

## The Effect of Posture and WBV on Neck Muscle Activation Requirements

Jonathan Mortensen, Andrew Merryweather  
University of Utah Department of Mechanical Engineering, Salt Lake City, Utah

**Introduction:** Commercial truck drivers have a high incidence of neck pain, approximately 51%.<sup>1</sup> While lower back pain of commercial truck drivers has received significant attention in the literature, our understanding of the factors that lead to neck pain remains limited. Whole body vibration (WBV) has been identified as a potential contributor to neck pain.<sup>2</sup> This work aims to investigate the relationship between posture, WBV, and musculoskeletal stress.

OpenSim is an open source musculoskeletal modeling platform that has the ability to investigate the effects of posture and WBV by predicting muscle activation and joint loading<sup>3</sup>. OpenSim is used to simulate gait,<sup>4</sup> tendon transfer surgeries,<sup>5</sup> and sports movements.<sup>6</sup> Recently an OpenSim model of the head and neck, known as the HYOID model, was developed which is the first OpenSim model to deliver realistic strength in each principal direction of movement in the neck.<sup>7</sup>

The long term goal of our work is to understand the effects of driving time, posture, and WBV on commercial truck driver neck pain and neck fatigue. With observational studies planned in the future to determine the effects of drive time on posture and how WBV is transmitted to the head, this study is focused on using the HYOID model to define a relationship between posture, WBV, and muscle activation requirements.

**Methods:** The HYOID model includes 72 muscle actuators, passive elements, realistic inertial properties, and kinematic constraints which lower the degrees of freedom in the model to six.<sup>7</sup> The HYOID model has been shown to be able to reproduce experimentally observed functional movements of the neck more effectively than previous models.<sup>7</sup> One of the strengths of using OpenSim is the ability to interface directly with MATLAB. We created a custom MATLAB script which enables a parametric simulation study in which we altered posture and WBV characteristics. We simulated every combination of three upper cervical spine postures, 3 lower cervical spine postures, 3 torso postures, 2 WBV frequencies, and 3 WBV amplitudes for a total of 162 simulations. After each simulation, our script recorded the average of the sum of all muscle activation in the model. With this data, we performed a TukeyHSD analysis in RStudio to determine which factors have a significant effect on muscle activation. We also developed a linear model to predict muscle activation based on posture and WBV characteristics.

**Results:** The TukeyHSD results indicate that the amplitude and frequency of WBV have significant effects on required muscle activation. While the TukeyHSD results indicate no significant effects of posture on required muscle activation, the linear model reveals complex interactions between posture degrees of freedom and WBV characteristics. The linear model has an adjusted  $R^2$  value of 0.85 and indicates significant effects from WBV amplitude, the interaction between WBV amplitude and frequency, and several interactions between cervical spine posture, torso posture, and WBV characteristics.

**Conclusions:** The results indicate that there is a meaningful relationship between the characteristics of WBV, posture, and muscle activation requirements. The three degrees of freedom for posture in this analysis can interact to either amplify or dampen the effect of posture in this relationship. For example, the neck can be in flexion while the torso is rotated anteriorly allowing more of the loads from WBV to travel through the spine. Future work includes determining the relationship between driving time and posture. If truck drivers fail to alter their neck posture in response to altering torso posture increased neck activation, fatigue, and loading may occur and lead to increased pain.

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