Validation of a computer tablet software for quantification of scapular motion during clinical assessment of scapular dyskinesis

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Scapular dyskinesis

- The alterations in the position of the scapula and the dysfunctional pattern of scapular motion in relation to the posterior thoracic wall during the movements of the upper limb are called “scapular dyskinesis”.

  Kibler et al 2010, 2013

- These alterations produce an abnormal scapular **medial border and / or inferior angle prominence relative to the thoracic cage (winging)** or **dysrhythmia**. The altered kinematics may include a combination of excessive protraction, and/or anterior tilt, and/or internal rotation, and/or downward rotation.

  McClure et al 2009, Kibler and Sciascia 2016

- Scapular dyskinesis has been reported in 68% to 100% of individuals with shoulder disorders, including glenohumeral instability, rotator cuff disorders, and labral tears.


- Consequently, early and accurate recognition of the presence of scapula's dyskinesis contribute to address not only the symptoms of shoulder disease but also the etiology.
Scapular dyskinesis test

- Scapular dyskinesis is currently assessed with subjective visual observation of the scapular motion during elevation and lowering of the arms, the so called “scapular dyskinesis test”.

- Prominence of any part of the medial border is qualitatively recorded in a “yes” (dyskinesis present) or “no” (dyskinesis not present) manner. 

  McClure et al 2009

- Disadvantage of the scapular dyskinesis test is the qualitative assessment of dyskinesis.

- Dyskinesis may have varying degrees; severe, moderate or mild.

- The quantitative measurement of scapular motion would improve the accuracy of assessment of the existence and grade of scapular dyskinesis in the diagnostic process.
Purpose of the present study is to establish an objective and easily applicable method that will allow clinicians to quantitatively assess scapular motion during the clinical examination for scapular dyskinesis using a computer tablet software.

Specifically, we aim to validate an existed video analysis software (PIVOT™, Impellia, Pittsburgh, PA, USA) for use in scapular dyskinesis evaluation. This method has been successfully applied for the measurement of rotating motion on the knee joint, during the pivot-shift test.

Hypothesis is that the inferior angle of the dyskinetic scapulae present greater winging motion – deviation from the thoracic wall – compared to the non-dyskinetic ones and that the software will be able to record those differences.

Hoshino et al 2012
Materials and Methods

**Study group**
Patients suffering from unilateral shoulder or back pain associated with dyskinesis

All participants: 18 - 50 years old

**Control group**
Healthy controls without any symptoms around the shoulder and the scapula region

Following clinical evaluation, the scapulae of all participants were divided into three groups

**Group A:**
Dyskinetic scapulae with symptoms

**Group B:**
Contralateral non-dyskinetic scapulae without symptoms

**Group C:**
Healthy controls - no dyskinesis or symptoms
The principal investigator initially evaluated and recruited the patients in the groups.

The scapular dyskinesis test was applied in individuals of both groups.

A second investigator (AG), certified orthopaedic surgeon, separately assessed both groups with the same test and recorded his judgement.

According to the clinical findings of both investigators, the following cases were excluded:

a) discrepancy between the two observers
b) study group patients with bilateral dyskinesis
c) control group individuals with dyskinesis in any scapula
The markers placement and the orientation of the i-pad were adjusted following trials.

First static marker (S1) → T2 spinous process (landmark: the palpable A7)

Second static marker (S2) → on the same transverse plane and 80mm lateral to S1

Mobile marker (M1) → with its lateral margin beside the medial border of the inferior angle of the scapula

i-pad
- locked in landscape mode
- left shoulder → rotated 90° clockwise
- right shoulder → rotated 90° counter-clockwise
- about one meter away from the patient, in the height of the scapular spine, perpendicular to the ground level

As for the cephalo-caudal direction, the M1 marker was placed at the site of the thumb that was touching the medial border. In the medio-lateral direction, the marker was located with its lateral margin just beside the scapula medial border.
Active forward flexion of the arms 120° while inhaling, using the thumbs-up position.

Pause for a second.

Arms lowering over a three-second count, while exhaling, with shoulders relaxed.

The stickers were tracked throughout only the phase of lowering.

According to the movement pattern of the medial border of the scapula inferior angle, the center of the mobile marker (M1) is translated towards the midline more or less.

The application demonstrates the mediolateral translation of the M1 projected to the S1-S2 line on a graph and extracts the height of the curve to a value.

