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The Effect of Hologram Distance/Size on Shoulder Stress during Augmented Reality Interactions

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Abstract: The objective of this study was to evaluate and compare the biomechanical stress in the shoulder by different hologram distances/sizes during standardized augmented reality (AR) interactions. Twenty participants (10 males) performed a 3-D cube placement task with three hologram distances (0.3, 0.6, and 0.9 meters from the participant) and a web-browsing task with three hologram sizes (small [30% smaller than default], medium [1.0 X 1.1 meters], and large [30% larger than medium]). The 3-D cube placement task involved gaze, pinching, and dragging gestures to choose, move, and place cubes in 27 locations in 3-D space (3 X 3 X 3). The web-browsing task involved gazing, tapping, pinching, and scrolling gestures to navigate provided websites to find answers to a series of questions. During these two AR tasks, shoulder postures (flexion and abduction angles), muscle activities (upper trapezius, anterior and middle deltoid), and task performance (speed) were measured. During the 3-D cube placement task, the holograms presented at the far distance (0.9 meter) showed the highest shoulder flexion (46°) and abduction (41°), middle deltoid muscle activity (14% of the maximum voluntary contractions), and the longest completion time (p's < 0.001). For the web-browsing task, the large hologram size showed the best task performance (p = 0.001) whereas the hologram size did not affect the shoulder posture and muscle activity (p's > 0.15). Given the significant effects of hologram distance and size on the shoulder posture and muscle activity, the hologram placement (locations) and sizes appear to be important factors to mitigate potential shoulder stresses during AR interactions.

Keywords: Electromyography; Computer human interaction; Interface design; Shoulder postures

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