The clinical assessment of shoulder joint-position sense with interactive data analysis

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AIMS

The primary objective of this study was to evaluate the clinical feasibility of measuring shoulder proprioception in a busy musculoskeletal clinic setting. Secondary aims were to present the results in an clear, interactive format appropriate for patient involvement and to establish normal values for shoulder joint-position sense.

INTRODUCTION

Proprioception has been described as a sixth sense, formed by the integration of sensory input about joint position, muscle tension and the orientation of the body in space. The three distinct elements of proprioception are joint position sense (JPS), awareness of force application and kinaesthesia. These neural impulses originate in mecanoreceptors within joint capsules, ligaments, muscles, tendons and skin. Proprioceptive pathways combine in the CNS, undergoing integration with information from other branches of the nervous system. Proprioception is vital for co-ordinated movement patterns and functional stability throughout the human body.

Abnormalities in proprioceptive feedback loops have been implicated in shoulder pathology and its management. Despite much academic interest, the clinical assessment of shoulder proprioception remains rare. One reason for this is practicality. In the laboratory setting, electromagnetic tracking and isokinetic dynamometry have provided elegant, yet complex solutions to proprioceptive assessment. Unfortunately, these methods are poorly suited to the time and resource-limited environment of a busy musculoskeletal clinic.

Balke et al. reported a clinically feasible alternative JPS assessment method: the laser pointer assisted angle-reproduction test (LP-ART). This method, which requires a calibrated laser and a target, was found practical and effective for use in clinic. However, the authors of this study described problems mounting a suitable laser pointer. A further challenge to the assessing clinician is presenting test results in a clinically useful format.

The present study proposes a revised LP-ART, with hardware fixes and introduces a novel, interactive data presentation and analysis format suitable for use in busy orthopaedic and physiotherapy clinics.

MATERIALS AND METHODS

Subjects

A convenience sample of 30 healthy volunteers; 15 males and 15 females aged 20-50 years (mean age 30.2, SD 5.47), participated in this study. Subjects were recruited from waiting rooms in a busy orthopaedic and physiotherapy clinic. Exclusion criteria were based on factors known to affect JPS (table 1). Subjects received both verbal and written instructions prior to the testing procedures. Informal, written consent was obtained prior to data collection in all cases.

Testing Apparatus

A target board system was constructed, consisting of 3 individual targets, numbered 1-3, on a millimetre grid lined made from 3 sheets of size A3 graph paper (fig. 1). The board was vertically mobile, with target 2 located at mid-glenohumeral joint level for each subject. With subject standing, 1m from the target, this provided shoulder elevation measurements of 55°, 90° and 125°. A co-ordinate system based upon the millimetre grid was used to measure the error of each attempt.

RESULTS

Interactive results plots were made available to subjects via an email link, which included their subject number. This allowed volunteers to compare their JPS results to that of other subjects. Interactive results for all subjects are available to view here: http://extuitive.co.uk/shoulderResearchResultsPlot/

DISCUSSION

This study aimed to assess the viability of the LP-ART as a measure of shoulder JPS in clinical practice. All subjects followed the instructions in detail and completed the testing procedure within 10 minutes. While the interactive scatterplots showed significant subject-to-subject variance (green ellipses), the within-subject variance (blue ellipses) was less pronounced. This may have clinical significance, allowing clinicians to measure a single attempt at each target, rather than 3 separate attempts. This would separate and significantly improve the clinical utility of the LP-ART. This finding, however, may reflect the fact that subjects were healthy volunteers. Further research involving patients is required to clarify this. A weakness of the LP-ART is the size of the target, which requires a large, flat wall and is awkward to move up and down between subjects.

Subjects engaged readily with the interactive scatterplots, which can be viewed on a modern smartphone. This novel concept allowed greater involvement of subjects; a concept which could be extended to a patient population. Clear visual representation of proprioceptive deficits may improve patient understanding, a key factor in surgical consent and rehabilitation concordance. Future studies should investigate this format with patients, as this study was limited to a small sample of healthy volunteers. A weakness in this method was the time taken to enter co-ordinates from the digital photographs. This process would benefit from automation.

With many readers now accessing research articles electronically, interactive data analysis may also enhance scientific literature. Digital datasets allow an audience to explore trends in the data, rather than merely being recipients of the authors’ subject matter. In the case of this study, for example, the reader could choose to quickly compare the results of all left-handed to right-handed subjects by simply using the drop-down menu.

This study provides JPS values for the LP-ART in healthy individuals. Consistent with the findings of previous studies, table 2 demonstrates improved proprioceptive accuracy with increasing capsuloligamentous tension towards the upper degrees of shoulder elevation. Abduction attempts (fig. 6) also show a clear tendency for subjects to drift anteriorly at all targets. A weakness of this study, and the LP-ART in general, is the failure to collect data on medial and lateral shoulder rotation. This is particularly relevant when examining patients with shoulder instability.

REFERENCES

LP-ART provides a solution to measuring JPS in musculoskeletal clinics, although future modifications may be of benefit. Interactive data presentation allows greater subject involvement and may improve future scientific literature.

JPS improves with shoulder elevation in healthy subjects.

Table 1: All Subjects - flexion

<table>
<thead>
<tr>
<th>Target</th>
<th>Flexion</th>
<th>Abduction</th>
<th>Flexion</th>
<th>Abduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (125°)</td>
<td>2.3</td>
<td>2.8</td>
<td>2.1</td>
<td>2.6</td>
</tr>
<tr>
<td>2 (90°)</td>
<td>2.6</td>
<td>4.1</td>
<td>1.5</td>
<td>2.2</td>
</tr>
<tr>
<td>2 (55°)</td>
<td>2.7</td>
<td>2.7</td>
<td>2.6</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Positive values in elevation error result from pointing above the related target. Negative values occur from pointing below.

ACKNOWLEDGEMENTS

Mr T. Orthopaedic dept, St George’s University Hospitals NHS FT. Dr. John Welford PhD

Table 2: All Subjects - abduction error

<table>
<thead>
<tr>
<th>Target</th>
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<td>2 (55°)</td>
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<td>2.2</td>
<td>1.8</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Positive values in abduction error result from pointing posterior to the related target. Negative values occur from pointing anterior.