Influence of Obesity on Thoracic Injury Severity in Side-Impact Collisions

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I. INTRODUCTION

Side-impact crashes represent one of the most critical crash types in traffic accidents, often leading to severe injuries and fatalities.

Statistical accident data indicate that obese drivers are at higher risk of injury in side-impact crashes. The most frequently affected body region is the thorax, with notable injuries including rib fractures, lung trauma, and damage to the thoracic aorta [1]. According to the *World Obesity Atlas 2025* report, global obesity rates have increased significantly over the past decades. If this trend continues, it is estimated that by 2030, 17% of men and 22% of women will be living with obesity (BMI over 30 kg/m²) [2]. This highlights the growing importance of thoracic protection for obese drivers in side-impact scenarios. Moreover, research from University of Michigan Transportation (UMTRI) shows that thoracic morphology varies significantly based on gender, age, stature, and BMI, affecting injury risks in frontal crashes [3]. However, side-impact studies remain relatively limited in comparison. Therefore, this study aims to investigate the thoracic injury mechanisms of obese occupants in side-impact crashes.

II. METHODS

In this study, a detailed midsize male occupant model from the Global Human Body Models Consortium (GHBMC M50-O V5.0) was used as the baseline model and analyzed using LS-DYNA version11.2. In addition, this model was morphed into a BMI 30 kg/m² model, using the mesh morphing technique developed by Wang et al., [4,5](Obese body model). The height and weight of an occupant with a BMI 30 was used as a reference from actual accident data reported to NASS-CISS.

A D-class sedan model was used as the vehicle, and the restraint system included an activated belt pretensioner and side airbags. Both the pretensioner and side airbags were set to deploy 6.5 ms after impact. The crash simulation was conducted with standard and obese GHBMC using the Advanced European Mobile Deformable Barrier (AE-MDB) 60 km/h test, which is widely employed as a conventional evaluation metric [6]. The crash scenarios are shown in Figure 1. Injury values for ribs, lungs, and thoracic aorta, which are the commonly reported injuries, were compared between standard and obese model. For the rib injury, the deflection of each rib was normalized by the initial width from the spine to the center of the rib. The maximum principal strain-time history was output for organ injury.

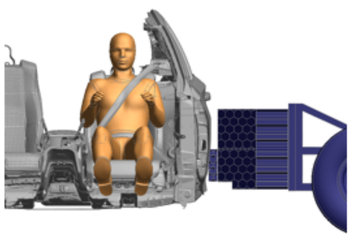
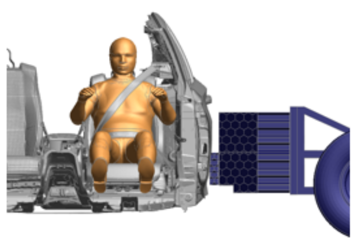
Crash scenario	Standard	Obese
Primally degree of impact : 90 degree Impact velocity : 60 km/h The striking vehicle : AE-MDB Occupant : two types (Standard/Obese) Restraint devices : side air bag , belt pretensioner Time to fire of restraint system : 6.5ms		

Fig1. The crash scenarios

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III. INITIAL FINDINGS

Figure 2 shows the comparison of normalized rib deflection and organ strain-time history between the standard body model and the obese body model. In the obese model, the normalized deflection of the upper ribs (RIB1-5) and lower ribs (RIB6-10) increased by 14% and 45%, respectively. The lower ribs had higher deflection than upper ribs. Using the function of rib deflection and injury probability in cadaveric studies reported by Cavanaugh et al.[7], the risk of AIS3+ injury in lower ribs due to obesity is increased by 54% to 85%. The highest normalized deflection rate was observed at RIB7, which corresponds to the impact location near the armrest of the door panel . At the moment of full airbag deployment, the clearance to the door panel was 18 mm smaller for obese occupants.

In the obese model, the maximum principal strain in the lung and thoracic aorta increased by 32% and 22%, respectively, compared to the Standard model. Higher aorta strain located in the lower of that close to T6 and T7 of spine.

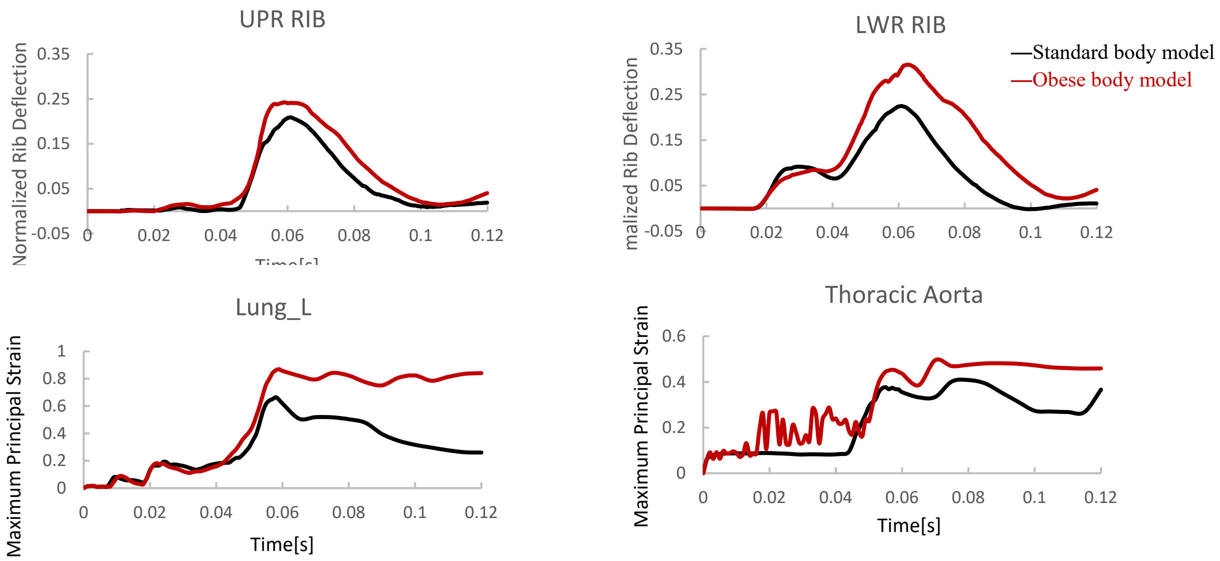

Fig.2 Comparison of injury values between the Standard body model and the Obese body model

IV. DISCUSSION

The injury mechanism is thought to be caused by the deflection of the rib, leading to compression of the lung and aorta between the ribs and the spine. The increased risk of thoracic injuries in obese occupants can be attributed to two factors. Firstly, greater body weight results in higher energy requirements to displace the occupant's spine. Secondly, due to the expanded thoracic cage, the clearance to the door panel, which is necessary for energy absorption, is reduced. Consequently, the side airbag may not be able to absorb sufficient energy, leading to bottoming out against the door panel. This study is the first to use a human body model to investigate thoracic injury risk in side impact crashes for obese occupants. In the case of the previous study, a frontal collision, the increased risk was due to the higher mass of the occupant and the weak pelvic restraint [3]. In the case of side impact, this study found that the increased risk might be due to the higher mass of the occupant and the smaller space to the door. In future works, investigating different side-impact scenarios and developing injury criteria for thoracic injuries is needed.

V. REFERENCES

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