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Original Research

Comparing the Efficacy of Methods for Immobilizing the Thoracic-Lumbar Spine

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A B S T R A C T

Objective: The purpose of this study was to compare the relative efficacy of immobilization systems in limiting thoracic-lumbar movements.

Methods: A dynamic simulation system was used to reproduce transport-related shocks and vibration, and involuntary movements of the thoracic-lumbar region were measured using 3 immobilization configurations.

Results: The vacuum mattress and the long spine board were generally more effective than the cot alone in reducing thoracic-lumbar rotation and flexion/extension. However, the vacuum mattress reduced these thoracic-lumbar movements to a greater extent than the long spine board. In addition, the vacuum mattress significantly decreased thoracic-lumbar lateral movement relative to the cot alone under all simulated transport conditions. In contrast, the long spine board allowed greater lateral movement than the cot alone in a number of the simulated transport rides.

Conclusion: Under the study conditions, the vacuum mattress was more effective for limiting involuntary movements of the thoracic-lumbar region than the long spine board. Moreover, the increased lateral bend observed with the long spine board under some conditions suggests it may be inadequate for immobilizing this anatomic region as presently designed. Should emergency medical service providers choose to immobilize patients with suspected injuries of the thoracic-lumbar spine, study results support the use of the vacuum mattress.

Approximately 17,000 cases of spinal cord injury (SCI) are reported in the United States each year.[1] However, this represents just a small fraction of the millions of trauma patients with the potential for spine-related injuries who are transported by air or ground to medical facilities annually.[2,3]

With respect to thoracolumbar spinal injury, a trauma center study of 5,593 adults who had received prehospital spinal immobilization found that 4.3% of them had an acute thoracolumbar fracture, dislocation, or subluxation.[4] Of these, approximately 12% had an unstable injury. Although patients with unstable injuries of the thoracolumbar spine represented a small fraction of the trauma population, studies show that prehospital providers have a low degree of accuracy in predicting the presence of a spinal fracture.[5-7] Thus, failure to recognize and appropriately manage unstable spinal injuries during transport remains a risk.[4]

Patients are exposed during transport to shocks and vibrations that can lead to involuntary movements of the spine. Repetitive movements can occur in response to vibrations, and nonrepetitive movements can result from acute forces on the patient (eg, from shocks transmitted to the patient through the transporting platform). For patients with suspected SCIs, concern exists that these forces on the spine might exacerbate existing trauma and/or its associated cellular and molecular damage.

The most direct evidence for potentially harmful effects from movements during patient transport come from studies of involuntary repetitive movements that occur in vibrational environments (ie, whole-body vibration [WBV]). Both animal and human studies show that WBV can induce pain, exacerbate injury, and cause damage at the cellular level.[8-11] In addition, a study on human

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subjects during helicopter transport suggested that the level of vibration transmitted to the patient may cause bleeding in unstable bone fractures, such as those involving the pelvis.[12] DeShaw and Rahmatalla[13] also showed that involuntary repetitive movements under WBV caused discomfort at different locations on the human body, with more intense discomfort at the cervical and lumbar areas. In all of these studies, the level of adverse effects was proportional to the intensity of the motion.

Spinal immobilization with a cervical collar and a long spine board has been the standard of care for prehospital management of patients with potential spinal injury for many years. This was the medical community's answer to a number of reports that described patients with acute neurologic deterioration whose injured spines were not recognized early and for whom it was believed that appropriate precautions were not taken.[14-16]

Despite this long-term practice, there is relatively little information on the efficacy of different immobilization systems in stabilizing critical anatomic regions. In the study by Perry et al,[17] they found that different head immobilization systems varied in their ability to limit cervical movement in response to lateral shocks. In addition, a single randomized clinical trial tested the relative efficacy of the long spine board and the vacuum mattress in limiting voluntary movements by trauma patients during transport.[18] The long spine board with head blocks was more effective at limiting cervical movement, whereas the vacuum mattress was more effective for other areas of the spine.

