Author's response to reviews

Title: The reliability of three-dimensional scapular attitudes in healthy people and people with shoulder impingement syndrome.

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Author's response to reviews: see over
Dear Doctor Saltman:

Please find the revised version of the manuscript entitled: “The reliability of three-dimensional scapular attitudes in healthy people and people with shoulder impingement syndrome” (MS: 1129382421124100). We would like to thank the reviewers for the time and energy they put in the review process of the first version of this article. We would also like to thank BMC Musculoskeletal Disorders for giving us the opportunity to comment on the recommendations and concerns of the reviewers.

The most important changes brought to the manuscript were made following the comments of Dr. P. Ludewig. In the comment number 1, under the Major Compulsory Revisions part of her report, she brought a concern on the coordinate system used to calculate the 3D scapular attitudes. She proposed that we should follow the ISB recommendation in order to generalize the results. We decided to follow her recommendation and to calculate the 3DSA in accordance with the ISB recommendations. This modification implies changes in the method, results, discussion, as well as in the tables and figures.

The next pages respond, point-by-point, to the comments and concerns raised by the three reviewers.

Sincerely yours,

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Reviewer: Joseph B Myers

1. Abstract Methods:
   To be consistent with the ISB recommendation, the terms flexion and abduction were replaced by the terms humerothoracic flexion and humerothoracic abduction, respectively (see point 5 below).

2. Abstract Results:
   The range of ICC and SEM were included. The text now reads:
   “…good to very good between sessions (ICCs from 0.62 to 0.97; SEM from 1.2° to 4.2°) when using the method of calculation relative to the trunk.”

3. Background, first element, first paragraph, second sentence:
   The term subacromial was inserted and it now reads:
   “Shoulder impairments, such as subacromial shoulder impingement syndrome (SIS), have been associated with abnormal movement of the scapula during elevation of the arm.”

In the Methods, subjects’ selection section, first paragraph (first sentence), the term primary subacromial was added and the new text is:
   “Fifteen healthy subjects and eight subjects with primary subacromial SIS voluntarily participated in the study.”

4. Background, second element:
   The reviewer might refer to Borstad JD, Physical Therapy, 86(4), April 06, 549-57 in which only asymptomatic subjects were assessed. The Reference #3 (Borstad & Ludewig) is a study that compared scapular orientation during both the concentric (elevation) and eccentric (lowering) phases of scapular plane abduction in subjects with and without shoulder impingement. In the background of this study, the authors indicate that abnormal scapular kinematics has been identified in shoulder impingement patients during the concentric phase of arm elevation, and under static conditions, and because abnormal scapular motion is observed clinically during the eccentric phase of arm elevation, the analysis of this phase of motion is warranted. Therefore, they assessed 26 asymptomatic and 26 healthy subjects.

5. Methods, study design section:
   According to the ISB recommendation, for the motions of the humerus relative to the thorax (as measured in our study), when the plane of elevation is 0°, it refers to abduction, and when the plane of elevation is 90°, it refers to forward flexion (Wu G et al. 2005)
   So the terms flexion and abduction for humerothoracic movements are correctly used.

   The term humerothoracic has been added before flexion and abduction:
   “At each session, both shoulders were evaluated in three static positions: arm at rest, shoulder at 70° of humerothoracic flexion (in the sagittal plane), and shoulder at 90° of humerothoracic abduction (in the frontal plane).”
6. Methods, Measurements, first element:

The selection of the sites of the body landmarks digitized was standardized according to the ISB recommendations as followed (see changes in the methods, measurement section, first paragraph):

The posterolateral tip of the acromion: *acromial angle, most laterodorsal point of the scapula.*

The tip of the inferior angle: *inferior angle, most caudal point of the scapula.*

The inferior edge of the spine of the scapula: *root of the spine, the midpoint of the triangular surface on the medial border of the scapula in line with the scapular spine.*

The Medial epicondyle: *Most caudal point on medial epicondyle of the humerus.*

The lateral epicondyles: *Most caudal point on lateral epicondyle of the humerus.*

7. Methods, Measurements, second element:

A photo (Figure 1) has been added to illustrate the methods.

