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A dynamic finite element analysis of metatarsal stress during forefoot and rearfoot strike

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Abstract: Finite element (FE) method enables the prediction of internal stress distribution of the foot due to its ability to model irregular geometries and complex material properties of different tissues with assigning specific boundary and loading conditions. The purpose of this study is to investigate the bony stresses in metatarsals during forefoot and rearfoot strike. A detailed subject specific FE foot model is developed and validated. A hexahedral dominated meshing scheme was applied to the components of bones and the encapsulated soft tissue. An explicit solver (Abaqus/Explicit) was used to stimulate the transient processes of foot strikes. All materials except for the encapsulated soft tissue considered as hyperelastic property were considered isotropic and linearly elastic. The main bony geometries were embedded in the encapsulated soft tissue volume. The displacement-time data from kinematical experiments was applied on the cross sections of tibia and fibula. The time period of landing phase took 0.1s from initial to full contact. It showed an overall higher average stress level in the metatarsals during the entire landing phase of forefoot strike. The increase rate of the metatarsal stress from initial contact to full contact is 30.76% and 21.39% for forefoot and rearfoot strike respectively. The maximum rate of stress increase among the five metatarsals is observed on the 1st metatarsal in both landing modes. The results indicate that relatively higher stress level during forefoot landing may increase potential of metatarsal injuries such as bony fracture.

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