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Finite element simulation in biomechanics of running and footwear: Insights for running-related musculoskeletal injuries

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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 21 October 2024 and was last updated on 21 October 2024.

INTRODUCTION

Review question / Objective This review aimed to provide a systematic overview of the latest advancements in applying FE methods to running biomechanics and footwear design. By critically assessing the current research, we would outline the general approach to build foot-running shoe FE models, discuss their applications and challenges, and offer insights for future research. Additionally, we aim to reveal the gap between the mechanical responses predicted by FE models and the actual occurrence of RRMI in real-world scenarios, ultimately contributing to improved running shoe designs and injury prevention strategies.

Condition being studied The application of finite element methods for running and running shoe biomechanics with the purpose of reducing the potential risk of running-related musculoskeletal injuries.

METHODS

Search strategy English-language searches of electronic databases, including Web of Science, PubMed, and Scopus, were conducted to identify relevant studies up to July 20, 2024. Each database was searched using specific retrieval terms, and Medical Subject Headings (MeSH) terms were employed in PubMed. Keywords from four categories (finite element analysis, biomechanics, running, and shoe) were utilized to identify pertinent studies.

Participant or population Runners.

Intervention Not applicable.

Comparator Not applicable.

Study designs to be included Finite element modeling studies on running and footwear were included in this review.

Eligibility criteria Studies were included in this review if they met the following criteria: 1) Original journal articles were included, while other types (e.g., reviews, conference abstracts) were excluded; 2) The biomechanical analyses of running shoes under running scenario using the FE method (including interactions with the lower limbs or feet) was essential for the inclusion of the study; and 3) The papers should provide methodological details and results.

Information sources English-language searches of electronic databases, including Web of Science, PubMed, and Scopus, were conducted.
Reference lists of eligible articles and retrieved reviews were examined to ensure no relevant papers were overlooked.

Main outcome(s) The effects of various running shoe design features and running conditions on the mechanical response of internal foot tissues using foot-running shoe FE models.

Additional outcome(s) None.

Data management The paper screening process was conducted using Rayyan QCRI. Data from the included studies were extracted and summarized in tables by one author and subsequently verified by another author. The following information was collected: 1) author characteristics (first author and publication year); 2) study objectives; 3) participant characteristics; 4) model characteristics (geometry design and material properties); 5) boundary and loading conditions; 6) validation; and 7) primary findings. Mendeley Desktop Reference Management Software (Mendeley Ltd., Netherlands) was utilized for organizing articles and generating citations.

Quality assessment / Risk of bias analysis The quality of all included studies was assessed independently by two authors using the Methodological Quality Assessment of Subject-Specific Finite Element Analysis Used in Computational Orthopaedics (MQSSFE) tool.

Strategy of data synthesis Data was analysed following the three main sessions: 1) Overview of the foot-running shoe FE modelling; 2) Current application of foot-running shoe FE models in running biomechanics; and 3) Future development and application for foot-running shoe FE models in running biomechanics.

Subgroup analysis Not appliable.

Sensitivity analysis Not appliable.

Language restriction Only English papers were considered in this study.

Country(ies) involved China, Canada.

Other relevant information None

Keywords running; footwear biomechanics; computational simulation; RRMI.

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