Details were also added in the measurement section (first paragraph):

“For each trial, nine body landmarks were digitized using the Optotrak probing accessory (Figure 1). This probing accessory is attached to a rectangular rigid body incorporating six infrared transmitters used to define the coordinates of the tip of the probe, and therefore the coordinates of any point in contact with it [8]. The landmarks probed by the evaluator were, in this order...”

8. Methods, Measurements, third element:

In accordance with one of the reviewers’ comments, we have made a decision to change our calculation method of 3DSA to follow the ISB recommendations (Please see the comment number 1 provided to Dr Ludewig, under Major Compulsory Revisions). The sentence you are referring to (*The difference observed was less than 3.5° between the two systems for all scapular rotations, except for L-MR, where the differences were more than 45°*) was therefore deleted.

9. Data analysis:

The ICC model used was the (1,1) for intrasession reliability and the (1,k) model for intersession measurements. The following precision was added:

“The intra and intersession reliability was estimated by calculating the intraclass correlation coefficients (ICCs) and its 95% confidence interval (using SPSS 12.0; Reliability; Intraclass correlation coefficient).”

10. Results:

We added a Table to show the intrasession SEM. We considered that adding two tables to present both the intra- and intersession ICCs would not have given an added value to the manuscript and we believe that presenting the ICCs by graphs provides a better global picture of the results of our study. Moreover, presenting in Tables the SEMs is probably more clinically relevant for the readers.
Reviewer: Paula M Ludewig

Major Compulsory Revisions

1. We thank Dr Ludewig for her comment and we finally decided to follow her suggestion to calculate the 3DSA in accordance with the ISB recommendations. Therefore, the axes alignments and sequence of rotations were changed accordingly. These modifications imply changes in the method (measurement section, fourth paragraph), results (in all paragraphs), discussion (in the first, third, fourth and the fifth paragraphs), as well as in the tables (2, 3 and 4) and figures (2, 3, 4 and 5). We made this decision to allow a better comparison of our results with other studies.

2. For healthy subjects, although we agree with the reviewer that measuring 30 shoulders on 30 different subjects would have been ideal, we have considered sides as independent observations for two reasons. First, we wanted to have a good representation of the left and right shoulders, since the difficulty for the evaluator was different depending on the side evaluated: and retrospectively, we are even more convinced that assessing the right and the left sides does not represent the same challenge because of the differences in the subjects and evaluator positioning. Secondly, no indication, sign, mark, sticker or what so ever was kept from the first side assessed that could help or guide the evaluation of the second shoulder. The inter-shoulder variability is probably lowered since 15 subjects/30 shoulders were analysed. To take into account the reviewer’s comment, a sentence was added in the last paragraph of the discussion to address this issue.

   However, as suggested by Dr Ludewig, for the SIS subjects, results of both sides have been analysed separately. The comment of Dr Ludewig was relevant since the repeatability could have been different with the presence of impairment. See the changes made in the methods (data analysis section, first paragraph), results (fourth paragraph), and discussion (third and fifth paragraphs).

Concerning the number of subjects: the goal of the study was to evaluate the reliability of this method on normal-asymptomatic subjects. In addition to that primary goal, as part of a master degree experiment, the reliability of this method was also explored in people with SIS. Since the reliability results for subjects with SIS were available, we taught it would be of interest for the readers to see these results. The results with subjects with impingement support the idea that the method used with asymptomatic subjects can also be used with SIS. We have modified the wording of the objective to reflect the explorative nature of the reliability results for the subjects with SIS (abstract, background section; background, fourth paragraph) as following stated in the abstract:

   “The objective of this study is to evaluate the intra and intersession reliability of 3-dimensional scapular attitudes measured at different arm positions in healthy people and to explore the same measurement properties in people with shoulder impingement syndrome using the Optotrak Probing System.”

