Altered Alignment of the Shoulder Girdle and Cervical Spine in Patients With Insidious Onset Neck Pain and Whiplash-Associated Disorder

Harpa Helgadottir, Eythor Kristjansson, Sarah Mottram, Andrew Karduna, and Halldor Jonsson, Jr.

Clinical theory suggests that altered alignment of the shoulder girdle has the potential to create or sustain symptomatic mechanical dysfunction in the cervical and thoracic spine. The alignment of the shoulder girdle is described by two clavicle rotations, i.e., elevation and retraction, and by three scapular rotations, i.e., upward rotation, internal rotation, and anterior tilt. Elevation and retraction have until now been assessed only in patients with neck pain. The aim of the study was to determine whether there is a pattern of altered alignment of the shoulder girdle and the cervical and thoracic spine in patients with neck pain. A three-dimensional device measured clavicle and scapular orientation, and cervical and thoracic alignment in patients with insidious onset neck pain (IONP) and whiplash-associated disorder (WAD). An asymptomatic control group was selected for baseline measurements. The symptomatic groups revealed a significantly reduced clavicle retraction and scapular upward rotation as well as decreased cranial angle. A difference was found between the symptomatic groups on the left side, whereas the WAD group revealed an increased scapular anterior tilt and the IONP group a decreased clavicle elevation. These changes may be an important mechanism for maintenance and recurrence or exacerbation of symptoms in patients with neck pain.

Keywords: neck pain, whiplash, scapula, posture

Clinical theory suggests that altered alignment of the shoulder girdle has the potential to create or sustain symptomatic mechanical dysfunction in the cervical and thoracic spine by inducing compressive, rotational, and shear forces in the tissues (Behrsin & Maguire, 1986; Janda, 1994; Jull et al., 2004b, 2008). Until now the alignment of the shoulder girdle in patients with cervical disorders has been investigated only by measuring the upward and forward displacement of the acromion with reference to the 7th cervical spinous process or by angular measurements using these landmarks. These studies evaluating the protraction/retraction and elevation/depression of the shoulder girdle do not take into consideration the alignment of the thoracic cage, nor do they measure scapular orientation (Braun, 1991; Szeto et al., 2002; Yip et al., 2008).

This study applies the definition of body segment and joint coordinate system proposed by the Standardization and Terminology Committee of the International Society of Biomechanics. This includes measuring the three-dimensional orientation of the shoulder girdle described by two clavicle rotations—elevation and retraction, and by three scapular rotations—upward rotation, internal rotation, and anterior tilt (Figure 1) (Karduna et al., 2001; Wu et al., 2005).

The alignment of the shoulder girdle varies considerably between individuals within the general population. In general, the clavicles should be symmetrical, elevate around 6 degrees and retract around 20 degrees at the sternoclavicular joint (Ludewig et al., 2009). The scapula sits between the second and the seventh ribs on the posterior thoracic wall (Williams & Warwick, 1980), approximately 8 cm lateral to the spinous processes (Sobush et al., 1996). The optimum alignment of the scapula with the arms by the side has been described as the mid-position of the scapula between the individual available range of upward and downward rotation, external and internal rotation, and posterior and anterior tilt (Motttram et al., 2009). This has been described as the “scapula neutral position.” There is minimal support from the passive osteo-ligamentous system in this position so the myofascial structures, in particular the trapezius and the serratus anterior, are considered to have an important role (Motttram et al., 2009).

Potential mechanisms that can alter the alignment of the shoulder girdle include pain, tightness in the soft...
tissues, imbalances in muscle activity or strength, muscle fatigue, and the cervical and thoracic curves (Kebaetse et al., 1999; Michener et al., 2003; Sahrmann, 2002). The presence of pain is associated with altered muscle activity in the trapezius and the serratus anterior muscles (Falla et al., 2004a, 2007a; Ludewig & Cook, 2000; Sterling et al., 2001). Paralysis of these muscles due to injury to the accessory nerve and the long thoracic nerve illustrates their contribution in maintaining optimum scapular orientation. Trapezius paralysis results in a scapular orientation characterized by a reduced elevation and retraction of the clavicle, and increased upward rotation of the scapula. Serratus anterior paralysis results in increased elevation of the clavicle, medial translation, and downward rotation of the scapula (Kuhn et al., 1995). Tightness and overactivity of both the levator scapulae and the rhomboid muscles tend to adduct, downwardly rotate, and elevate the most medial part of the scapula (Behrson & Maguire, 1986; Sahrmann, 2002). The pectoralis minor, the biceps brachii (caput brevis), and the coracobrachialis muscles, which attach to the coracoid process, can create forward pull on the scapula causing anterior tilting of the scapula and protraction of the clavicle and along with the pectoralis major; the pectoralis minor may also cause downward rotation of the scapula (Kibler & McMullen, 2003; Williams & Warwick, 1980).

