

Interactions between the Pelvis and the Lap Belt for Diverse Occupants in Various Postures

Yuya Takeuchi ¹⁾ Yoshihiko Tanaka ²⁾ Koji Mizuno ³⁾ Minoru Yamada ⁴⁾ Yoshitake Yamada ⁵⁾
 Yoichi Yokoyama ⁶⁾ Masahiko Jinzaki ⁷⁾

1) 2) 3) Nagoya University, Furocho, Chikusa, Nagoya, Aichi, 464-8601 Japan
 4) 5) 6) 7) Keio University, 35 Shinanocho, Shinjuku, Tokyo, 160-8582, Japan

KEY WORDS: Safety, Crash safety, Injury mechanism, ASIS, Submarining, THUMS, BMI, Body shape [C1]

Passengers of different body shapes and sizes such as male, female, obese, and lean can sit in a car seat assuming various postures. Diverse occupants in various postures are considered to have different risks of submarining. This study aims to understand the interaction of the lap belt with the pelvis in a vehicle frontal impact scenario for occupants of various shapes, sizes, and sitting postures.

A mid-size male Total Human Model for Safety (THUMS) was morphed to develop a high and a low body mass index (BMI) human model using geometry data obtained by computer tomography (CT) images of sitting participants wearing a lap belt. Frontal impact finite element (FE) simulations were conducted for various occupant models (THUMS high-BMI, AM50, low-BMI, and AF05) under standard, reclined, and slouched sitting postures in the rear seat. The lap belt interaction with the ASIS were compared using the belt-pelvis angle and the belt overlap with the anterior superior iliac spine (ASIS) in the lap belt direction (Fig. 1).

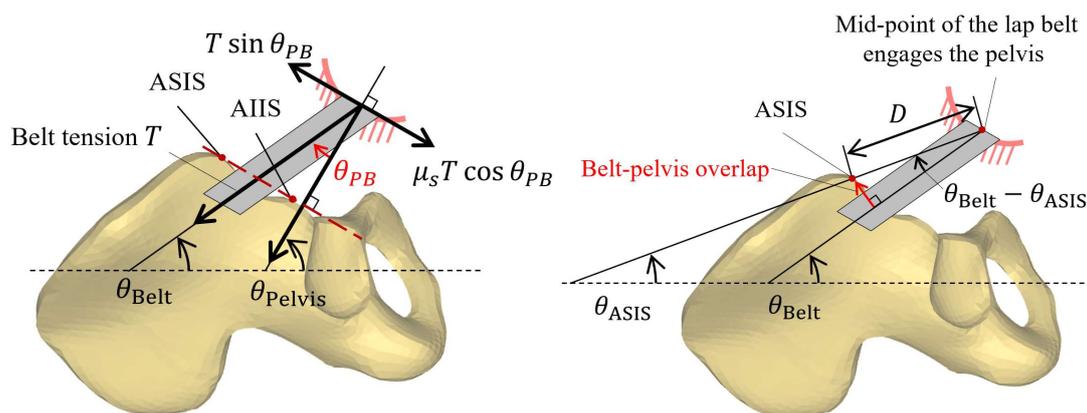


Fig. 1 Definition of pelvis-belt angle (θ_{PB}) (left) and belt-ASIS overlap (right)

From FE simulations, submarining occurred more in the reclined and slouched postures than in the standard posture because of the large initial rearward pelvis tilt (Table 1). Submarining occurred in fewer cases in the high-BMI model due to smaller pelvis rotation and larger belt-ASIS overlap than in other models. In the THUMS AF05, even though the belt-ASIS overlap was comparable, the pelvis began to rotate earlier and rotated more than in male models. Submarining occurred in more cases in the slouched posture than in the reclined posture. This is because the belt-ASIS overlap was smaller in the slouching posture due to the shallow belt angle, which could increase the risk of submarining.

Table. 1 Submarining occurrence in FE simulations

Posture	High-BMI	AM50	Low-BMI	AF05	
Standard	○	△	△	△	○: No submarining
Reclined	○	×	×	×	△: The lap belt slipped over during the rebound phase
Slouched	×	×	×	×	×: Submarining

In this study, a new parameter to evaluate the belt engagement with the ASIS was proposed, which is the belt-ASIS overlap in the lap belt direction. The occurrence of submarining in various occupants and postures could be examined by using the belt-pelvis angle and the belt-ASIS overlap. These two parameters will be useful in designing a restraint system to interact with the pelvis in various conditions.