3. As suggested, the 95%CI was calculated for all ICCs and SEM. These results are reported in Tables 2 and 3 and in Figures 3, 4 and 5. In the manuscript (results section in the abstract; first, second and fourth paragraph of the results and in the third, fourth, fifth and seventh
paragraphs of the discussion), changes have been made in accordance with the new data presented.

4. As a result of the modifications previously mentioned, the lowest ICC is now 0.62, which is considered a good reliability. However, for some intersession reliability, the 95%CI is quite large and the lower bound relatively low. Therefore, a sentence was added to the first paragraph of the discussion to comment this wide 95%CI.

5. Following the recalculation of the angular positioning of the scapula, the calculation of the 95%CI and the suggestions of Dr Ludewig, changes were made in the third paragraph of the discussion. Other explanations were also added to the text to explain the differences.

Minor Essential Revisions

1. The requested information has been added as follow (abstract; results section):
   “…good to very good between sessions (ICCs from 0.62 to 0.97; SEM from 1.2° to 4.2°) when using the method of calculation relative to the trunk.”

2. The sentence referring to the superior reliability for the subjects with SIS has been deleted. The new sentence now reads (abstract; results section):
   “Higher levels of intersession reliability were found for the method of calculation relative to the trunk in A-PT at 70° of flexion compared to the method of calculation relative to the scapula at rest.”

3. Changes were done. A new paragraph was added in the background to clarify the terminology (background, second paragraph):
   “Scapular movements during elevation of the arm are the result of three scapular rotations. According to the International Society of Biomechanics (ISB) recommendations [7], the three scapular rotations are defined as: lateral/medial rotation (L-MR) (also called upward/downward rotation or external/internal rotation), anterior/posterior tilting (A-PT) (also called posterior/anterior tilting [8]), and protraction/retraction (PRO-RET) (also called external/internal rotation or anterior/posterior transverse rotation).”

4. The article we are specifically referring to (McClure PW et al. 2001; p.275, Table: Scapular rotations measured by various authors) compares results from different studies.

5. Thank you, as suggested, a sentence was added (background, third paragraph):
   “These differences across studies support the ISB recommendation to adopt standards for joint coordinate systems to allow a better comparison between studies.”

6. Clarifications were added in the last paragraph of the background as follow:
   “Scapular attitude measurements calculated with this method were found accurate and showed a good concurrent validity with a mean difference between the Optotrak probing system method and fixed infrared markers of only 1.7° on an anatomical model (the markers are a measurement standard provided by Northern Digital that were attached on the model).”

If the editor considers that more details are required, the following information may clarify the method used:
“The fixed infrared markers, along with the software package used with the Optotrak system, were a measurement standard by Northern Digital. The infrared markers were attached to the three noncolinear landmarks of the scapula on an anatomical model of the scapula, to which angular displacements were imposed. After each imposed angular displacement, the 3D positions of the three landmarks of the scapula were successively recorded, first using the probe and second the fixed markers.”


We agree with the reviewer about the importance to highlight the justification of the choice of only three positions. We think that the results reported in this abstract, and summarised in the Methods (first paragraph of the study design section), justify the selection of these three positions.

We believe that the lack of known generalizability to the other shoulder positions or motions is implicit throughout the manuscript. Indeed, in the original version, this information was provided throughout the manuscript by presenting the results by position. Upfront, precisions that only three positions were evaluated were added in the conclusion section of the abstract. Precisions were also added in the first paragraph of the discussion and in the conclusion.

8. The examiner was not blinded to group status, but was blinded to the past values when retesting. Also, since during the session, the evaluator is probing a series of landmark, it is not possible for him to know about the scapular displacement as the final outcome (3DSA) involves a calculation that is done afterward. Regarding the blinded status, a sentence was added in the first paragraph of the Study design section, which reads as follow:

“A test-retest design was used. Participants were involved in two measurement sessions one week apart (mean 6.3 ± 0.9 days) with the same protocol repeated by the same evaluator. The evaluator was not blinded to group status. However, he was blinded to the past values obtained in the first session when retesting during the second session.”

