Proprioceptive Measures of Active Glenohumeral Movements

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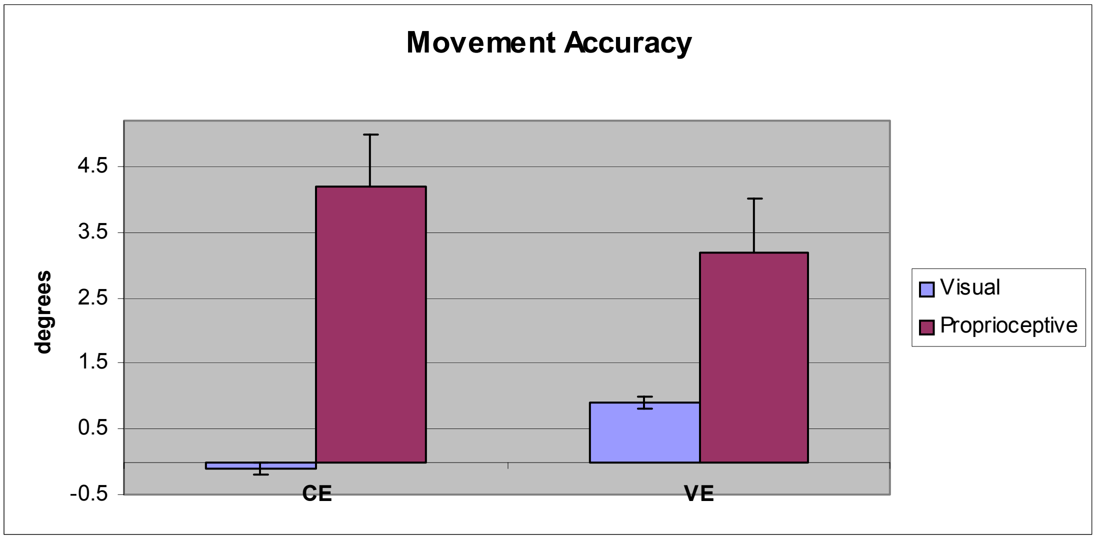
Introduction: Studies of shoulder kinesthesia (conscious awareness of limb position) have evaluated the ability to detect motion or to replicate position. Kinesthesia is believed to be an important component for human function. Previous shoulder kinesthesia studies usually incorporate passive movements and are generally performed at slow velocities, neglecting the afferent aspect of the proprioceptive feedback arc. These shoulder kinesthetic studies tend to measure only the mean or constant error (CE) of the distal segment with respect to the target position. CE is based on deviations from the target where the sign (+/-) associated with this measure can indicate a bias to over or under-shoot the target. Variable error (VE) is the measure of variance associated with each subjects' performance and believed to be a better indicator of proprioceptive acuity. The purpose of this study is to establish normal proprioceptive acuity that includes kinesthesia and active movements performed at functional speeds using measures of CE and VE.

Statement of Clinical Significance: Upper extremity movements use visual feedback in order to generate accurate goal directed movements. There are however instances when vision is obscured and emphasis is placed on proprioceptive feedback. Large measures VE and CE could indicate specific proprioceptive deficits may represent different movement characteristics. Deficits of CE represent internal bias and could suggest adaptive measures, while deficits of VE could be over come with proper therapeutic strategies.

Methodology: Twenty healthy subjects were seated and performed an active repositioning task of their dominant upper extremity. Subjects were seated with their upper extremity positioned in the "plane of the scapula", abducted 90^{o} and externally rotated 75^{o} while enchased in a shoulder wheel apparatus. Subjects were instructed to internally rotate the shoulder wheel apparatus 27^{o} at three different speeds with either visual feedback from a video monitor or from kinesthetic memory following passive positioning of the apparatus to the target position. Kinesthetic movements are referred to as the proprioceptive condition because of the afferent and efferent nature of the movement. High-speed motion analysis cameras detected retro-reflective markers on the shoulder wheel apparatus recorded kinematics of movements and terminal position. Subjects performed eight trials at the three different speeds for both the visual feedback and proprioceptive feedback condition. Both CE and VE were calculated from all eight trials for each movement condition. Repeated measures ANOVA (α=0.05) was performed on both CE and VE, with post-hoc pair-wise comparisons and a Bonferroni correction to α in order to compare differences among the three movement speeds.

Results: There was a significant difference ($F_{(1,19)}$= 29.3, $p<0.01$) between the CE of the movements with visual feedback compared to movements without visual feedback, or proprioceptive movements . There was also a significant difference ($F_{(1,19)}$= 129.1, $p<0.01$)

between VE for the movements with visual feedback compared to proprioceptive movements. While there was a trend for decreased accuracy at faster movement speeds these differences were not significant.



Discussion: Typically, most shoulder joint repositioning studies report CE of 1-4^o, neglecting VE associated with slow passive movements. This study we compared CE and VE of movements with visual feedback to movements that stressed the proprioceptive feedback loop. CE was greater for proprioceptive movements suggesting CE might be a more sensitive measure of proprioceptive acuity. However visual feedback significantly reduced both bias (CE) and variability (VE) of the movements where VE was greater than CE. This indicates that VE is truly a more sensitive measure of movement acuity. We believe that VE is more sensitive measure of proprioceptive acuity; the performance in this task is represented by the fact that subjects "over-shot" the target by 4^o(CE), with a total variability of 3^o(VE).

There was also a trend for diminished accuracy at greater speeds that was not significant. This could imply that movement speeds might not be compromised as a strategy to overcome diminished proprioceptive feedback.

Some suggest that VE is most affected by learning whereas bias or CE will remain relatively unchanged after initial learning. Because these two scores can represent two different aspects of proprioceptive performance it is critical to measure both of these two performance outcomes when assessing movement accuracy.

References:

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