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Development of Human Body FE Model with Different Body Shapes Based on CT image

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In Japan, the population with underweight is larger than that with obese, but in Western countries, the population ratio of obese is higher, so research on injury risk in traffic accidents is biased toward obese occupants. The purpose of this study is to determine how differences in body type, such as underweight and obesity, affect the trend of crash injuries. To evaluate the difference in injury risk in automobile accidents due to body shape, it is easy to morph and deform a human body finite element model. There are two methods: an automated whole-body morphing using statistics, which has already been developed, and manual method to obtain target geometry by measuring the human body. Since the method using statistics may not fully reproduce the actual human body shape, in this study, we measured the human body by CT scanning, obtained the target geometry by three-dimensional modeling, and morphed the occupant and pedestrian models of THUMS to obtain the high and low BMI model (Fig. 1).

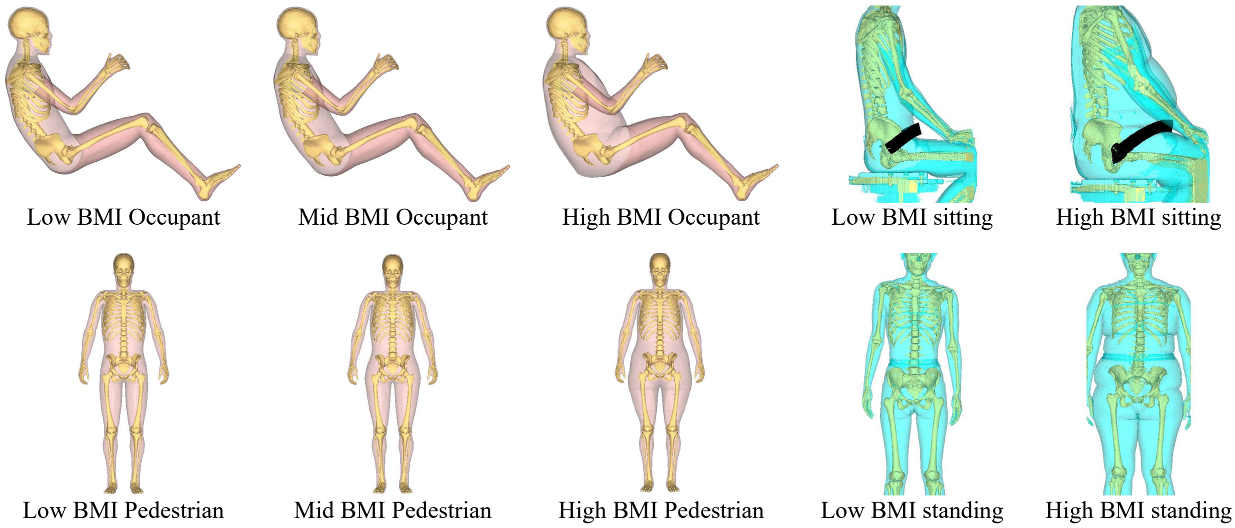

Fig. 1 Modified and original models and referenced CT images

Impact simulations using occupant models were performed using high and low BMI models based on CT images of male volunteers and the original THUMS Version 4.02 AF05 as the standard BMI model to simulate a 50 km/h frontal full-wrap crash. The high BMI model increased lumbar forward displacement and lap belt tension due to the greater lumbar mass and compression of the thicker abdominal soft tissues. In addition, as the trunk tilted backward, the shoulder belt path became closer to the neck, resulting in torsional behavior of the trunk. Therefore, high BMI occupants may be at increased risk of in-vehicle crashes and neck injury from shoulder belts. The low BMI model showed a backward pelvic tilt that could cause submarining. To confirm this trend, calculations were performed using a model with the initial pelvic angle tilted backward by 5°. Similarly, the thinner the abdominal soft tissue, the more the pelvis tilted backward, and submarining occurred at low and standard BMI. Therefore, low BMI occupants may be at higher risk for submarine and abdominal injury.

Impact simulations using pedestrian models were performed using high and low BMI models based on CT images of female volunteers and the original THUMS Version 4.02 AF05 as the standard BMI model, and a small sedan model with a side impact at 40 km/h with the center of the vehicle. Whole-body behavior after impact did not change significantly depending on body type. The sectional force at the femoral neck, which transfers the load to the pelvis, had a higher peak when the lumbar soft tissue was thinner, and tended to be distributed by the soft tissue into a load path that did not pass through the femoral neck. The maximum bending moment of the femur shaft was the smallest in the standard BMI model, followed by the low BMI model in which load concentration occurred due to the thin soft tissue, and the largest in the high BMI model, suggesting that the bending moment was increased by inertial forces due to the large lumbar mass. The areas of high fracture risk in the femur differ between high and low BMI. However, the third rib and tibia have greater bone strain than the femur, so it is necessary to morph the shoulder and lower leg, which could not be deformed this study, in order to assess injury risk. The model created in this study may be used to evaluate injury risk in collisions with vehicles with high hood heights.