9. The insertion of the deltoid was digitized for the mid-upper arm (clarification added in the paper). The body landmarks of the arm were used to verify posture variation between trials and sessions by comparing to position of the arm relative to the trunk. Also, the three landmarks on the arm were digitized to measure the humerothoracic elevation range of motion. However, since these measures were not used in this reliability study, this sentence was deleted.

10. The scapular landmarks were re-palpated in each position and different stickers were used for each elevation position. A sentence was added in the first paragraph of measurements: “Within a session, different stickers were used for each elevation position. The stickers were kept in place for the trials in the corresponding elevation position to allow the examiner to quickly locate each body landmark.”
The flexible template was also locked in the position once the landmarks were found at the beginning of the first session. A clarification was added (methods, measurement section, second paragraph)

11. Figures 3 and 4 and Table 2 have been changed to clearly show the effect of the number of trials on reliability (both ICC and SEM), and the second paragraph of the results was also modified. The same level of reliability refers to the fact that the ICC and SEM values were in the same range. The addition of the 95%CI supports this result.

   The term «same» was changed for «similar»:
   “Only two trials in each position were recorded since the level of reliability was similar whether two or three trials were used (see results).”

12. This figure has been changed.

13. Other limitations were added to the list in the last paragraph of the discussion:
   “One of the limits of the current proposed method is that 3DSA were measured in static positions. Thus, this method does not allow one to characterize dynamic changes in scapular attitudes from one position to another one. Also, the present results cannot be generalized to other shoulder positions since the method has only been tested in three arm positions. In addition to the variation in individual performance, other factors may explain the measurement errors found in the study. These other factors are related to the evaluator, the instruments and the measurement technique, including locating the landmarks, measuring arm position in elevation and manipulating the probe. A limited number of subjects was included in the group with SIS. This could explain the large variations in the 95%CI obtained for some rotations in this group. Finally, the use of the left and right shoulders of the healthy subjects as independent observations for the reliability could have lowered the between shoulder variability, thus influencing the ICCs and the SEM.”
Reviewer: Heiko Graichen

General aspect
1. One of the comments formulated by this reviewer is that the technique used in our study suffers from the same problems as other marker analysis (soft tissue movement, marker fixation). However, our technique is a palpation-based technique, so no markers were used, and soft tissue movement is not an issue. The advantage of using a palpation-based technique as we did is that the bony landmarks are palpated in each trial.

2. We do not understand the comment regarding the fact that no clinically relevant data for the patients with impingement syndrome was presented. The goal of this study was to evaluate the reliability of a palpation-based technique. It is an essential step before using this technique to quantify scapula attitude.

Specific comments
1. Abstract:
   - The first comment concerned the addition of the position description of the transducers and the fixation in the abstract. However, since this is a palpation-based method, no transducers or fixation were used.
   - The second comment was about the clarification of the statement that reliability was good to very good in the results section of the abstract. The ICCs and the SEM were added in the abstract and it now reads: “…good to very good between sessions (ICC from 0.62 to 0.97; SEM from 1.2° to 4.2°) when using the method of calculation relative to the trunk.”

2. Background:
   The reviewer stated that there are MR based techniques that should have been referred to in the background. Studies using optoelectric and electromagnetic system were mainly targeted in the background since our technique is more related to this kind of measurement making more relevant for the reader to specifically refer to this type of studies.

