RESPONSE TO SUDDEN LOAD BY PATIENTS WITH BACK PAIN

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Introduction

As mechanical shock and vibration environments evolve, it is important to understand their potential effect on human operators. Human beings are sophisticated mechanisms comprised not only of passive components with mass, damping, and stiffness characteristics, but also of components that can actively affect apparent mass, stiffness, and damping. Because the lumbar spine can exhibit local, short-column buckling, stability of the human trunk depends on the responsiveness of the neuromuscular control system.[1-2] We have been evaluating the ability of patients with back pain to respond to a series of sudden loads. We believe the results have implications for isolation design and standards development.

Methods

153 patients, aged 21 to 55, presenting with back pain agreed to enroll in a research study that randomly assigned them to one of three treatment arms: high velocity low amplitude spinal manipulation, low velocity variable amplitude spinal manipulation, or wait for 2 weeks and then be randomized to one of the above groups. Response to sudden load testing was one of a battery of baseline evaluations performed upon entry into the study and prior to treatment. EMG electrodes were attached to the skin over the paraspinal muscles of the standing participant bilaterally 3 cm from midline at the L3 level. While standing upright on a force plate (Bertec), participants were fitted with a strap around their back and hooked to a load cell in front of their chest. An accelerometer was rigidly attached to the load cell. Impact was applied to the chest using a cord attached to a falling weight. The weight's fall distance was varied between 9 and 13 inches to account for the size of the subject. The subject was blindfolded and wore headphones playing white noise to prevent cueing of when the weight was dropped to apply the load. Hence, although the participant knew a load was about to be applied, he or she did not know the instant it would occur. Just before the weight was dropped, a 4 second data collection process was started for the two EMG electrodes, load cell, accelerometer, and force plate. The load drop was repeated 6 times, at irregular intervals, over a period of 2 minutes. The raw data thus collected was reduced to obtain several values: 1) length of time from the pull on the harness to the beginning of the response of the left and right paraspinal muscles (LES, RES), 2) time and magnitude of the maximum response, 3) force and acceleration experienced at the chest, and 4) the time and magnitude of the center of pressure location (COP). A general linear model was used to evaluate the results.

Results

For the EMG data, of the 1,824 observations made, 90% of them indicated a response. Prior to the sudden load, resting muscle activity was different between left and right sides ($p=0.0001$) and between males and females ($p=0.0001$). Female subjects began to respond to the sudden load within 92 to 110 ms and males from 101 to 109 ms. Females exhibited more variation in starting their responses than did males. Females began to respond to the second sudden load significantly sooner (92 ms) than the males (109 ms) with p=0.0027, otherwise they were similar to the males. There was no significant effect of sudden load trial (1^{st}, 2^{nd}, 3^{rd}, etc) on the amount of time taken to create the peak EMG response to the sudden load (179-193 ms LES, 186-198 ms RES), but the muscle side responding more quickly had a trend of an effect (p=0.0568). Peak muscle response was not affected by gender, but was affected by trial. The first peak response differed significantly from the rest (2^{nd} p=0.0108, 3^{rd}-6^{th} p<0.0001). Thereafter, only the peak response at trial 2 was different from that at trial 6 (p=0.0498). Females exhibited greater variation in their peak responses than did males. The females experienced significantly lower forces at the chest during the sudden pull than did the males (121.1 v 131.4 N, p<0.0001). The females experienced significantly larger accelerations at the chest during the sudden pull than did the males (1.76 v 1.39 ms^{-2}, p<0.0001). In response to the sudden load, subjects counteracted the overturning moment by shifting forward the center of pressure (COP) under their feet. The shift was larger in the first trial (84mm) and decreased over the trials (79, 77.2, 75.4, 74.7, and 73.7 mm). The time to shift the COP forward was smallest in the first trial (388.0 ms), increased up to the 5^{th} trial (433.4, 444.1, 480.6, and 488.4 ms), and then decreased slightly by the 6^{th} trial (486.5 ms).

Discussion

In a study trying to predict who would respond well to different chiropractic treatment methods, baseline data were obtained on patients that provide insight into the response of people with back pain to sudden loads applied at the chest. The primary observation is that people take finite amounts of time to respond to a sudden load. People are able to adapt to some aspects of exposure to a train of sudden loads: adjusting back muscle activity magnitude, and the speed and magnitude of changing the center of pressure in order to stabilize their stance. There is however, no significant adaptation of the time the back muscles take to respond to the load. Although efforts were made to adjust the suddenly applied load according to subject size, the females presented a more compliant and faster moving trunk to the loading device. In summary, although people with back pain can make some adaptations to a train of similar impacts, their first response is always unique. It always takes a certain amount of time to respond to various aspects of sudden load. The reciprocals of the above response times provide insight into some of the observed psychophysical and mechanical sensitivities to vibration and repetitive mechanical shock.

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