

Hand Aperture Decreases with Increased Shoulder Abduction Loading in Individuals with Chronic Stroke

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Loss of voluntary hand movements are very common among individuals with stroke, characterized with the inability to open the hand to grasp and release an object. We propose that shoulder abduction (SABD) has a significant impact on hand opening due to the abnormal muscle coupling between shoulder abductor and wrist/finger flexors following stroke. It is therefore postulated that hand aperture will decrease with increased the SABD loads among individuals with stroke but not in able-bodied controls.

Methods and Equipment: Subjects were instructed to maximally open their hand while abducting at the shoulder with various loads (table, 15%, 25%, 35%, 50% of each individual’s maximal SABD torque). We used an ACT3D robot to provide a haptic environment where different SABD loads had to be generated by the participant. A combination of the Optotrak 3020 and Optotrak Certus (NDI, Inc., Waterloo, Ontario, Canada) motion analysis systems was used to capture the hand aperture. Five IRED markers were placed on the tip of each individual finger and thumb. Hand opening was quantified by 3D distance

between individual fingers and hand pentagon area as shown in the Results section¹.

Results: The top figure shows the mean and standard error of normalized opening distance between thumb and the rest of the fingers while subjects (N = 5) were generating different SABD loads. The aperture decreases as a function of increased SABD loads. Similarly, the pentagon area formed by all the fingers also decreases as a function of SABD load. The bottom figure compares the normalized pentagon area between a control subject (N=1) and a stroke group (N=5). In the stroke group, the pentagon area is negatively affected by SABD loads while in control group the pentagon area does not change across SABD loads. Difference in the rest condition is attributed to the difference in pentagon max between one control and five stroke subjects.

Discussion: The main finding of this preliminary study is that after a stroke the ability to open the hand is decreased as a function of SABD loading. This can be shown by the decreasing trend in both finger aperture and hand pentagon area in stroke but not in the control subject. This is postulated to be linked to a greater dependence on reticulospinal motor pathways after a loss of corticospinal projections⁴. Our finding provides evidence that shoulder abduction is an important

feature that needs to be considered in hand rehabilitation after stroke, i.e. restoring the ability to open the hand to grasp an object. The muscle coactivation between shoulder abductor and wrist/finger flexors, however, is not evident in the control subjects. This suggests that reducing the abnormal coactivation between the shoulder abductors and wrist/finger flexors by stimulating the use of wrist/finger extensor muscles may help to regain some basic hand function in individuals with stroke.

[1] Supuk T, Kodek T, Bajd T. Estimation of hand preshaping during human grasping. *Medical Engineering & Physics*. 2005. 790-797.

