regions on patellar tendon ultrasound: A 4-year clinical and ultrasound followup of 46 tendons.	Full text unavailable for verification
10898301	Prospective imaging study of asymptomatic patellar tendinopathy in elite junior basketball players.	Full text unavailable for verification
9262888	Patellar tendon ultrasonography and jumper's knee in female basketball players: a longitudinal study.	Baseline abnormal group included current and previous symptoms

Appendix C. Included-study extraction

Study	Sample	Sport	Structure	Modality	Follow-up	Key finding
Le Beaumont 2026	22 athletes; 44 tendons/fasciae per structure	NCAA Division I, mixed sports	Patellar tendon; Achilles tendon; plantar fascia	Ultrasound	2 years	No baseline abnormalities resolved; three initially normal Achilles tendons became abnormal and later developed pain/injury.
Cushman 2025	695 athlete-seasons; 538 unique athletes	18 NCAA Division I sports	Patellar tendon; Achilles tendon; plantar fascia	Ultrasound	1 year after each preseason scan; 3 study years	Among athletes without pain at scanning, adjusted RRs were 10.7, 19.2, and 13.3 for patellar, Achilles, and plantar time-loss injury.
Cushman 2024	242 athletes; up to 484 structures	NCAA Division I, mixed sports	Patellar tendon; Achilles tendon; plantar fascia	Ultrasound	1 year	In asymptomatic structures, abnormal imaging strongly increased patellar and Achilles pain risk; plantar estimates were sparse.

Study	Sample	Sport	Structure	Modality	Follow-up	Key finding
Katakura 2024	31 dancers; 62 feet/ankles	Professional ballet	Bone, joints, and tendons	3-T MRI	12 months	MRI abnormalities were common; 14 foot/ankle injuries occurred, but only two were attributable to baseline MRI findings.
Mersmann 2023	44 adolescent athletes; 37 analyzed	Mixed adolescent sports	Patellar tendon	Ultrasound plus inverse dynamics	One season; 4 assessments	Tendon strain $\geq 9\%$ was associated with a 2.3-fold risk of developing symptoms (95% CI 1.1–4.9).
Beletsky 2022	29 included pitchers (41 imaged; 7 injured/22 healthy)	Baseball	Rotator cuff, labrum, capsule, biceps, humeral head	MRI	Career follow-up after 2005–2017 preseason imaging	No MRI finding predicted future injured-list placement; partial articular cuff tear and biceps hyperintensity were associated with surgery.
Cushman 2022	138 runners; 276 Achilles and 276 patellar tendons	Half/full-marathon running	Achilles and patellar tendons	Ultrasound	1, 3, 6, and 12 months	Abnormal Achilles tendons had 34.2% pain versus 12.8% when normal; patellar results were 22.9% versus 15.1%.
Cushman 2021	139 enrolled; 104 analyzed	Half/full-marathon running	Achilles and patellar tendons	Ultrasound	12 months	Abnormal imaging was associated with roughly 2–3 times the risk of pain.
Nowak 2024	138 runners; 276 Achilles tendons	Half/full-marathon running	Achilles tendon	Ultrasound	12 months	Three specific echogenic patterns were associated with later pain.
Shitara 2021	82 youth baseball players with medial elbow abnormalities	Baseball	Medial epicondyle region	Ultrasound	One season	22 of 82 (26.8%) developed a symptomatic elbow.
Shitara 2021	210 youth baseball players	Baseball	Medial epicondyle apophysis	Ultrasound	1 year	Elbow injury occurred in 17/59 with apophysitis versus 18/151 without it.
Garcia 2019	41 asymptomatic professional pitchers	Baseball	UCL, posteromedial elbow, cartilage	MRI	Career follow-up after 2005–2017 imaging	UCL heterogeneity, humeral-sided partial tears, and posteromedial impingement were associated with later injured-list placement.
Shanley 2018	70 asymptomatic professional pitchers	Baseball	UCL/ulnohumeral joint	Stress ultrasound	One season	Seven pitchers sustained UCL injury; gapping ≥ 5.6 mm was associated with sixfold risk.
Gutierrez 2017	26 asymptomatic professional pitchers	Baseball	UCL, cartilage, tendons, posteromedial elbow	MRI	1 year	Six pitchers were placed on the disabled list; no single baseline MRI finding predicted this outcome.
Visnes 2015	141 asymptomatic elite junior volleyball athletes; 282 patellar tendons	Volleyball	Patellar and quadriceps tendons	Ultrasound	Mean 1.7 years	Twenty-two athletes (35 tendons) developed jumper's knee; baseline hypoechoic area predicted symptoms (adjusted OR 3.3, 95% CI 1.1–9.2).
Jhingan 2011	18 elite professional soccer players; 36 tendons	Soccer	Achilles tendon	Ultrasound	1 year	Symptoms developed in 5/23 abnormal versus 1/13 normal tendons; greater tendon thickness was also associated with symptoms.

