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Whiplash Simulation: How Muscle Modelling and Movement Interact

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Whiplash injury and associated disorders are costly to society and individuals. Accurate simulations of neck movement during car accidents are needed to assess the risk of whiplash injury. Existing simulations indicate that Hill-type muscle models are too compliant, and as a result, predict more neck movement than is observed during *in-vivo* experiments.

Simulating head and neck movement is challenging because many of the neck muscles operate on the descending limb of the force-length curve [1], a region that Hill-type models inaccurately capture. Hill-type muscle models have negative stiffness on the descending limb of the force-length curve and so develop less force the more they are lengthened [2]. Biological muscle, in contrast, can develop large transient forces during active lengthening and sustain large forces when aggressively lengthened [3].

Recently, a muscle model has been developed [4] that mimics the active impedance of muscle in the short range and can capture the large forces generated during extreme lengthening. In this work, we will compare the accuracy of simulated neck movements, using both a Hill-type model and the model of Millard et al. [4], to the *in-vivo* neck movement. If successful, the improved accuracy of our simulations will make it possible to predict and help prevent neck injury.

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