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From Pelvis to Foot, Part II: A Longitudinal Kinetic Chain Hypothesis for Eversion Ankle Sprains in Athletes

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Abstract

Background

Eversion ankle sprains, although less common than inversion injuries, are often associated with greater severity and more complex recovery patterns. Their biomechanical origin remains less clearly understood.

Objective

To propose a functional, longitudinal kinetic chain model in which anterior innominate rotation (AS) may contribute to the development of eversion ankle sprain injuries.

Methods

This hypothesis-driven model is based on clinical observation and biomechanical reasoning. Anterior innominate rotation may lead to pelvic asymmetry, a functional long-leg pattern, internal femoral rotation, and toe-in mechanics.

Results (Hypothesis)

These adaptations may increase medial loading, promote collapse of the medial longitudinal arch, and alter ground reaction forces. This may compromise medial stability and reduce the capacity to control eversion forces, increasing susceptibility to injury.

Conclusion

Eversion ankle sprains may represent the distal expression of proximal biomechanical dysfunction. Recognition of anterior innominate rotation may improve injury prevention strategies.

Introduction

Eversion ankle sprains, although less common than inversion injuries, are often associated with greater severity and more complex recovery patterns. Despite their clinical significance, their biomechanical origin remains less clearly understood. This paper expands upon the previously proposed proximal-to-distal kinetic chain framework addressing inversion ankle sprain mechanisms in athletes described by Quintero (2026).

Traditional approaches emphasize local joint factors; however, increasing evidence supports the role of proximal biomechanics in influencing distal joint function. Alterations in hip mechanics, lumbopelvic stability, and lower limb alignment have been shown to affect movement patterns and injury risk [1, 2, 3].

Anterior innominate rotation may represent an underexplored factor within this framework. This condition may lead to a functional long-leg presentation, internal femoral rotation, toe-in mechanics, and increased medial loading, potentially influencing distal joint behavior [4, 5].

Proposed Biomechanical Model

Traumatic Origin and Pelvic Mechanics

Anterior innominate rotation may develop within the sacroiliac joint following trauma such as a fall onto the posterior superior ischial spine, posterior iliac crest, or anterior knee with extended leg, where force is transmitted proximally toward the pelvis. The pubic symphysis may function as a stabilizing anterior reference point during rotational displacement of the innominate.

Posterior innominate rotation may also develop following traumatic impact to the anterior aspect of the pelvis, where force transmission through the pelvic ring may induce rotational displacement at the sacroiliac joint. This mechanism may contribute to functional short-leg patterns, external femoral rotation, and toe-out mechanics associated with inversion ankle sprain susceptibility.

Pelvic Asymmetry and Functional Long-Leg Pattern

Anterior rotation may create pelvic asymmetry and a functional long-leg pattern, altering load distribution across the lower extremities.

Compensatory Femoral Rotation and Toe-In Mechanics

Pelvic asymmetry may be associated with internal femoral rotation, contributing to toe-in gait patterns and altered alignment during dynamic activities.

Knee Alignment and Dynamic Valgus

Medial loading and pronation may be associated with dynamic knee valgus, representing a continuation of the proximal-to-distal kinetic chain [1, 6].

Distal Tibiofibular and Rearfoot Contribution

Alterations in fibular positioning and rearfoot mechanics may influence ankle stability and load transmission, affecting the ability to control eversion forces [7].

Medial Loading and Collapse of the Longitudinal Arch

These adaptations may increase medial loading and contribute to collapse of the medial longitudinal arch, particularly under repetitive stress [4, 5].

Increased Susceptibility to Eversion Loading

The combined effect of these biomechanical adaptations may increase susceptibility to eversion loading, particularly during dynamic athletic movements.

Clinical Implications and Differential Diagnosis

Clinical Screening

- Pelvic asymmetry
- Toe-in gait
- Medial loading patterns

- Arch collapse
- Knee valgus
- Asymmetrical footwear deformation

AS vs Iliopsoas Dysfunction

These conditions may coexist and present with overlapping symptoms. Iliopsoas dysfunction may involve deeper anterior hip pain and functional limitations, whereas anterior innominate rotation is more consistently associated with observable biomechanical patterns along the kinetic chain.

Functional vs Structural Flatfoot

- Functional: unilateral, asymmetrical, dynamic
- Structural: bilateral, stable, hereditary

Discussion

This paper proposes a longitudinal kinetic chain model linking anterior innominate rotation to eversion ankle sprain risk. The model extends existing knowledge on proximal influences in injury mechanisms.

The condition may coexist with other dysfunctions and may present with non-classical symptom distributions. It should be interpreted within a functional context.

Even though focused on athletes, similar patterns may exist in the general population. This model may complement previously proposed inversion-based mechanisms within a longitudinal kinetic chain framework.

Although speculative, this hypothesis proposes a plausible biomechanical framework linking proximal pelvic dysfunction with distal ankle injury mechanisms. Further clinical and biomechanical investigation is warranted.

Limitations

This model is hypothesis-based and has not yet been validated experimentally. Variability in anatomy and movement patterns must be considered.

The proposed model should be regarded as a biomechanical hypothesis derived from clinical observations and theoretical analysis. Future investigations should evaluate the reproducibility, predictive value, and external validity of this framework through prospective clinical studies, biomechanical modeling, motion analysis, and multicenter collaborations. Comparative studies involving asymptomatic individuals, athletes with eversion ankle sprains, and independent research groups will be necessary to determine the applicability and generalizability of the proposed mechanism.

Future Directions

Further research should investigate:

- pelvic asymmetry and medial loading
- arch collapse and stability
- tibiofibular mechanics
- effectiveness of targeted interventions

Conclusion

Anterior innominate rotation may contribute to eversion ankle sprain risk through a proximal-to-distal biomechanical pathway. Recognizing this pattern may provide a framework for future biomechanical investigation and potential injury prevention strategies.

Highlights

- AS may contribute to eversion ankle sprain risk
- Pelvic asymmetry may influence medial loading
- Toe-in and arch collapse may predispose to eversion
- Screening may improve prevention

Declaration of Generative AI Assisted Technologies in the Manuscript Preparation Process

During the preparation of this work the author used Chat GPT in order to generate better content organization and improve language and readability since his first language is Spanish, after using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.

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