Modular Incorporation of Detailed Lower Extremity into Simplified Human Body FE Model

William Decker[1,2], wdecker@wakehealth.edu
Bharath Koya[1], bkoya@wakehealth.edu
F. Scott Gayzik[1,2],sgayzik@wakehealth.edu
[1]Wake Forest School of Medicine; [2]Virginia Tech – Wake Forest University Center for Injury Biomechanics

Introduction: Finite element human body models (HBMs) can be used to investigate injury mechanisms and tolerance of the human body during various loading conditions. The modeling complexity required to achieve good biofidelity in HBMs can lead to long compute times. This has prompted the development of faster running simplified models (GHBMC M50-OS) that can be used primarily for kinematic/kinetic comparisons. These simplified models share the same body habitus as the detailed counterparts, but with rigid bony structures and simplified modeling approaches for viscera, joints etc. Previous studies have shown the ability to modularly incorporate organs with high biofidelity models, such as the detailed (GHBMC M50-O) brain, into the simplified model[1]. This technique allows for localized analysis of a region of interest in a fraction of the computational time required for the detailed model. The purpose of this study is to expand on this previous work by incorporating the previously-validated lower extremity of the M50-O into the computationally efficient M50-OS (M50-OS+LEx) and compare physical loading response to the M50-O in a localized knee bolster impact and a full vehicle buck simulation.

Materials and Methods: The modularly-incorporated components include all deformable bony structures from the sacrum to the foot, detailed soft tissue structures from the femur flesh to the foot flesh, and all explicitly meshed tendons and ligaments. The discrepancy in mesh size between the simplified pelvis flesh and the detailed femur flesh led to the incorporation of a mesh transition that uses the same material properties as the femur flesh. A visual comparison of the M50-OS+LEx and the M50-O can be seen in Figure 1.

Results and Discussion: Total force from the femur, upper tibia, and ilium were obtained and compared between the two models during the knee bolster impact, shown in Figure 1. Force data was also obtained from the lower tibia, as well as the upper and lower fibula but are not shown here due to relevance of the knee impact. Additionally, the M50-OS+LEx experience a 71% reduction in run-time when compare to the M50-O.

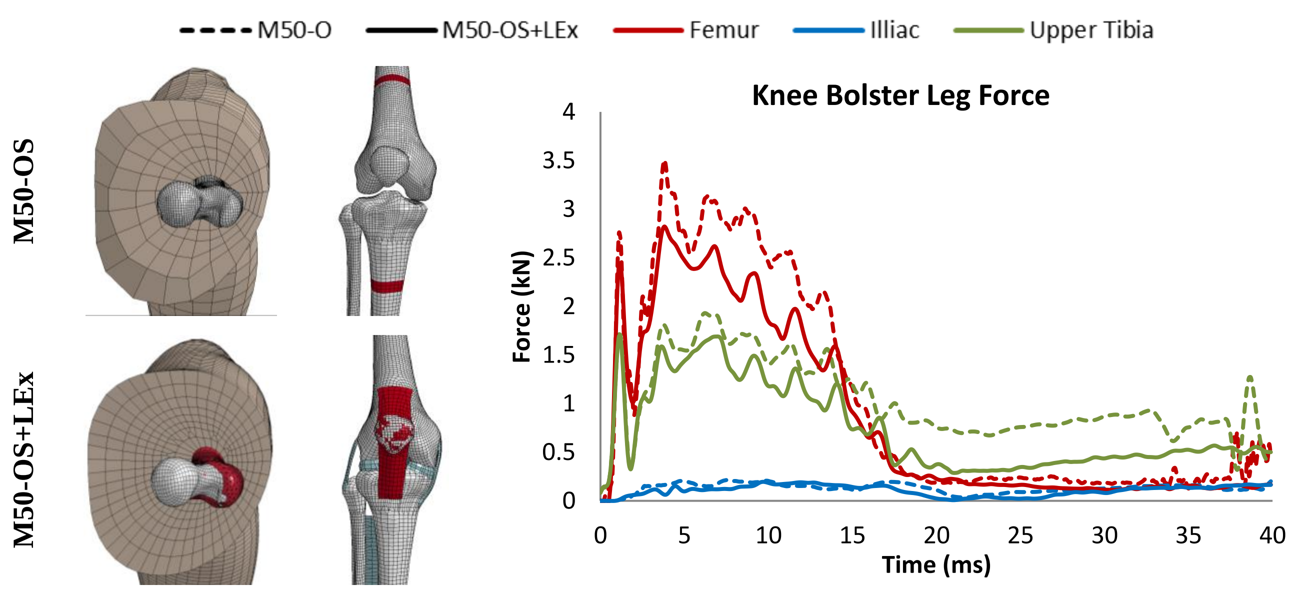

Figure 1. Visual comparison of mesh detail and force response between the M50-O and the M50-OS+LEx. Model symmetry allowed for a comparison of only data from left side of the models. Data was filtered at SAE 600.

Conclusions: The implementation of the detailed lower extremity provided force time histories that tend to agree with the overall shape and magnitude of the data from the M50-O. Further investigation into the validation of this technique will include full vehicle buck simulations and quantitative evaluation of the comparative data.

References: [1] Decker W, Koya B, Davis ML, Gayzik FS. Modular use of Human Body Models of Varying Levels of Complexity: Validation of Head Kinematics. *Traffic injury prevention.* 2017:0-0.