# Development of Finite Element Human Models to Represent a Diverse Population

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## Abstract

***Objective:*** *Among the whole population, obese, small, and/or older occupants are at increased risk of death and serious injury in motor-vehicle crashes compared with mid-size young male occupants. The objective of this study is to develop a method to rapidly generate 100 finite element (FE) human models to represent occupants with a wide range of human attributes.*

***Problem to be solved:*** *Current FE human models only have three body sizes (large male, mid-size male, and small females) and the time needed to develop an FE human model using the traditional method is measured in years.*

***Methodology:*** *Landmark-based radial basis function (RBF) interpolation was used to morph the baseline model into target geometries and a reginal mesh morphing strategy was applied. The regional mesh morphing allowed RBF to be conducted at small region by small region, which significantly reduced the landmarks used in each mesh morphing, in turn reduced the computational time. Anthropometry data from the National Health and Nutrition Examination Survey (NHANES) data from the years 2011-2014 was used to determine the percentiles of stature, body mass index (BMI), and age in this study. Five stature levels (161.7, 169.1, 174, 179.6, and 187.1 cm), 5 BMI levels (20.4, 24.2, 27.4, 31.2, and 39.2 kg/m$^2$), and 4 age levels (20, 40, 60, and 80 years old) were selected. The THUMS V4 midsize male model was used as the baseline model, while target geometries were estimated using the statistical models of external body shape and the skeleton, including ribcage, pelvis, femur and tibia. The statistical skeleton model and the body shape model were registered together using a set of body landmarks and joint centers that were available in the body shape models.*

***Results and Conclusions:*** *One hundred whole-body FE human models for male occupants with a wide range of age, stature and BMI were developed using the mesh morphing method.*
*The morphed models were found to match the target geometries well and sustain similar mesh quality with the baseline model. Crash simulations with a subset of the models were performed and they all terminated normally. The regional mesh morphing method used in this study is much more efficient than the whole-body mesh morphing method and it only took about 10 minutes to generate a morphed model using MATLAB R2015a in an 8-core PC. These 100 human models*