NOVEL APPROACH FOR STUDYING HUMAN RESPONSE TO WHIPLASH-LIKE PERTURBATIONS

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INTRODUCTION

Whiplash is a common and disabling condition with a significant associated health and economic burden. Much biomechanical research has attempted to understand the mechanism of this injury, and therefore enable strategies to lessen the severity and prevalence of whiplash injuries. This research has identified several primary sites of injury during whiplash including the facet joints [1] and musculature [2]. While the facet joint contribution can be studied using in vitro experimental approaches[1], in vivo human testing is necessary in order to evaluate the physiologic muscle responses to whiplash-type perturbations. To date the human testing experiments have either used experimental impacts with entire automobiles [3, 4], or have applied accelerations to sleds guided by rails [5-8]. Previous experiments have determined that awareness of the impact timing [7], impact direction [5] and head rotation [6] modulate the muscular response, however previous investigations have not been able eliminate the subjects' awareness of the impact direction; the nature of the automobile setup, or the orientation of the rails, has provided clues about the impact direction. Placebo "collision" experiments show that the physiological and psychological factors strongly influence the observed responses to perturbations [4]. Accordingly, as the majority of rear-end collisions are unexpected, experiments must incorporate unknown timing and direction in order to gain insight into "typical" responses to whiplash impacts. The purpose of this paper is to describe the novel experimental system that we have developed for applying low-velocity whiplash-like perturbations in arbitrary directions.

METHODS

We have assembled a novel experimental system for performing human studies using low-velocity whiplash-like perturbations. This system consists of an automobile seat, leg rest, and seatbelt restraint system mounted on a six degree-of-freedom parallel robotic platform. The six degree-of-freedom capacity make this system ideally suited for applying perturbing motions in any direction. Preliminary efforts have been limited to developing appropriate motion pathways for producing the whiplash-like perturbations, and for developing the necessary associated instrumentation. To date we have concentrated on anterior accelerations/displacements, simulating rear end impacts.

RESULTS AND DISCUSSION

The robotic testing platform, showing the platform, automobile seat, seatbelt and footrest is shown in Figure 1. We have determined, through experimentation, that the system is limited to translations less than 20 cm, velocities less than 0.8 m/s (3 km/hr) and accelerations less than 1 g. Pilot testing has determined that platform motions with 1 g peak accelerations (peak acceleration at 0.05 s) result in head accelerations of less than 4 g (Figure 2). These perturbation parameters are similar to one previous study [8], and less severe than the low-velocity impacts that are frequently reported in the literature (either 4 , 8 or 9.3 km/hr) [2-6]

Figure 1: Automobile seat mounted on robotic platform. The platform motion has been programmed to simulate whiplash-like perturbations.

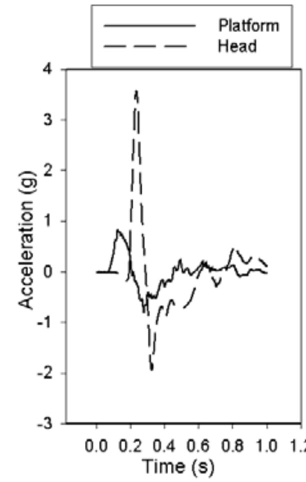

Figure 2: Platform and Head accelerations during whiplash-like perturbation.

CONCLUSIONS

We have assembled a powerful and versatile testing platform for evaluating the biomechanics of whiplash-like perturbations. This system offers unparalleled flexibility due to the ability to translate and/or rotate in any direction. Accordingly, this system is ideally suited to assess the biomechanical effects of low-velocity whiplash-like perturbations due to impacts in different directions, or combinations of directions, more closely simulating real-world (unexpected) impact situations.

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