Effect of an Upper Limb Brace on Target Position Error and Movement Kinematics During Proprioceptive Tasks in Subjects with Multidirectional Shoulder Instability

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INTRODUCTION

The role of sensory feedback control mechanisms in providing and maintaining joint stability has become the focus of recent research interest, in particular with respect to the knee and injuries of the anterior cruciate ligament. Multidirectional shoulder instability (MDI) occurs atraumatically, has no known etiology and is frequently associated with bilateral symptoms and generalized ligamentous laxity. Individuals with MDI possess the following key clinical features: 1) the majority of symptoms are experienced in the midrange positions of glenohumeral motion and occur while performing activities of daily living and 2) upon physical examination, patients may demonstrate the ability to subluxate or dislocate anteriorly, posteriorly and inferiorly.

Studies of proprioception in subjects with shoulder instability are limited and can be categorized into those that used either passive or active joint repositioning tests to assess the degree of proprioceptive function. Proprioceptive deficiencies in the upper limb have been shown to cause major deficits in movement control along with increased movement variability and an inability to correct motion errors based on limb movement information. Several studies have also found that applying an elastic bandage or neoprene sleeve to the knee results in improved position sense awareness at that joint. In the case of MDI, neuromuscular feedback mechanisms may be particularly important given that symptoms occur in the midrange of glenohumeral motion where dynamic stability is most critical and in the absence of trauma to the passive anatomical restraint mechanisms.

With respect to the upper limb, a considerable amount of time and effort has been dedicated to investigating the kinematics of goal-directed reaching movements. Several studies have attempted to identify common or invariant characteristics in continuous goal-directed reaching and discovered that hand trajectories display smooth, bell-shaped velocity profiles. These profiles have been shown to be asymmetric, in that the ratio of acceleration time to deceleration time is skewed to the left for slower speed movements. The purpose of this study was to determine the effect of an elastic upper limb brace on target position accuracy and movement kinematics in MDI subjects and in controls with normal shoulders on three active, upper limb target repositioning tasks.

METHODS

Twelve test subjects (9 male, 3 female; average age = 27.0 ± 8.3 yrs.) with clinically diagnosed MDI and twelve control subjects (9 male, 3 female; average age = 26.3 ± 5.4 yrs.) with no clinical evidence of MDI, participated in the study. Exclusion criteria for subjects in both groups included mental incompetency and any prior musculoskeletal or neurological abnormality other than MDI. Control subjects had no prior history of shoulder specific injuries or surgery. Subjects were required to self-select a point in space with their hand (the starting position or target) and to move the upper limb in a specified manner so as to reproduce the target position ten times without visual feedback. Three different upper limb movements (overhead reaching, scapular plane pointing and a combination of shoulder abduction with external rotation) were performed while the subject was blindfolded. To assess whether the brace had an immediate effect on performance accuracy, subjects in both groups performed the three test movements with and without a brace. The brace was made of an extensible material (Dacron and Lycra).
and was measured to fit tightly on the chest and upper arm. All subjects were instructed to accurately reproduce the specified arm movement and initial self-selected target position with a consistent, self-selected movement speed. A 3D-motion analysis system tracked reflective markers placed at the shoulder, elbow, wrist and hand. To eliminate subjectivity in identifying the appropriate video field for the endpoint position of each repetition, marker position data were smoothed with a zero-lag, 2nd order Butterworth low-pass digital filter at a cutoff frequency of six Hz. Reconstructed hand marker position coordinates were used to determine the three-dimensional radial target position error (TPE) for each movement repetition. Movement time (MT), peak velocity (PV), average acceleration (AA) and the ratio of acceleration time to deceleration time (AT/DT) were measured for the target phase of each movement cycle. Group mean values were compared using factorial analysis of variance (ANOVA) and post-hoc statistical tests were calculated with Schefié’s and Bonferroni/Dunn procedures.

**RESULTS AND DISCUSSION**

Mean TPE for MDI symptomatic and asymptomatic shoulders was significantly greater than for control shoulders (Fig. 1; p < 0.01). No significant differences in TPE were present between braced and non-braced trials for either group (Fig. 2).

![Figure 1. Control vs. MDI mean TPE (mm) by movement. *, ** & + = signif. at p < 0.01. Error bars = 95% confidence interval.](image1)

![Figure 2. Braced vs. non-braced mean TPE (mm) by group. No significant differences. Error bars = 95% confidence interval.](image2)

Significant interaction effects (p < 0.05) between subject group and brace factors were found for MT, PV and AT/DT (Fig.’s 3 & 4; for AA p = 0.06). The brace increased MT while decreasing PV and AT/DT for the control group but decreased MT and increased PV and AT/DT for the MDI group. Although subject type determined the effect of the brace on movement performance for all three tasks, there was no subsequent effect on target position accuracy for either group. Wearing the brace appears to give MDI subjects the ability to perform tasks in a manner more similar to controls in the non-braced condition. A deficiency in proprioceptive feedback control could account for higher TPE in the MDI group and the conflicting effect of the brace. If increased TPE is related to deficient proprioception, changes in movement kinematics may occur as a consequence of altered cutaneous feedback resulting from compressive contact with the brace.
Future research should attempt to determine further the effects of upper limb elastic brace supports on joint specific kinematics and total limb joint kinetics in subjects with stable and unstable shoulders during a variety of goal-directed reaching tasks.

REFERENCES


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