Comparison of Chest Expansion Measurement in Clients with Ankylosing Spondylitis and Healthy Individuals

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Abstract. The purpose of this study was to compare chest expansion (CE) measurements in two arm positions of and between healthy subjects and subjects with ankylosing spondylitis (AS). Twenty-two subjects with AS with a mean age of 41.41 years and 25 healthy subjects with a mean age of 41.04 years were tested in two arm positions: hands on head, and arms at the sides. The tape measure was placed at the level of the xiphisternum. Each tester recorded three trials in both arm positions on two separate occasions which were 10 minutes apart. Results showed there was no significant difference in CE measurement between the two arm positions and between healthy subjects and subjects with AS. It was concluded, that CE may not be an appropriate measurement tool of chest wall or thoracic spine involvement in subjects with AS.

Key words: Ankylosing spondylitis, Chest expansion and Chest wall

INTRODUCTION

Ankylosing spondylitis (AS) is a chronic, systemic inflammatory rheumatic disease of unknown etiology1, 2) in which limitations of costovertebral joints and chest wall mobility decrease with progress of the disease3). In the past various monitoring and assessment tools measures have been used, including measurement of chest expansion (CE), vital capacity (VC), thoracolumbar flexibility and Schober’s test. These have also been utilized to evaluate the benefits of exercise. However, there has been no consensus as to which are the most useful measurement tools for efficacy, accuracy, sensitivity or reliability as outcome measures for AS4). At present CE is the accepted method for assessing the involvement of the chest wall, particularly costovertebral and costotransverse joints, in subjects with AS. Restriction of costovertebral and costotransverse joints has also been implicated as a contributing factor in reducing pulmonary function5).

Rigidity of the thoracic cage has been recognised as a characteristic feature of AS: CE of less than 2.5 cm has been accepted as one of the diagnostic criteria for AS6, 7). Considering the significance of CE as a diagnostic objective measure it is surprising that only one normative study performed to establish a normal range of values for CE is available2).

Physiotherapists, doctors and other health professionals commonly use CE measurement to assess the involvement of the chest wall, mainly involving the costovertebral and costotransverse joints, for diagnosis8) and monitoring disease progression9) as a part of routine assessment. Despite normative CE data, international agreement has resulted in the arbitrary line definition of 2.5 cm
as a borderline between normal and abnormal expansion\(^6\). In fact, a widely varying normal range of values, significantly affected by age, sex and disease other than AS, shows that attention should be paid to this arbitrary line regarding CE\(^10\). Although an arbitrary 2.5 cm CE is used in epidemiological definitions of AS, there is a possibility of false positive diagnosis of AS if no correlation is made for age and gender\(^11\). Due to a lack of sensitive diagnostic criteria and measurement tools there are often delays in diagnosis\(^4\).

However, there is no standardised method of measuring CE in various arm positions; in addition different landmarks have been used\(^5, 9, 12\). Commonly used arm positions are hands on head\(^2, 9, 13\) and arms at sides\(^12\). Commonly used landmarks are the xiphisternum\(^9, 12\) and the fourth intercostal space\(^3, 5\).

Chest expansion as a measurement tool for the management of AS requires further investigation in order to allow physiotherapists to make informed decisions about whether to use CE as a measurement tool in research or in clinical practice. This study aimed to extend and contribute to the body of knowledge for physiotherapists regarding the use of CE in the assessment and management of AS. The purpose of this study was twofold. Using subjects with AS and healthy subjects as a comparison,

1. to compare CE measurement between arm positions, and
2. to compare CE measurement between healthy subjects and subjects with AS.

**METHODS**

**Subjects**

Subjects were recruited from the metropolitan area of Perth, Western Australia. The 22 subjects with AS comprised 13 males and 9 females, with a mean age of 41.41 years (SD = 11.64; range = 22 to 61), mean, SD and range of disease duration of 12.91, 11.94 and 1 to 46 years respectively. The 25 healthy subjects (16 males and 9 females) had a mean age of 41.04 years (SD = 12.05, range = 26 to 65). The subjects with AS were measured on two occasions by three investigators, while the healthy subjects were measured on two occasions by two investigators. Measurements were taken at the level of the xiphisternum in a standing position, using two different arm positions: hands on head, and arms at the sides.

Three investigators (A, B and C) were used for the subjects with AS and two (A and C) for the healthy subjects. The measurement instrument for this study was a simple, retracting, flexible metal tape of three meters. This instrument was chosen for its simplicity, ease of use, inexpensiveness and wide use in clinical trials of this nature, being routinely used in clinics to assess subjects with AS.

