Podium Presentations

Session V: Health Effects III

Chairs: Thomas Jetzer and Danny Riley

SEATED HUMAN RESPONSE TO SIMPLE AND COMPLEX IMPACTS

D Wilder, T Xia[1], J Ankrum, K Spratt[2]
Iowa Spine Research Center, Biomedical Engineering Department,
[1]University of Iowa, Iowa City, Iowa, U.S.A.
[2]Orthopaedics, Dartmouth College, Hanover, New Hampshire, U.S.A.

Introduction

The human lumbar spine is inherently an unstable structure and requires sophisticated neuromuscular control to maintain its stability and for performing physical tasks. As a consequence, it is important to understand the potential health effects on human operators of mechanical stimuli such as shock and vibration.[1] Impact applied to a vehicle operator combines the risk of sudden, unexpected load with the mechanical stress of the seated posture.[2] Because many work environments contain the potential for multiple, unexpected impacts, it is important to understand how the trunk muscles respond to complex conditions. We believe the results have implications for isolation design and standards development.

Methods

Muscle activity was recorded during simple and complex impacts, applied randomly and without warning, while subjects sat on an air-suspension truck seat located on a man-rated 6-DOF motion platform (Rexroth-Hydraudyne). Simple (single) impacts consisted of 100 ms quarter-sine jolts in the side-to-side (L and R) and vertical upward (V) directions with peak amplitude at 0.4 g. Complex impacts consisted of combinations of two simple (single) impacts in sequence (LV, RV, VL, VR), separated by 100 ms. Twelve right-handed males (23.7 ± 7.8 years old) were tested without a blindfold under 2 posture conditions (supported while leaning back and unsupported, sitting upright) and 2 seat suspension conditions (present or absent). Each type of impact was repeated three times under each posture and suspension condition, resulting in 84 impacts in total. Surface EMG signals from the left and right erector spinae (ES), rectus abdominis (AR), external obliques (EO) and internal obliques (IO) were recorded and transformed to 25ms RMS values. The response time, defined as the time the muscle activity exceeded the mean + 2 STD of the pre-impact resting period, peak response amplitude, and time were then derived. A mixed-model repeated measures analysis of variance was used to evaluate statistical significance, where type I error rate was set at .05.

Results

One question we asked of these data was whether there were differences in responses related to simple single strike impacts (L, R, or V) and complex, double-strike impacts (LV, RV, VL, VR). There are 21 possible combinations of comparisons of simple and complex impacts to each other. The differences found are listed in Table 1.

Table 1. Number of significant contrasts in muscle response to different impact types (the format below is: Peak response amplitude (response start time, time at peak response)

	Muscle Groups				
Comparison	ES	AR	EO	IO	Total
Simple vs. Simple	1 (0, 0)	0 (0, 0)	1 (0, 1)	3 (2, 2)	5 (2, 3)
Simple vs. Complex	3 (3, 4)	2 (0, 0)	1 (3, 1)	5 (5, 6)	11 (11, 11)
Complex vs. Complex	0 (3, 2)	0 (0, 0)	0 (2, 0)	2 (4, 5)	2 (9, 7)
Total	4 (6, 6)	2 (0, 0)	2 (5, 2)	10 (11, 13)	18 (22, 21)

The contrast between impact types shows differences in the muscles. Overall differences occurred more often in the Simple vs. Complex comparisons. The analysis also showed that posture had a significant effect but the suspension had little effect.

Discussion

These results corroborated prior work showing that the back muscles play an important role in balancing the trunk in seated impact environments and confirmed that abdominals and external obliques are less able to discriminate between impact types and are likely unable to respond effectively. This study shows, for the first time, that the behavior of the internal obliques is more sensitive than that of the erectors to impact types. Just as a bent beam has one side under tension and the other side under compression, the act of sitting for a human lengthens the posterior aspect of the body and shortens the anterior aspect. During sitting, the lengthened (posterior) muscles are more sensitive and the passively shortened and hence, loose anterior muscles are less sensitive. In the standing posture, all trunk muscles play a role in postural control, however in the sitting posture, a demand on the internal obliques was observed. Long-term exposure to this unbalanced condition may retrain the muscles and control system in an undesirable fashion. Concern about responses to a complex strike is because the first impact may displace the body and the second may further destabilize it, especially with the first strike being an asymmetric impact. These results suggest that a single strike from the side may not be a simple mechanical stimulus, as has traditionally been hypothesized, because it is asymmetric and fundamentally different from a vertical strike. There was one limitation of the study. The low level of the impacts might have contributed to a lack of suspension effect.

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References

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