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# Association Between Androgenic-Anabolic Steroid Use and Achilles Tendon Injury: A Systematic Review of the Literature

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**ADMINISTRATIVE INFORMATION**

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**Review Stage at time of this submission -** Completed but not published.

**Conflicts of interest -** None declared.

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**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 29 July 2026 and was last updated on 29 July 2026.

## INTRODUCTION

**Review question / Objective** Is the use of anabolic-androgenic steroids associated with the occurrence of Achilles tendon injury or rupture?

**Condition being studied** The use of anabolic-androgenic steroids (AAS) has become increasingly common among athletes and recreational exercisers seeking to enhance muscle mass, strength, and athletic performance. These synthetic derivatives of testosterone, the hormone responsible for the development of male sexual characteristics, also play a key role in protein synthesis and skeletal muscle growth. However, despite their performance-enhancing effects, AAS use has been associated with a wide range of adverse outcomes, including an increased risk of musculoskeletal injuries and tendon rupture.

The Achilles tendon, also known as the calcaneal tendon, is the strongest and largest tendon in the human body. It connects the gastrocnemius and soleus muscles to the calcaneus, transmitting the force generated by the calf muscles to produce plantar flexion of the ankle, a movement essential for walking, running, and jumping. The tendon contains a relatively hypovascular region located approximately 2 to 6 cm proximal to its insertion on the calcaneus, making this area particularly susceptible to degeneration, injury, and rupture.

Therefore, the aim of this literature review is to analyze the available evidence regarding the association between anabolic-androgenic steroid use and the occurrence of Achilles tendon injury or rupture, with emphasis on the main pathophysiological mechanisms involved, predisposing factors, and the current clinical evidence.

## METHODS

**Search strategy** This study is a systematic literature review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. The

review protocol was developed prior to the study selection process and included the research question, eligibility criteria, information sources, search strategy, and data extraction and analysis procedures.

The research question was formulated using the PECO framework, considering: P (Population) – adult individuals, athletes, or physically active individuals; E (Exposure) – use of anabolic-androgenic steroids (AAS); C (Comparison) – individuals not exposed to these substances, when available; and O (Outcome) – partial or complete Achilles tendon injury or rupture. Accordingly, the following research question was established: "Is the use of anabolic-androgenic steroids associated with the occurrence of Achilles tendon injury or rupture?"

The literature search was conducted in the MEDLINE/PubMed and Virtual Health Library (VHL) databases from the inception of each database until the date of the search. Controlled vocabulary terms from MeSH and DeCS, together with free-text terms related to anabolic-androgenic steroids and Achilles tendon rupture, were used. Descriptors and their synonyms were combined using the Boolean operators AND and OR.

The search strategy used in PubMed was:

("Anabolic Androgenic Steroids"[MeSH Terms] OR "Anabolic Agents"[MeSH Terms] OR anabolic steroid*[Title/Abstract]) AND ("Achilles Tendon"[MeSH Terms] OR "Achilles tendon"[Title/Abstract]) AND ("Tendon Injuries"[MeSH Terms] OR rupture*[Title/Abstract] OR tear*[Title/Abstract])

The search strategy was adapted to the specific syntax and controlled vocabulary of the Virtual Health Library (VHL). In addition, the reference lists of all included studies were manually screened to identify potentially eligible articles that had not been retrieved through the electronic database search.

**Participant or population** Primary studies evaluating individuals exposed to agents with anabolic and/or androgenic activity (including anabolic-androgenic steroids, exogenous testosterone, androgen precursors, and selective androgen receptor modulators [SARMs]) and reporting data on Achilles tendon injury, degeneration, or partial or complete rupture were included. Given the expected scarcity of studies on this topic, eligible designs comprised observational studies (cohort, case-control, and cross-sectional studies), as well as case series and case reports providing sufficient information regarding both exposure and outcomes.

Experimental studies involving animal models or laboratory investigations were also considered exclusively for the assessment of potential pathophysiological mechanisms. Their findings were analyzed and presented separately from the clinical evidence.

Review articles, editorials, letters to the editor without case descriptions, conference abstracts lacking sufficient data, book chapters, expert opinions, and studies addressing tendon injuries without specific data on the Achilles tendon were excluded. Studies evaluating only the therapeutic use of corticosteroids, without exposure to anabolic-androgenic steroids, were also excluded, as were studies in which no temporal or clinical relationship between exposure and tendon injury could be established. No restrictions were applied regarding language or year of publication.

Search results were exported to a reference management software (EndNote), where duplicate records were identified and removed. Subsequently, two independent reviewers screened titles and abstracts. Potentially eligible studies underwent full-text review by the same reviewers. Disagreements were resolved through consensus or, when necessary, by consultation with a third reviewer. Reasons for exclusion after full-text assessment were documented.

The processes of study identification, screening, eligibility assessment, and inclusion were documented using the PRISMA 2020 flow diagram. The numbers of records identified in each database, duplicates removed, records excluded during screening, full-text articles assessed, reasons for exclusion, and the final number of included studies were reported.

Data extraction was performed by one reviewer using a standardized data extraction form developed prior to the review. The following information was collected: author and year of publication, study design, population characteristics, type of anabolic-androgenic steroid used, type of Achilles tendon injury, diagnostic method, treatment performed, main findings, and study conclusions.