**Procedure**

Each tester took three trials in each of the two arm positions on each occasion. (Trials 1, 2, 3 on each occasion). Subjects were seen on two occasions, ten minutes apart, on the same day, which by minimising attendance time was convenient for subjects and testers. Ten minutes was chosen as the time period between CE measurement occasions in the expectation that this time interval would prevent experimental bias by minimising memory of the previous results. Within the given measurement period, each tester measured at least two subjects, and this was also intended to obviate the possibility of tester memory affecting results. Subjects were asked to wear one layer of clothing during testing.

The tape was placed in the center of the xiphisternum, in such a way as to ensure that it remained horizontal with the xiphisternum by using a grid as a guide. Subjects were instructed to “fill your lungs right up with air and hold while I measure, then breathe out completely and then I will measure you again”. Encouragement such as ‘right in’ was not given since providing encouragement might influence CE measurement from trial to trial\(^14\).

The CE measurements at maximal inspiration and at maximal expiration were recorded on each trial. The measurement data sheets were passed on to the principal investigator, who calculated the CE. This system was adopted to minimise the possibility of inaccuracies, which might have occurred had the testers calculated the CE on the spot, and also to reduce the likelihood of contamination of results due to the testers’ memory of the previous record.

**RESULTS**

**Comparison of CE measurements in the two arm positions**

In order to compare CE measurement between the two arm positions, hands on head and arms by the
sides, a paired t-test was used. As shown in Table 1, the mean CE ranged from 5.38 to 6.99 cm (SD = 2.17 to 2.60) for the hands on head position and from 5.62 to 7.03 cm (SD = 2.16 to 2.71) for the arms at side position. The arms at side position produced slightly higher CE measurements than hands on head position. However, the mean differences were minimal, ranging from 0.01 to 0.64 cm.

The paired t-test revealed no significant difference between the means of the two arm positions. The p values were greater than 0.05 in all cases, although, in subjects with AS as measured by tester A, the p-value was of borderline (p=0.07) significance, with a higher mean CE for the arms at sides than hands on head (difference 0.64 cm). Therefore the results provide evidence of a negative answer to the research question: “Is there a difference in CE measurement between the two arm positions?”

### Table 1. Comparison of the CE measurement between arm positions using a paired t-test for both groups of subjects

<table>
<thead>
<tr>
<th></th>
<th>Hands on head in cm</th>
<th>Arms at side in cm</th>
<th>Mean difference (95% CI)</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean (SD)</td>
<td>mean (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tester A</td>
<td>5.73 (2.33)</td>
<td>6.19 (2.71)</td>
<td>–0.64 (–0.96 to 0.04)</td>
<td>–1.92</td>
<td>21</td>
<td>0.07</td>
</tr>
<tr>
<td>Tester B</td>
<td>5.38 (2.23)</td>
<td>5.62 (2.49)</td>
<td>–0.22 (–0.67 to 0.23)</td>
<td>–1.03</td>
<td>21</td>
<td>0.32</td>
</tr>
<tr>
<td>Tester C</td>
<td>6.54 (2.60)</td>
<td>6.62 (2.64)</td>
<td>–0.08 (–0.51 to 0.35)</td>
<td>–0.40</td>
<td>21</td>
<td>0.70</td>
</tr>
<tr>
<td>Healthy group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tester A</td>
<td>6.99 (2.18)</td>
<td>7.03 (2.39)</td>
<td>–0.03 (–0.54 to 0.47)</td>
<td>–0.14</td>
<td>24</td>
<td>0.90</td>
</tr>
<tr>
<td>Tester C</td>
<td>6.85 (2.17)</td>
<td>6.84 (2.16)</td>
<td>0.01 (–0.31 to 0.33)</td>
<td>0.06</td>
<td>24</td>
<td>0.95</td>
</tr>
</tbody>
</table>

### Table 2. Mean, standard deviation, mean differences and independent t-value with 95 per cent confidence interval for both groups in both positions

<table>
<thead>
<tr>
<th></th>
<th>AS group Mean (SD) in cm</th>
<th>Healthy group Mean (SD) in cm</th>
<th>Mean difference (95% CI)</th>
<th>t(45)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>hands on head</td>
<td>arms at side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tester A</td>
<td>5.73 (2.33)</td>
<td>7.00 (2.18)</td>
<td>–1.26 (–2.59 to 5.96)</td>
<td>–1.92</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>6.19 (2.70)</td>
<td>7.03 (2.40)</td>
<td>–0.84 (–2.34 to 0.66)</td>
<td>–1.13</td>
<td>0.27</td>
</tr>
<tr>
<td>Tester C</td>
<td>6.54 (2.60)</td>
<td>6.85 (2.17)</td>
<td>–0.31 (–1.71 to 1.10)</td>
<td>–0.45</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>6.62 (2.64)</td>
<td>6.84 (2.16)</td>
<td>–0.21 (–1.63 to 1.19)</td>
<td>–0.31</td>
<td>0.76</td>
</tr>
</tbody>
</table>