3. Methods:
   - Comment about the number of subjects: Please see the comment number 2 provided to Dr Ludewig, under Major Compulsory Revisions.
   - The reviewer stated that the inclusion criteria were very unspecific and that a lot of different pathologies can lead to a clinical impingement. This is a surprising comment as the criteria we used were very operational (i.e. reproducible) and detailed enough and they have been previously used in numerous studies dealing with the same population. An experienced shoulder orthopedic surgeon also has evaluated all our subjects to eliminate those not responding to our inclusion-exclusion criteria. All the subjects had an X-ray performed on their shoulder to eliminate calcification, fracture, and type III acromion. Furthermore, if a rotator cuff tear was suspected, an ultrasound examination of the rotator cuff was performed by a radiologist. A previous study has shown that ultrasound...
examination is as specific as MRI for shoulder diagnoses (Dinnes J, Loveman E, McIntyre L, Waugh N. *The effectiveness of diagnostic tests for the assessment of shoulder pain due to soft tissue disorders: a systematic review. Health Technol. Assess.* 2003).

The following sentence was added to the text to clarify the use of ultrasound when necessary:

"When a rotator cuff tear was suspected, an ultrasound examination of the rotator cuff was performed by a radiologist."

- Comment about the clarification of the rotation angle of the different arm positions: the arm was at 0° of rotation. A clarification was added to the text:

  "The glenohumeral joint was in a neutral position of axial rotation."

- Comment on why those positions have been chosen and no other more relevant ones: This was clearly explained and stated in the first paragraph of the study design. These positions were specifically chosen because of their clinical relevance based on a previous study. In this previous study, it was shown that torque deficits in shoulder abduction and lateral rotation, pain intensity during maximum voluntary contraction, the presence of a painful arc in abduction, and a posterior scapular tilting asymmetry at 70° of flexion and 90° of abduction, in addition to age and gender, explain a large proportion \( (R^2 = 91\%) \) of the level of pain and disability of persons with SIS (Hébert et al., 2003). This explanation is provided in the first paragraph of the study design section:

  "The specific elevation positions were chosen because it has been shown that a reduced posterior tilting at 70° of flexion and 90° of abduction, along with five other variables, could explain as much as 91% of the variance of the pain and disability level experienced by people with SIS."

- Comment about the addition of a sketch of the set-up that would help understand the technique more clearly: A photo (Figure 1) has been added to illustrate the methods.

- Comment about the large differences of L-MR rotations: In accordance with one of the reviewers’ comments, we have made a decision to change our calculation method of 3DSA to follow the ISB recommendations (Please see the comment number 1 provided to Dr Ludewig, under Major Compulsory Revisions). The sentence you are referring to (The difference observed was less than 3.5° between the two systems for all scapular rotations, except for L-MR, where the differences were more than 45°) was therefore deleted.

- Comment on the problematic to include both shoulders of the same patient: This comment has been already answered to. Please see the comment number 2 provided to Dr Ludewig, under Major Compulsory Revisions.

4. Discussion:

- This reviewer believes that the error presented in terms of any other position than arm at rest is too high to provide valid information: We do not understand this comment and we do not think that our findings support the reviewer’s belief. As stated in the fifth
paragraph of the discussion, a reduced posterior tilting of the scapula during flexion or abduction is the typical perturbation seen in people with SIS. The 95%CI for the SEM found in our study for this movement with the arm in elevation in healthy subjects is 1.4 to 2.4° at 70° of flexion and 1.7 and 2.9° at 90° of abduction, which is quite low for this kind of measurement.

- The reviewer stated that the comparison of the mean to describe the deviations is not appropriate: we do not see any substantiation for not using the mean. We do not understand this comment and if the reviewer would like to elaborate his view, we would be pleased to answer.

- The reviewer comments that there are entities that are associated with alteration of scapular motion patterns; however, there are some that are not. According to the reviewer, those groups should be investigated separately. The reviewer should precise what exactly he means by entities and provides some references to support his comment. As far as we know, there is no valid and reliable golden test developed that could precisely evaluate the presence or absence of an alteration of scapular motion patterns. Kibler et al. have developed a clinical evaluation system for which the reliability was only fair (0.4) (Kibler et al, 2002).