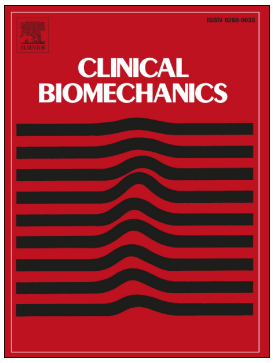

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Musculoskeletal Modelling of Human Ankle Complex: Estimation of Ankle Joint Moments

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***Abstract*—**

Background: A musculoskeletal model for the ankle complex is vital in order to enhance the understanding of neuro-mechanical control of ankle motions, diagnose ankle disorders and assess subsequent treatments. Motions at the human ankle and foot, however, are complex due to simultaneous movements at the two joints namely, the ankle joint and the subtalar joint. The musculoskeletal elements at the ankle complex, such as ligaments, muscles and tendons, have intricate arrangements and exhibit transient and nonlinear behaviour.

Methods: This paper develops a musculoskeletal model of the ankle complex considering the biaxial ankle structure. The model provides estimates of overall mechanical characteristics (motion and moments) of ankle complex through consideration of forces applied along ligaments and muscle-tendon units. The dynamics of the ankle complex and its surrounding ligaments and muscle-tendon units is modelled and formulated into a state space model to facilitate simulations. A graphical user interface is also developed during this research in order to include the visual anatomical information by converting it to quantitative information on coordinates.

Findings: Validation of the ankle model was carried out by comparing its outputs with those published in literature as well as with experimental data obtained from an existing parallel ankle rehabilitation robot.

Interpretation: Qualitative agreement was observed between the model and measured data for both, the passive and active ankle motions during trials in terms of displacements and moments.

***Keywords*—Ankle joint, musculoskeletal model, joint moments, parallel ankle robots.**

I. INTRODUCTION

UNDERSTANDING the mechanical properties of the human ankle musculoskeletal system is important for simulating human movements, in the study of multi-joint