The paired t-test revealed no significant difference between the means of the two arm positions. The p values were greater than 0.05 in all cases, although, in subjects with AS as measured by tester A, the p-value was of borderline (p=0.07) significance, with a higher mean CE for the arms at sides than hands on head (difference 0.64 cm). Therefore the results provide evidence of a negative answer to the research question: “Is there a difference in CE measurement between the two arm positions?”

**Comparison of CE measurements between two groups**

Comparisons were made between subjects with AS and healthy subjects using an independent t-test. The mean (SD), mean differences (95% CI), t value and p value for each arm position and tester are presented in Table 2. The mean value of CE in subjects with AS ranged from 5.73 to 6.62 cm (SD = 2.33 to 2.70) and in healthy subjects the mean ranged from 6.84 to 7.03 cm (SD = 2.16 to 2.40). The mean value for the healthy group was higher than that of the subjects with AS, but not significantly so. The mean differences were small, ranging from 0.21 to 0.84 cm, except in the case of Tester A when measuring far the hands on head position (1.26 cm).

There was no significant difference between groups. However, Tester A in the hands on head position gave a p-value 0.06 whilst the p value for Testers B and C in both positions, and Tester A in the arms at sides position ranged from 0.27 to 0.76. These results provide evidence of a negative answer to the research question: “Is there a difference in CE measurement between healthy subjects and people with AS?”

**DISCUSSION**

**Comparison between two arm positions**

The present study implies that there is little difference in mean CE between the two arm
A slightly greater CE measurement is noted in the arms at sides' position (0.01 to 0.64 cm). However, this is not statistically significant implying that there is no difference between using the hands on head position or hands by the side position to measure CE.

Moll and Wright\(^2\) suggested that CE measurement should be taken in the hands on head position because it prevents maximum contraction of the pectoralis and latissimus dorsi muscles thus obviating exaggerated expansion by voluntary contraction of these muscles. In this position the scapulae and breasts are lifted clear of the line of measurement, the field of measurement is more readily observed, and the application of the tape measure is easier in this position.

The marginally greater CE for arms at the side may be due to the “bucket handle” effect, which causes the rib cage to be already slightly expanded when the hands are on the head. As the CE is the maximum inspiration minus the value at maximum expiration, it will be affected if the chest is already expanded\(^15\).

**Comparison between healthy subjects and subjects with AS**

The mean value was slightly higher in healthy subjects than subjects with AS. The t-test however, indicates there was no mean difference in CE between groups, which is surprising. It is thought that subjects with AS will have decreased CE as a diagnostic criteria for this condition is a CE of less than 2.5 cm\(^5, 16, 17\). No comparison of CE measurement in regard to subjects with AS and healthy subjects was found in the literature. However, CE data obtained for both groups in the present study are similar to those of other studies.

Moll and Wright\(^2\) measured CE in 262 healthy subjects (111 males and 151 females) and reported that for the age group 35 to 44 years mean CE was 6.56 cm (SD = 2.07 cm) for males and 4.57 cm (SD = 0.99 cm) for females. These findings are similar to the findings in the healthy group of the present study. Furthermore, it has been reported that a range of two standard deviations from mean normal values has been found and a gradual decrease occurs with advancing age\(^2\).

In the present study, subjects with AS demonstrated mean values of CE ranging from 5.73 to 6.62 cm. These values are comparable with other findings\(^18, 13\). The present study provides evidence against the arbitrary definition of 2.5 cm CE between normal subjects and subjects with AS as proposed in the New York criteria\(^19\). Similarly, Moll and Wright\(^2\) and Haslock et al.\(^11\) reported that there is the possibility of false positive diagnosis due to extensive normal scattering of CE with two standard deviations.

**CONCLUSION**

The comparison between two arm positions showed no statistically significant difference, suggesting that CE measurement can be taken either with hands on head or arms at sides. Surprisingly, the results showed no significant CE measurement difference between subjects with AS and healthy subjects. This indicates that CE may not be an appropriate measurement tool for diagnosis or for monitoring progression of chest wall or thoracic spine involvement in subjects with AS.

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**REFERENCES**