Changes in cervical and thoracic alignment (Kibler & McMullen, 2003) as well as slouched posture are also known to contribute to altered alignment of the scapula (Finley & Lee, 2003; Kebaetse et al., 1999). Altered cervical alignment is considered to be an important mechanism influencing cervical (Edmondston et al., 2005; Szeto et al., 2005b) and scapular kinematics (Kibler & McMullen, 2003; Thigpen et al., 2010). Evidence is emerging demonstrating that cervical alignment is associated with the efficient function of the deep cervical flexors (Falla et al., 2007b), the trapezius and the serratus anterior muscles (Weon et al., 2010). However, there is conflicting evidence as to whether there is a difference in cervical alignment between patients with neck pain and asymptomatic subjects (Edmondston et al., 2007; Harrison et al., 2004; Yip et al., 2008). Association between prolonged neck pain and more flexed cervicothoracic posture has been reported in adolescents (Straker et al., 2009) but association has not been found between changes in the thoracic curve and cervical spine disorders in adults (Szeto et al., 2005a).

The aim of the study was to determine whether there is a pattern of altered alignment of the shoulder girdle, and the cervical and thoracic spine, at rest, in patients with cervical spine disorders. The hypothesis is that patients with cervical spine disorders demonstrate an altered

Figure 1 — Clavicle and scapular rotations.
alignment of the shoulder girdle and the alignment of the cervical and thoracic spine.

Methods

Subjects
The current study included patients with insidious onset neck pain (IONP) and patients with whiplash-associated disorder (WAD) grade II, following a motor vehicle accident (Spitzer et al., 1995), since a difference may exist in impairments between these groups. A difference has been observed between these two groups of patients in the sagittal configuration of the cervical spine (Kristjansson & Jonsson, 2002), the fatty infiltration in the cervical extensor muscles (Elliott et al., 2008), the activity of the trapezius muscle, and the level of pain and disability (Falla et al., 2004a; Nederhand et al., 2002). Twenty-one subjects with IONP (19 women and 2 men) and twenty-three subjects with WAD (20 women and 3 men) were recruited at physical therapy clinics, on a voluntary basis, in the Reykjavik municipal area. This study was approved by the Bioethics Committee of Landspitali University Hospital and all subjects signed a consent form. A sample of convenience consisting of 20 asymptomatic subjects (17 women and 3 men) served as a control group (Table 1). All subjects were right handed. The subjects in the control group were selected to match the subjects in the symptomatic groups, according to their height, weight, age, gender, and physical activity level. Physical activity level was assessed by asking whether the subject engaged in some kind of physical activity on regular bases (sports, exercises etc.). If the answer was yes, the subject was asked what kind of physical activity and how many times per week. Demographic information (height, weight, age, gender, and physical activity level) were collected. Disability was measured by the Neck Disability Index (NDI), which is a self-reporting questionnaire (Vernon & Mior, 1991). Pain intensity was evaluated with a 10-cm Visual Analog Scale (VAS) anchored by no pain and pain as bad as it can be. The VAS was used to indicate the average intensity of neck pain experienced over the past seven days.

Inclusion criteria for the pain groups were age 18–55, a score of at least 10 on the NDI, and neck symptoms of more than six months in duration. Score below 10 on the NDI are scored as “no disability” (Vernon & Mior, 1991) and symptoms that have lasted more than six months are considered chronic (Hartling et al., 2001). Subjects were allocated to one of two groups: Group 1 included subjects with IONP who had no history of any accident or whiplash injury; Group 2 included subjects diagnosed with a WAD that had no history of symptoms in the neck area before the accident. A third group included the controls (Group 3), who were age 18–55 with neither cervical nor shoulder dysfunction. The cervical spine was examined by a trained physical therapist to confirm the presence or absence of cervical segmental joint dysfunction in patients with neck pain and controls, respectively. The glenohumeral joints were examined for pain, restriction, and impingement signs (Magee, 1987). Subjects were excluded if they had any known pathology or impairment in the shoulder joint, history of head injury or spinal fractures, systemic pathology, and serious psychological condition.

Before initiating the study, a sample of 20 subjects per group was calculated to provide 80% power to detect differences of 3 degrees between the groups. Calculations were based on our judgment of what are clinically meaningful differences.

Instrumentation and Measurements

Equipment. Three-dimensional kinematic data were collected at 40 Hz with the Polhemus 3-Space Fastrak device (Polhemus Colchester, VT), which has an accuracy of 0.8 mm and 0.15°. The device consisted of a global transmitter, three sensors, and a digitizing stylus, all of which were hardwired to a system electronic unit. The electronic unit determined the relative orientation and position of the digitizer and the sensors through the electromagnetic field emitted by the global transmitter. Information collected by the Fastrak system was sent to a computer with a software system developed by KINE (Hafnarfjordur, Iceland).