5 repetitions - the mean value was used for data analysis.
88 scapulae were initially included in the study (28 men and 16 women)

12 participants were excluded because they did not fulfil the exclusion criteria

Diagnosis in Group A: 13 scapular elevator muscle spasm, 9 supraspinatus tendinopathy, 2 rhomboid muscle spasm, 1 SLAP lesion

<table>
<thead>
<tr>
<th>Table 1. Patients’ demographics.</th>
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<td>Group size (scapulae)</td>
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<tr>
<td>Gender</td>
</tr>
<tr>
<td>Mean age (SD)</td>
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<tr>
<td>Mean weight, kg (SD)</td>
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<tr>
<td>Mean height, m (SD)</td>
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<td>Mean BMI (SD)</td>
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Results

Pivot App

- Significantly greater motion in the dyskinetic scapulae group (A), relative to the contralateral non-dyskinetic scapulae group (B) \((p<0.01, \text{ Wilcoxon signed ranks test})\) and the healthy control group (C) \((p<0.01, \text{ Mann-Whitney U test})\).

- No significant difference was noted between Groups B and C \((p=0.08, \text{ Mann-Whitney U test})\).

- A significant positive correlation of scapula motion with weight and height \((p\leq0.01, \text{ Spearman’s rho test})\) was found.

- The correlation of the motion with the BMI was not significant \((p=0.08, \text{ Kendall’s tau test})\).

Table 2. Comparisons between Group A (dyskinetic) and Group B (contralateral healthy) mean scapular motion.

<table>
<thead>
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<th>Group A</th>
<th>Group B</th>
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<tbody>
<tr>
<td>All scapulae mean motion</td>
<td>24.6 ± 7.3</td>
<td>14.7 ± 4.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Men subgroup mean motion</td>
<td>26.9 ± 6.2</td>
<td>15.9 ± 5.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Women subgroup mean motion</td>
<td>19.8 ± 7.3</td>
<td>12.1 ± 1.9</td>
<td>0.01</td>
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</table>

All values are mean ± SD and in millimetres. The comparisons were assessed with Wilcoxon signed ranks test.

Table 3. Comparisons between Group A (dyskinetic) and Group C (healthy control) mean scapular motion.

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</tr>
<tr>
<td>Women subgroup mean motion</td>
<td>19.8 ± 7.3</td>
<td>7.7 ± 3.6</td>
<td>0.01</td>
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</table>

All values are in mean ± SD and in millimetres. The comparisons were assessed with Mann-Whitney U test.
The clinical assessment of the patients was achieved using the scapula dyskinesis test which has a moderate inter-rater agreement (79%), sensitivity (76%), and positive predictive value (74%) (Uhl et al 2009). In the present study, two orthopaedic surgeons evaluated the patients during five repetitions of active arm elevation and lowering, which is the best-case scenario to enhance the validity and reliability of the clinical examination. In case of discrepancy, the patient was excluded for improving the accuracy of the results.

Another limitation is the correlation of the scapular motion with the body habitus of the patients. According to the literature, BMI may affect the clinical methods for the diagnosis of dyskinesis (Uhl et al 2009). Moreover, dyskinesis is less common in obese patients, although not significantly, which can render the results skewed towards the low-BMI population (Oliveira et al. 2018, Preziosi et al. 2018). In our cohort, as well, dyskinesis was less common in patients with a higher BMI. Regarding the software measurements, in all observations (both healthy and dyskinetic scapulae), it seems that heavier and taller people (but not higher BMI) present a greater amount of scapula motion. We tried to reduce the error of the skin-based technique by restricting the arms range of motion below 120° (Karduna et al 2001).

A bias could emerge from the fact that different neuromuscular patterns may alter the contralateral healthy shoulders in individuals with scapular dyskinesis. To eliminate this bias, we included a healthy control group. The significant differences between dyskinetic scapulae and both the contralateral healthy shoulders group and the healthy control group, confirm the validity of the video analysis method.
The hypothesis of the study was confirmed. The inferior angle of the dyskinetic scapulae present significantly greater deviation from the thoracic wall (winging) during arms lowering compared to the non-dyskinetic ones.

The PIVOT image-based analysis software recorded the amount of this scapula movement and thus it was validated to provide quantitative data of scapula motion supplemental to clinical examination for scapular dyskinesis.

Due to the simplicity of this method, not only orthopaedic surgeons but also physical therapists and athletic trainers may use Pivot App to assess scapula motion in overhead athletes during the pre-participation examination. Following prescription of an exercise program, they may test the athletes again.

Following validation of this system, further observations are necessary to optimize the software for the scapula, define which amount of captured motion is clinically significant and find out whether the test is helpful to monitor dyskinesis treatment.

Conclusions

References