ARM AND SHOULDER MUSCLE ACTIVITY ARE GREATER WITH STEERING WHEEL VS. SEAT MOUNTED CONTROLS

L Frey Law, S Rahmatalla, D Wilder, N Grosland, T Xia, T Hunstad, M Contratto+, G Kopp+
University of Iowa, Iowa City, Iowa, U.S.A., +Caterpillar, Inc., Peoria, Illinois, U.S.A.

Introduction

Chronic whole-body vibration exposure, as expected in large construction and mining vehicles, has been associated with neck and back pain and injury.[1] While work has been done towards gaining a better understanding of the relationship between vibration and shock and muscle activity of the back musculature[2], relatively little information regarding the activity of neck, shoulder and upper arm muscles is known. Today's equipment designs must conform to domestic and international standards, however these standards do not specifically address the vibration exposure in the head and upper quarter. Further it is not well known how the control configuration within a vehicle (e.g. steering wheel versus arm controls) influences muscle voluntary and reflex activity levels. Greater muscle activity may lead to greater muscle fatigue – which in turn may be associated with greater risk of injury.[2] Thus, muscle contractions needed to maintain static postures as well as those resulting reflexively should be considered during an analysis of seating position. Unfortunately, little is known regarding the influence of arm position on head and neck muscle function. The purpose of this study was to investigate the relative muscle activities of 5 neck, shoulder, and upper arm muscles during riding simulations of large construction equipment, using three different arm control options.

Methods

Five typical heavy equipment ride files were "played back" through a man-rated Servo Test 6-degree of freedom (dof) vibration system. Each ride was repeated using 3 seat and control configurations (steering wheel (SW), floor mounted arm-rest controls (FM), seat mounted arm-rest controls (SM)). Two trials were performed for each ride and seat control combination (each trial: 60 sec of 6-dof and 60 sec of vertical vibration). Five channels of surface electromyography (EMG) of the right-side cervical erector spinae muscles (neck extensors), sternocleidomastoid (neck flexor), upper trapezius (shoulder elevator), biceps brachii (elbow flexor) and triceps brachii (elbow extensor) muscles were collected throughout each ride (~ 2min) using pre-amplified (10x), 1 cm silver bar electrodes, with 1 cm fixed inter-electrode distances (Delsys, Inc). Further analog amplification was set at 10k (1k for one subject), and sampled at 1000Hz using a 12-bit DAQ card and Labview 7.1 software (National Instruments). A total of 7 right-handed male subjects were tested, but only 5 had complete EMG data sets to analyze for this sub-study. EMG was analyzed using root mean square (RMS, in mV) of 20 ms moving windows, and then averaged across the entire trial for a measure of mean total muscle activity (voluntary and reflexive). The muscle activity to maintain the static posture was estimated as the mean RMS EMG over a 1 sec interval just prior to and/or after completion of the ride. Repeated Measures ANOVAs were used to test for with-in subject differences using $\alpha = 0.05$.

Results

The upper trapezius and triceps brachii muscles were significantly more active (mean EMG muscle activity) while using the steering wheel controls than for either the floor mounted or seat mounted arm rest controls. Whereas, the floor mounted arm controls tended to produce greater activity in the biceps brachii. Overall, the seat mounted controls resulted in the lowest mean EMG levels across all five muscles. No significant differences were observed in the neck flexor (sternocleidomastoid) or the neck extensor (erector spinae) muscles across control configurations.

Discussion

This pilot study suggests that muscle activity is indeed influenced by arm control postures. In our companion study on relative neck and shoulder motion, we indicate greater relative motion with the armrest control configurations. Interestingly, in this study we observed greater static and dynamic muscle activity with the steering wheel configuration. The arms may behave as active dampers particularly when the control configuration is not mounted to the seat (SW or FM), potentially attenuating head and neck motions. However, it is not entirely clear as to whether the greater relative motion or the potential for greater muscle fatigue over time may be the most problematic for equipment operators. Certainly the risk of injury may depend on the type of injury considered, e.g. overuse muscle injury versus repetitive motion joint pathology. There may be trade-offs between the potential for reduced fatigue associated with arm-rest controls, which is supported by our observations of decreased mean muscle activity, and the potential for greater apparent muscle and joint stiffness associated with tonic muscle activity – and thereby reduced motions. These preliminary results would suggest that the vibration community needs to consider the effect of and attenuation of vibration in the upper quarter considering the influence of postural muscle activity with different arm control configurations on the transmissibility of vibration into the head and neck.

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