Appendix D. Structure-specific effects

Study	Structure	Measure	Estimate (95% CI)	Events	Outcome	Primary
Cushman 2025	Patellar tendon	Adjusted RR	10.7 (4.1–27.8)		Pain, focal tenderness/load pain, and ≥ 1 missed practice or competition	Yes
Cushman 2025	Achilles tendon	Adjusted RR	19.2 (6.6–55.7)		Pain, focal tenderness/load pain, and ≥ 1 missed practice or competition	Yes
Cushman 2025	Plantar fascia	Adjusted RR	13.3 (1.4–104.8)		Pain, focal tenderness/load pain, and ≥ 1 missed practice or competition	Yes
Cushman 2024	Patellar tendon	Crude RR	9.5 (2.0–45.2)	14/148 vs 3/285	New pain in the imaged structure	No
Cushman 2024	Achilles tendon	Crude RR	23.1 (2.5–209.4)	5/42 vs 2/414	New pain in the imaged structure	No
Cushman 2024	Plantar fascia	Crude RR		0/14 vs 2/449	New pain in the imaged structure	No

Study	Structure	Measure	Estimate (95% CI)	Events	Outcome	Primary
Cushman 2022	Achilles tendon	Crude RR	2.67 (1.57–4.57)	14/41 vs 30/235	New self-reported tendon pain	Yes
Cushman 2022	Patellar tendon	Crude RR	1.52 (0.88–2.62)	16/70 vs 31/206	New self-reported tendon pain	Yes
Cushman 2021	Achilles tendon	Crude RR	3.14 (1.41–7.01)		New tendon pain	No
Cushman 2021	Patellar tendon	Crude RR	2.52 (1.37–4.62)		New tendon pain	No
Shitara 2021	Medial elbow	Crude RR	2.42 (1.36–4.31)	17/59 vs 18/151	Medial elbow symptoms preventing throwing for ≥8 days	Yes
Shanley 2018	Elbow UCL	Risk ratio	6.0		UCL tear requiring reconstruction	Yes
Visnes 2015	Patellar tendon	Adjusted OR	3.3 (1.1–9.2)	17/46 vs 18/236	New jumper's knee symptoms	Yes
Visnes 2015	Patellar tendon	Adjusted OR	2.7 (1.1–6.5)	15/27 vs 20/255	New jumper's knee symptoms	No
Mersmann 2023	Patellar tendon	Risk ratio	2.3 (1.1–4.9)	14/ vs /	Clinically relevant new tendon pain (VISA-P decrease ≥13)	Yes
Jhingan 2011	Achilles tendon	Crude RR	2.83 (0.37–21.6)	5/23 vs 1/13	New Achilles tendinopathy symptoms	Yes

Appendix E. Cohort-overlap map

Cluster	Reports	Handling
Collegiate lower-limb ultrasound	Cushman 2024; Cushman 2025; Le Beaumont 2026	Cushman 2025 primary for time-loss; others nonduplicative narrative
Distance-runner ultrasound	Cushman 2021; Cushman 2022; Nowak 2024	Cushman 2022 primary for pooling; other reports linked
Professional-baseball elbow MRI	Gutierrez 2017; Garcia 2019	Likely overlap; narrative linkage; no pooled double counting
Youth-baseball medial elbow	Shitara 2021 comparative; Shitara 2021 abnormal-only	Comparative report used for RR; abnormal-only report narrative

Appendix F. QUIPS judgments

Study	Participation	Attrition	Imaging	Outcome	Confounding	Analysis	Overall
Le Beaumont 2026	Moderate	Moderate	Low	Moderate	High	Moderate	High
Cushman 2025	Low	Low	Low	Low	Moderate	Low	Low
Cushman 2024	Low	Low	Low	Low	Moderate	Low	Low
Katakura 2024	Moderate	Moderate	Low	Moderate	High	Moderate	High
Mersmann 2023	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Moderate
Beletsky 2022	Moderate	Moderate	Low	Moderate	High	Moderate	High
Cushman 2022	Low	Low	Low	Low	Moderate	Low	Low
Cushman 2021	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Moderate
Nowak 2024	Moderate	Moderate	Low	Moderate	High	Moderate	High
Shitara 2021	Low	Low	Low	Low	Moderate	Low	Low
Shitara 2021	Low	Low	Low	Low	Moderate	Low	Low
Garcia 2019	Moderate	Moderate	Low	Moderate	High	Moderate	High
Shanley 2018	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Moderate
Gutierrez 2017	Moderate	Moderate	Low	Moderate	High	Moderate	High
Visnes 2015	Low	Low	Low	Low	Moderate	Low	Low
Jhingan 2011	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Moderate

All judgments are provisional because they were completed by one reviewer with automated language-model support and were not independently adjudicated.

Appendix G. Protocol access and deviations

PROSPERO record: <https://www.crd.york.ac.uk/PROSPERO/view/CRD420261502330>

- Registration date: Sep 22, 2026 .
- Selection/extraction: two independent reviewers/person-machine duplicate review.
- Risk of bias: QUIPS was used instead of the registered RoB 2/JBI plan because the eligible evidence consisted mainly of prognostic cohorts.
- Meta-analysis: DerSimonian–Laird random effects was used instead of REML with Hartung–Knapp adjustment.
- Adjusted and crude RRs were combined within exploratory structure-specific pools because separate categories had too few independent studies. The consequence is explicit in the manuscript and forest plot.