The methodological quality and risk of bias of the included studies were independently assessed by two reviewers. Cohort and case-control studies were evaluated using the Newcastle–Ottawa Scale (NOS). Cross-sectional studies, case series, and

case reports were assessed using the corresponding Joanna Briggs Institute (JBI) Critical Appraisal Tools. Any disagreements were resolved by consensus.

The results were organized into tables and synthesized narratively, taking into account the clinical and methodological characteristics of the included studies, the type and pattern of anabolic-androgenic steroid exposure, the proposed mechanisms of tendon injury, and the occurrence of Achilles tendon rupture. Clinical and experimental studies were analyzed separately.

As this review exclusively used data from previously published and publicly available studies, approval by a Research Ethics Committee was not required.

**Intervention** Anabolic-androgenic steroid use.

**Comparator** Patients who did not use anabolic-androgenic steroids.

**Study designs to be included** Observational studies, including cohort, case-control, and cross-sectional studies, as well as case series and case reports with sufficient description of the exposure and outcome.

**Eligibility criteria** Primary studies were included if they evaluated individuals exposed to agents with anabolic and/or androgenic activity (such as anabolic-androgenic steroids, exogenous testosterone, androgen precursors, and selective androgen receptor modulators [SARMs]) and provided information on injury, degeneration, or partial or complete rupture of the Achilles tendon.

**Information sources** The literature search was conducted in the MEDLINE/PubMed and Virtual Health Library (BVS) databases, from the inception of each database's indexing to the date of the search.

**Main outcome(s)** Ultimately, five studies were included in the synthesis: four clinical studies (two case reports, one matched retrospective cohort, and one cross-sectional cohort) and one experimental study using an animal model.

Among the clinical studies, the retrospective cohort analyzed 423,278 patients exposed to exogenous testosterone for at least three months, compared with controls matched for age, sex, smoking status, and diabetes (35–75 years). The cross-sectional cohort evaluated 142 bodybuilders aged 35 to 55 years, of whom 88 were anabolic steroid users. The case reports described asynchronous bilateral ruptures associated with androstenediol use in a 35-year-old bodybuilder, and successive tendon ruptures (Achilles and patellar tendons) in a 29-year-old athlete after prolonged use of testosterone, stanozolol, and methenolone. The experimental study evaluated nandrolone decanoate administration in 24 male Wistar rats over twelve weeks.

Methodological quality was assessed using the Newcastle–Ottawa Scale for cohort studies: the study by Albright et al. demonstrated good quality, with limitations related to its retrospective design and the lack of data on exact dosages; the cross-sectional cohort showed moderate quality and was subject to recall bias. The case reports, evaluated using the Joanna Briggs Institute critical appraisal tool, presented a low level of evidence, inherent to the study design, and the experimental study was limited by the small sample size and the absence of reported examiner blinding.

**Additional outcome(s)** Androgenic exposure significantly increased tendon-related risk. In the matched cohort, the Adjusted Odds Ratio (aOR) was 1.24 (95% CI, 1.15–1.33) for injury diagnosis and 1.54 (95% CI, 1.19–1.99) for subsequent surgery, with a Number Needed to Harm (NNH) of 371; the highest risks were observed among men (aOR = 1.66) and women (aOR = 1.82) aged 66–75 years. In the cross-sectional cohort, the risk of first rupture was nine times higher among steroid users, with upper-limb ruptures occurring exclusively in the exposed group. The case reports further reinforce the severity of these findings, associating continuous anabolic steroid use in the postoperative period with repair failure, reruptures, and infections. The animal model demonstrated a reversal of the exercise-induced gains in tendon strength: rupture stress decreased from 26.1 MPa (exercise) to 15.0 MPa (anabolic steroid plus exercise), accompanied by collagen dysplasia, increased vascularization, and epitendon thickening.

**Quality assessment / Risk of bias analysis** The methodological quality and risk of bias of the included studies were assessed by two independent reviewers. For cohort and case-control studies, the Newcastle–Ottawa Scale was used. Cross-sectional studies, case series, and case reports were evaluated using the corresponding critical appraisal tools from the Joanna Briggs Institute. Disagreements were resolved through consensus between the reviewers.

**Strategy of data synthesis** The results were organized into tables and analyzed through narrative synthesis, considering the clinical and methodological characteristics of the studies, the type and pattern of anabolic steroid exposure, the proposed mechanisms underlying tendon injury, and the occurrence of Achilles tendon rupture. Clinical and experimental studies were analyzed separately.

**Subgroup analysis** The results were organized into tables and analyzed through narrative synthesis, considering the clinical and methodological characteristics of the studies, the type and pattern of anabolic steroid exposure, the proposed mechanisms underlying tendon injury, and the occurrence of Achilles tendon rupture. Clinical and experimental studies were analyzed separately.

**Sensitivity analysis** The results were organized into tables and analyzed through narrative synthesis, considering the clinical and methodological characteristics of the studies, the type and pattern of anabolic steroid exposure, the proposed mechanisms underlying tendon injury, and the occurrence of Achilles tendon rupture. Clinical and experimental studies were analyzed separately.

**Country(ies) involved** United States.

**Keywords** Anabolic Androgenic Steroids; Anabolic Agent; Achilles Tendon; Tendon Injuries.

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