

A FINITE ELEMENT BASED APPROACH FOR ESTIMATING THE PER MUSCLE PERCENT CONTRIBUTION TO UPPER LIMB MOTION

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ABSTRACT

Vehicle safety countermeasures are designed to protect occupants in assumed, standard seated postures. Active safety features such as automated braking and maneuvering can force occupants into out of position postures that can diminish the effectiveness of these systems. This has motivated researchers to develop active muscle finite element human body models (HBMs). Active HBMs can be used in simulations of the pre-crash phase of an event, considering the state of muscle activation during the pre-crash timeframe. To model this, the contribution of each muscle to various motions must be quantified because a given skeletal muscle may contribute to multiple motion paths (e.g. the biceps brachii contributes to the flexion of the forearm and arm at the shoulder). Existing studies in the literature either provide percent contributions on a grouped basis or have assumed values of percent contribution of each muscle due to the lack of quantitative data. Therefore, our work seeks to address this gap in the literature via simulations with an active HBM. The Global Human Body Models Consortium (GHBMC) average male simplified occupant model with active muscle (M50-OS+Active v1β) was used in this study. All skeletal muscles of the upper extremity (n = 58, bilaterally) were modeled as one-dimensional beam elements (Hill type). Muscles contraction was simulated as a step function to full activation for each muscle in isolation. Dynamic joint angles were tracked at 5 locations (wrist flexion/extension, elbow flexion/extension and shoulder flexion-extension, adduction-abduction, and medial-lateral rotation). All nodes in the body outside the region studied were fixed in space. Angle changes were observed over the functional range (no hyperflexion or extension). For a given muscle, the relative change in angle was calculated for each motion and assumed to correlate to percent contribution of that motion. All simulations were carried out using LS-DYNA software (R. 9.1, LSTC, Livermore, CA). Preliminary findings show that the posterior deltoid muscle contributes to upper arm abduction (17%), extension (70%), and lateral rotation (13%). The study yielded a percent contribution of each muscle in a similar fashion. The muscle contribution calculated in this study will be used in future whole-body simulations with PID controlled muscle activation, incorporating the percent contributions of the muscles modeled.

Keywords: Active muscle, GHBMC, HBM, PID controller.

INTRODUCTION

Both active and passive vehicle safety systems are designed to prevent vehicle crash or, in the case in which the crash is imminent, minimize injuries to the occupant. These safety systems work best if the occupant is in an assumed seated position. There are many studies that have studied the effect of various emergency maneuvers on the occupant kinematics [1-10]. All these studies suggested that active safety systems are readily capable of altering occupant posture, resulting in occupants that are in an out-of-position state. This perturbation can diminish the ability of passive systems to mitigate occupant injury risk.

There are numerous studies in the literature supporting this notion. A series of papers [4, 6, 11-16] show muscle activation level plays a key role on the occupant posture and subsequent injuries. A volunteer study reported out-of-position posture of occupants after emergency maneuverers like steering and/or braking [2]. The same volunteer experiments were simulated using multi-body human body models and reported an increase in the risk of injuries to the occupant. Yet another group of researchers has used a finite element human body model to show the postural changes due to evasive maneuvers during the