Development and Validation of a Skateboard Shoe-Board-Foot Finite Element Model (Post-print)

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Abstract

This study explores effective approaches for loading biomechanical experimental data into a skateboard model to calculate the mechanical responses of foot structures. CT and 3D scanners were utilized to acquire data of the foot, skate shoes, and skateboard for establishing a finite element model, while pressure plates and pressure insoles were employed to validate the model's effectiveness under natural standing conditions. The established model comprises foot bones (including tarsals, metatarsals, phalanges, and distal tibia and fibula), soft tissues, skate shoe uppers, skate shoe soles, deck, connecting bridge, wheels, and ground, totaling 408,043 nodes and 260,400 mesh elements, with a mesh quality of 0.79. The measured peak plantar pressure was 80 kPa, whereas the simulation yielded 82.2 kPa, representing an error of 2.75%. The measured maximum pressure at the rear wheel of the board bottom was 2.314 MPa, and at the front wheel was 1.427 MPa; the simulated stress peaks were 2.392 MPa at the rear wheel and 1.479 MPa at the front wheel, with errors of 3.37% and 3.64%, respectively. The skate shoe-board-foot coupling model constructed in this study demonstrates good geometric and mechanical similarity and has been verified to be effective and reliable.

Full Text

Preamble

The following section establishes the foundational mathematical framework for this work. Key definitions and preliminary results are presented to support subsequent theoretical developments.

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This expression constitutes a critical component of the analytical apparatus employed throughout the investigation. The parameters and functional relationships defined herein will be referenced extensively in later sections.

Note: Figure translations are in progress. See original paper for figures.