A previous study measured lateral movements along the spine as an ambulance made turns on a closed course and found healthy immobilized subjects on a long spine board had greater overall lateral movement compared with those on a stretcher mattress.[19] To our knowledge, no other immobilization study to date has looked at involuntary movements of the thoracic-lumbar spine that could result from shocks and vibrations during transport. The goal of this work was to quantify and compare the relative ability of common immobilization systems to limit shock and vibration-induced movements of the thoracic-lumbar region using a dynamic simulation model.

Methods

Study Population

The participant group for this study consisted of 16 healthy men with a mean and standard deviation for age of 22.8 ± 3.8 years, height of 181.6 ± 5.0 cm, and weight of 82.2 ± 9.4 kg. Male subjects were recruited by word of mouth from the university's undergraduate and graduate student population. Subjects with a history of any chronic musculoskeletal disorder or any history of allergy or contact dermatitis to adhesives were excluded from participating in the study. Written informed consent was obtained from each subject before testing. The university's institutional review board approved the study.

Creating and Reproducing Ride Files

Figure 1 is an illustration of the creation and reproduction of simulated transport ride files. Real-world shock and vibration data were collected aboard a ground ambulance (Type I Ford Chassis) and a medical transport helicopter (EC-130-T2) with an immobilized healthy human subject on the transport cot. The ambulance ride consisted of 4 road segments: driving on a gravel road, an

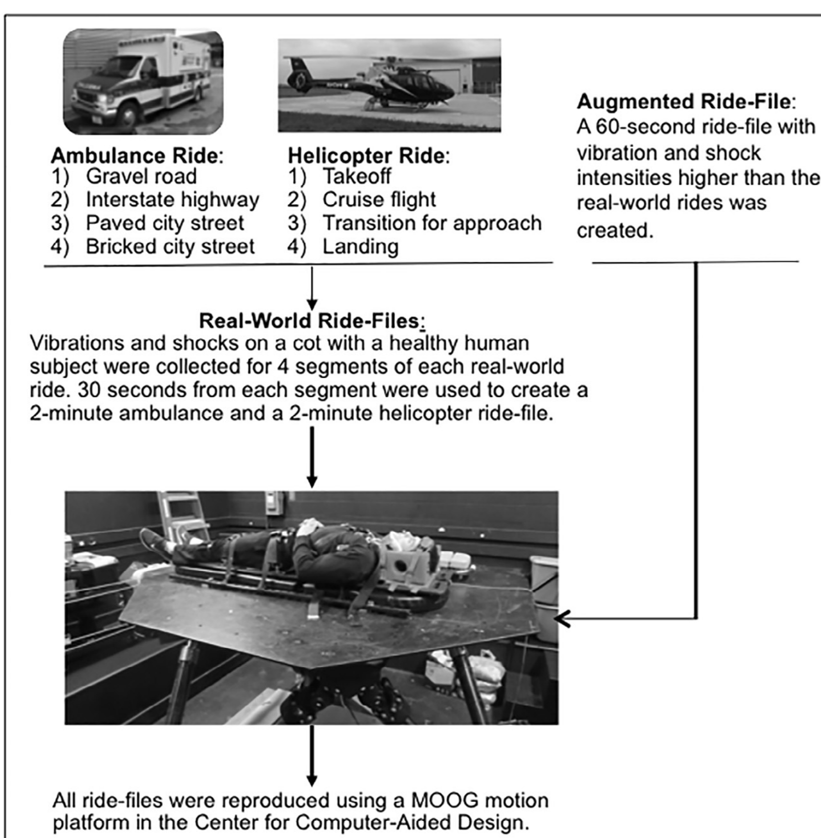

Figure 1. The creation and reproduction of ride files for transport simulations. A 2-minute real-world ride file was created with data collected from both an ambulance and a helicopter ride each with a human subject on the cot. A 1-minute augmented ride file was also created and was composed of shocks and vibrations of higher intensity than those of the real-world transports. All ride files were reproduced (computer generated) at the CCAD using a man-rated MOOG motion platform.