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A NEW MODEL TO STUDY THE TALOCRURAL-TALOCALCANEAL ARTICULAR COMPLEX OF THE HUMAN FOOT

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Summary: The foot is a complex structure that is adapted to allow orthograde bipedal locomotion, being the only part of the human body that is in regular contact with the ground. It comprises 28 separate bones and 31 articulations that enable the performance of several movements of the daily life. Amongst these 31 articulations, the talocrural and the talocalcaneal articulations are considered to be the focal point of this work. The talocrural articulation enables plantarflexion and dorsiflexion in the sagittal plane, and it is located between the talus of the foot and the distal ends of the tibia and fibula of the lower leg. The foot is also able to produce movement in the frontal plane, namely inversion and eversion. This motion is provided by the talocalcaneal articulation that is located between the tarsal bones of the posterior part of the foot, more specifically the calcaneus and the talus. A comprehensive inspection of the currently available scientific literature indicates that the human foot and its articulations can be modelled in distinct ways considering more or less complex approaches, which mimic more or less accurately the physiological features intrinsic to the foot. These approaches range from considering this anatomical structure as a unique segment articulating with the lower leg via the talocrural articulation to modeling the foot as a multi-segment structure with numerous articulations that enable diverse movements in different cardinal planes. However, to date, studies have not yet considered a more physiologically accurate modelling of the movements enabled by the talocrural and talocalcaneal articulations, which is a key aspect in studying the foot in clinical settings. Thus, the aim of this work is to propose a biomechanical model of the human foot incorporated with a new approach to study the talocrural-talocalcaneal articular complex. The proposed approach relies on the use of a modified type of universal joint, incorporated with a massless link assumption representing the talus. The first section of this work consists on the clear explanation of the rationale for using this new approach taking into consideration the physiological characteristics of the human foot. Then, the detailed description of the kinematic aspects associated with the formulation developed for the modified universal joint is provided. In this process, the kinematic constraint equations considered for this particular case of universal joint, along with the resultant Jacobian matrix and right-hand side of the acceleration equations are presented. The application of this new approach to the dynamic modelling and simulation of the human foot is investigated and validated against results available in the literature concerning the range of motion permitted by the talocrural and the talocalcaneal articulations during normal gait. Subsequently, the foot model developed in this work is compared to a model available in the literature. The results obtained from the comparison of these two biomechanical models are critically discussed.