INTRODUCTION

Anthropomorphic test devices (ATDs) are tools used to assess the risk of injury for a specific demographic in a motor vehicle collision (MVC). Most frontal impact vehicle safety standards and NCAP tests are centered around the use of the ATDs that represent mid-sized males. Consequently, occupant protection for small females is not commonly assessed in frontal MVCs. While recent studies have suggested the overall injury risk for females is not significantly different than males in similar MVCs, females exhibit higher injury risks in specific body regions, such as the lower extremities and the thorax, demonstrating considerable differences between the two demographics [1-4]. Therefore, the objective of this study was to compare the responses of the THOR-05F and Hybrid III-05F ATDs to each other and to their mid-sized male counterparts (the THOR-50M and Hybrid III-50M, respectively) in matched, frontal sled tests.

Frontal sled tests were conducted using a custom test buck and 56kph sled design to match the 2012 Toyota Camry US-NCAP test. The test buck utilized Camry parts, including a 3-point seat belt (pretensioner and 4kN load limiter), steering wheel and airbag, steering column, seat, D-ring adjuster, and buckle (Figure 1). The seatback was modified to allow lines of sight to the ATD spine. The knee bolster was simulated using 65si rigid polyurethane foam. Four tests were conducted with the Hybrid III-05F, and three tests were conducted with the THOR-05F (Figure 2). Four tests were previously conducted on the Hybrid III-50M and THOR-50M (two tests each) using the same test set-up and sled pulse (Figure 3) [5]. All ATDs were fully instrumented. Hybrid III injury risks were calculated using US-NCAP injury risk curves [6]. THOR-50M injury risks were calculated using the latest NHTSA injury criteria [7]. THOR-05F injury risks curves for HIC15 and femur load were the same as the Hybrid III-05F. The THOR-05F Rmax injury risk curve was obtained from an unpublished, preliminary injury risk curve [8]. Nij and consequent injury risks were not able to be calculated for the THOR-05F, as critical values are currently unavailable.

RESULTS

Measured responses and resulting calculated injury risk probabilities for the head, thorax, and femur are displayed in Figures 4, 6, and 7. Neck axial load and bending moment about the Y axis are displayed in Figure 5. HIC15 values never exceeded 200, resulting in P(AIS 3+) injury risks below 0.001. No considerable differences were observed between ATDs for HIC15 values. Both female ATDs recorded greater upper neck compression than their male counterparts. This difference was especially pronounced in the Hybrid III-05FATD (0.8-1.2kN). While the Hybrid III-05F ATD recorded a smaller flexion moment compared to the Hybrid III-50M, the THOR-05F recorded a larger flexion moment compared to theTHOR-50M. The THOR-05F was also the only ATD that recorded a much larger flexion moment than extension moment. Both THOR ATDs recorded larger chest deflections than the Hybrid III ATDs (42-45mm compared to 22-27mm). P(AIS 3+) thoracic injury risk was much larger for the THOR-50M compared to the Hybrid III ATDs, and the THOR-05F P(AIS 3+) injury risk was more than twice as large as the THOR-50M. There was not a considerable difference in femur loads between ATDs, with the exception of the slightly lower femur loads in the Hybrid III-50M. The injury risk for the femur was larger for the female ATDs but did not exceed 6% risk of AIS 2+ injury.

CONCLUSION AND DISCUSSION

The comparisons in the current study illustrated differences between ATDs for a given demographic group and differences between ATD types (Hybrid III and THOR). The low and relatively similar HIC15 values between ATDs was likely due to the airbag preventing impacts with the steering wheel. The differences in the upper neck loads and moments likely resulted from differences in how the head interacted with the airbag and the more compliant neck in the THOR ATDs. The THOR ATDs had higher chest deflections and injury risks compared to the Hybrid III ATDs, which was likely due to the THOR chests being more compliant and having multiple chest deflection measurements, producing a better approximation for maximum deflection. It is important to note that the female ATDs were positioned higher and closer to the wall than the male ATDs due to the difference in stature, which resulted in increased chest-airbag interaction compared to the male ATDs. While the preliminary injury risk curve for the THOR-05F ATD should be interpreted with caution, the fact that the smaller thoraxes of each female ATD recorded similar chest deflections as their male counterparts, i.e., higher percent compression, suggests an increased risk for thoracic injury in small females, which agrees with what has been observed in real world data [1-3]. While the calculated femur injury risk was small for all ATDs, the risk was substantially larger for the female ATDs, which also agrees with what has been observed in real world data [1-3]. Future work will entail running matched sled tests with small female post-mortem human surrogates (PHMs), which will generate data that can be used to assess female ATD biofidelity and potentially improve the thoracic injury risk curves for the THOR-05F ATD.

REFERENCES


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