EFFECT OF ACTIVE HEAD RERAINT ON RESIDUAL NECK INSTABILITY DUE TO REAR IMPACT

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INTRODUCTION

Rear automotive crashes commonly result in injurious neck strains and whiplash injuries. These strains lead to clinically observed symptoms of neck, shoulder, and back pain, headache, dizziness, paresthesias, and vertigo. Multiple epidemiological studies have reported that traditional passive head restraints and standard seat designs have been ineffective or provided up to only 20% effectiveness in preventing neck injuries. While previous studies have indicated potential benefits of active injury prevention systems, including the active head restraint (AHR), no studies have evaluated their effects on residual neck instability due to whiplash. The goals of the present study were to determine residual neck instability due to simulated rear impacts of a new Human Model of the Neck (HUMON). The impacts were performed with and without the AHR at two impact severities.

METHODS

The experimental protocol is outlined in Figure 1. The whole cervical spine specimen was used for flexibility testing while intact and following rear impacts with and without the AHR. HUMON (Figure 2) was used to simulate rear impacts and consisted of the cervical spine specimen mounted to the torso of a rear impact dummy and carrying an anthropometric head, stabilized with muscle force replication. The muscle force replication was deactivated prior to flexibility testing. Pure flexion-extension moments were applied to the occipital mount of the whole cervical spine specimen in four equal steps up to peak loads of 1.5 Nm. To allow for viscoelastic creep, 30-second wait periods were given following each load application. Two preconditioning cycles were performed and data were recorded on the third loading cycle using a digital. From the resulting load displacement curves, the flexibility parameters of total (flexion plus extension) neutral zone (NZ) and total range of motion (RoM) were determined for all spinal levels.

Single factor, repeated measures ANOVA and pairwise Bonferroni post-hoc tests were used to determine significant differences (p<0.05) in the flexibility parameters among the test conditions for each spinal level. Linear regression analyses were performed to identify correlation (R^2>0.3; P<0.001) between the flexibility parameter increases measured following impact and the high-speed spinal rotation peaks measured during impact with and without the AHR for both the 7.1 and 11.1 g impacts combined.

Figure 1. The experimental protocol in which flexibility testing was performed following each rear impact of the Human Model of the Neck (HUMON). Impacts were performed with and without the active head restraint (AHR).
RESULTS AND DISCUSSION

Our results indicated significant increases in the average flexibility parameters, up to 3.1°, at C2/3, C3/4, and C5/6 due to 7.1 g rear impacts even in the presence of the AHR. Subsequently, increases in the flexibility parameters progressed and spread to head/C1 and to the inferior spinal levels following the 11.1 g impacts. Correlation was observed between the C7/T1 extension peaks measured during impact and the flexibility parameter increases measured following impact (Figure 3). The flexibility parameter increases were generally larger due to the impacts without, as compared to with the AHR. Extrapolation of our results indicated that every 1° of extension beyond the physiologic limit during whiplash contributed approximately 0.5° of residual rotation following whiplash.

CONCLUSIONS

1. The present study determined residual neck instability due to simulated rear impacts with and without the AHR using HUMON.

2. Our results indicated residual neck instability, up to 3.1°, due to rear impact even in the presence of the AHR. Increased neck flexibility was initially observed at C2/3, C3/4, and C5/6 due to 7.1 g impacts with the AHR, and subsequently progressed and spread to head/C1 and the lower cervical spine at the higher impact severity.

3. Assuming that the present correlation between the C7/T1 extension peaks and resulting residual instability may be applied throughout the middle and lower cervical spine, then every 1° of extension beyond the physiologic limit during whiplash may contribute approximately 0.5° of residual rotation.

4. Greater residual neck instability was generally observed due to rear impacts without, as compared to with the AHR.

5. The present data underscored the protective effect of the AHR in reducing residual neck instability due to whiplash.

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