WHIPLASH INJURY PREVENTION WITH ACTIVE HEAD RESTRAINT

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INTRODUCTION

Previous epidemiological studies observed that a gap greater than 10 cm between the head restraint and back of the head was associated with higher neck injury risk and greater incidence of chronic symptoms in whiplash patients [1]. Active neck injury prevention systems, such as the active head restraint and energy absorbing seat, have been developed for some automobiles. However, their implementation is without thorough understanding of their injury prevention mechanisms.

The goals of this study were to develop a new Human Model of the Neck (HUMON) for whiplash simulation, consisting of a neck specimen mounted to the torso of a rear impact dummy and carrying an anthropometric head, and to use the model to investigate the relation between the active head restraint (AHR) position and whiplash injuries.

METHODS

HUMON (Figure 1) consisted of a neck specimen mounted to the torso of BioRID II and carrying an anthropometric head stabilized with muscle force replication. HUMON was seated and secured in a Kia Sedona seat with AHR on a sled. The AHR was activated by HUMON’s momentum pressing into the seatback during whiplash and rotated forward via a pivoting mechanism between it and the seatback. Whiplash was simulated with the AHR in the each of the five positions immediately prior to impact (Figure 2): minimum gap and height (AHR 1), midrange gap and maximum height (AHR 2), maximum gap and height (AHR 3), midrange gap and minimum height (AHR 4), and midrange gap and height (AHR 5). Subsequently, whiplash was simulated without the AHR. The impacts were first performed at a maximum measured horizontal sled acceleration of 7.1 g and subsequently at 11.1 g. Peak spinal motions were contrasted with physiologic ranges obtained from intact flexibility tests. Significant reduction (P<0.05) in the spinal motion peaks with the AHR, as compared to without, were determined. Linear regression analyses identified correlation between head/AHR gap and peak biomechanical parameters (R²>0.3 and P<0.001).

Figure 1. Photograph of the Human Model of the Neck (HUMON) and rear impact apparatus.

Figure 2. Schematic of the average active head restraint (AHR) position immediately prior to impact for each of the five positions studied.
RESULTS AND DISCUSSION

The AHR significantly reduced average peak spinal motions throughout the middle and lower cervical spine, however these peaks exceeded the physiologic range in flexion at head/C1 and in extension at C4/5, C6/7, and C7/T1. The AHR position with the smallest gap generally allowed the least motion in excess of physiologic. Correlation was observed between the head/AHR gap and extension peaks at C4/5 and C5/6 (Figure 3). Based upon these correlations, motion beyond the in vivo physiologic range may occur at C5/6 and C4/5 due to head/AHR gaps in excess of 9.2 and 9.6 cm, respectively, causing extension injuries. These results are consistent with previous epidemiological studies which observed higher neck injury risk [1] and greater incidence of chronic symptoms for a head restraint gap larger than 10 cm.

CONCLUSIONS

1. A new, novel Human Model of the Neck (HUMON) for whiplash simulation was developed consisting of a neck specimen mounted to the torso of BioRID II and carrying an anthropometric head. The model was used to investigate the relation between active head restraint (AHR) position and whiplash injury.

2. The AHR significantly reduced the average peak spinal motions throughout the middle and lower cervical spine, as compared to no AHR, however these peaks exceeded the physiologic range in flexion at head/C1 and in extension at C4/5, C6/7, and C7/T1.

3. Correlation was observed between head/AHR gap and extension peaks at C5/6 and C4/5. Based upon these relations, motion beyond the in vivo physiologic range may cause injury at these spinal levels due to head/AHR gaps in excess of 9.2 and 9.6 cm, respectively.

4. The AHR may not be fully activated at the time of peak spinal motions, thus reducing its protective effect.

5. Improved understanding of the whiplash prevention mechanisms may lead to improved injury prevention systems and reduced neck injury risk.

REFERENCES


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