The Impact of an Upper Limb Brace on Upper Body Kinematics During Activities of Daily Living
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Introduction: This study analyzes the impact of a unilateral upper limb brace on the range of motion and compensatory motion of healthy individuals. Understanding compensations associated with a loss in range of motion of the distal limb will lead to a better understanding of the fundamentals of human motion and can be used to design better prosthetics, orthotics, rehabilitative therapies, interfaces, and devices.

Materials and Methods: All procedures were approved by the University of South Florida institutional review board and informed consent was obtained prior to subject participation. Ten healthy individuals completed a series of 8 range of motion (RoM) tasks and 5 activities of daily living (ADLs), first without wearing a brace, and then with a brace attached to their dominate arm. The brace was a Restorative Care of America Incorporated (St. Petersburg, FL) wrist and elbow brace, where the elbow was not restricted. An 8 camera Vicon (OMG plc, Oxford, UK) motion analysis system was used to record the motion of the upper body while performing the tasks. The RoM tasks were used to find the subjects un-braced and braced voluntary RoM, as well as to find the joint centers of the upper body. RoM was found by calculating the difference between the minimum and maximum joint angle for each joint. The ADLs were used to evaluate the compensatory motions of the braced users by finding the joints that had a significantly different range of motion relative to the same joint and task for the un-braced subjects. Significance was determined by analysis of variance and multiple comparison tests in Matlab with a 95% confidence interval.

Results and Discussion: The brace had a significant impact on subjects’ total RoM and the RoM during ADLs. The impact of the brace on RoM is given in Figure 1, and the joints with significantly different RoM for the ADLs are given in Table 1. Joint number corresponds to the joints of the upper body model from proximal to distal. Joints 1-3 are torso flexion, lateral flexion, and rotation; 4-6 are scapular protraction, depression, and rotation; 7-9 are upper arm flexion, elevation, and rotation, 10-12 are forearm flexion, carrying angle, and pronation, 13 and 14 are wrist flexion and abduction respectively. The dominant / braced arm is marked by D, and the non-dominant or un-braced arm by an N. For all ADLs except the lifting tasks an increased RoM of the proximal limb and decrease in RoM of the distal limb was observed. This shows the compensation associated with that task. It is possible that the lifting task did not show compensation because it is a load supporting task and does not require dexterous movement, therefore there is no need for compensation.

Conclusions: The addition of a brace to the upper limb significantly restricts the range of motion of the distal limb. Persons with limited motion in their distal limb will compensate for that restriction by increasing the motion of their proximal joints. This knowledge can be used to design devices and therapies that utilize safe compensations while limiting compensations that are likely to result in overuse injuries.

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