Table 1  Demographic details of the three groups

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>IONP Group</th>
<th>WAD Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women (n = 17); Men (n = 3)</td>
<td>Women (n = 19); Men (n = 2)</td>
<td>Women (n = 20); Men (n = 3)</td>
</tr>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>Age (years)</td>
<td>29.70</td>
<td>7.75</td>
<td>21–51</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>171.83</td>
<td>7.77</td>
<td>155–188</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.30</td>
<td>10.23</td>
<td>56–100</td>
</tr>
<tr>
<td>NDI</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Evaluation of Shoulder Girdle Alignment. For evaluation of the alignment of the shoulder girdle, the study used the definition of body segment and joint coordinate system for the upper extremity proposed by the International Society of Biomechanics. These coordinate systems were defined using digitized anatomical landmarks to evaluate clavicle and scapular orientation (Wu et al., 2005). The digitizing stylus connected to the magnetic tracking device was used to manually digitize the coordinates of the landmarks listed in Table 2. All landmarks were palpable except for the center of glenohumeral rotation (GH). The GH was estimated by moving the humerus through short arcs (<45 degrees) of midrange glenohumeral motion. The GH was defined as the point on the humerus that moved the least with respect to the scapula when the humerus was moved and was calculated using a least-squares algorithm (Biryukova et al., 2000; Harryman et al., 1990). Based on standard matrix transformation methods, the global axes defined by the sensors of the Fastrak device were converted to anatomically defined axes derived from the digitized bony landmarks (Karduna et al., 2001).

| Table 2  Digitized anatomical landmarks |
|--------|-----------------------------------------------------------------------------------|
| Thorax | Processus spinosus of the seventh cervical vertebra                               |
|        | Processus spinosus of the eighth thoracic vertebra                                 |
|        | Deepest point of incisura jugularis (suprasternal notch)                         |
|        | Processus xiphoideus, most caudal point of the sternum                           |
| Clavicle| Most ventral point on the sternoclavicular joint                                   |
|        | Most dorsal point on the acromioclavicular joint                                  |
| Scapula| Trigonum spinae scapulae, the midpoint of the triangular surface on the medial border of the scapula in line with the scapular spine |
|        | Angulus inferior, most caudal point of the scapula                                |
|        | Angulus acromialis, most laterodorsal point of the scapula                        |
| Humerus | Most caudal point on lateral epicondyle                                            |
|        | Most caudal point on medial epicondyle                                            |

Evaluation of Cervical and Thoracic Alignment. The cervical and thoracic alignment was measured two dimensionally. This study used coordinates provided by the digitizer to measure cervical alignment and distinguished between the alignment of the upper cervical spine (cranial angle) and the lower cervical spine (cervical angle) (Edmondston et al., 2007; Straker et al., 2009). To evaluate cranial and the cervical angles, the corner of the right eye, the tragus of the right ear, and the spinous process of the 7th cervical vertebra were digitized. The coordinates of these anatomical landmarks were used to calculate the cranial and the cervical angles illustrated in Figure 2. To measure the midthoracic curve (MTC), the digitized coordinates of the spinous processes ranging from T2 to T11 were used. A curve was drawn along the thoracic spinous processes and a straight line directly between the spinous processes T2 and T11 (Figure 3). The longest perpendicular distance (h) between the curve and the straight line was calculated using the coordinates. The MTC was calculated using the formula presented on Figure 3. The line labeled length (l) is the straight-line distance between spinous processes T2 and T11. The line labeled height (h) is perpendicular to l and intersects the curve at a digitized point of the midthoracic process that
visually demonstrated the top of the curve (Bullock et al., 2005). This method in evaluating the thoracic curve has shown a good intra- and interrater reliability with a ICC level of 0.99 (Kristinsson, 2008).

**Experimental Procedure.** The anatomical landmarks were palpated and marked. Three Fastrak sensors were attached to each subject. Using adhesive tape, the first sensor was attached to the skin of the sternum (distal to the sternal notch) and the second sensor to the flat part of the acromion. The second sensor evaluated the clavicle and scapular rotations. The third sensor, attached to an elastic strap (Mylatex wrap, 45 cm, Chattanooga Group, USA), was placed distally on posterior aspect of humerus proximal to the epicondyles. These placements have been used previously and validated for these measurements (Karduna et al., 2001; Ludewig & Cook, 2000). The height of the chair used in the study was adjusted for each subject, and a 15 degree obliquely aligned cushion was used to facilitate neutral spinal curves.

The subject was instructed to sit in a comfortable upright position such that the sacrum was in contact with the back of the chair with the feet placed parallel on the floor (Figure 4). The following instructions were verbalized to each subject: “Visually focus on a point, directly ahead, on the chart in front of you.” “Allow your hands, shoulders, and arms to assume the position they would normally assume by the side.” The subject was instructed to maintain this position throughout the digitization and the GH estimation procedures. Following this, the raw data from the sensors were converted into anatomically defined rotations (Karduna et al., 2001). The right and left sides were assessed separately. Two measurements were conducted on each subject on both sides (the Fastrak sensors on the scapula and the arm had to be moved to the opposite side). The two measurements were averaged to get one measure for each side. The order of testing was randomized (sides and groups).

**Figure 3** — Illustration and calculation measuring the midthoracic curve (MTC).

**Figure 4** — Experimental setup. A sensor was attached to the skin of the sternum, to the flat part of the acromion and on the posterior aspect of the humerus. The EMG surface electrodes on the subject were not used in this study.

Formula for the MTC.

\[
mtc = 4 \times \left[ \arctan \left( \frac{2 \times h}{l} \right) \right]
\]

**length (l)**

**height (h)**
The subjects were not aware that the alignment of the spine and the shoulder girdle was measured. They were informed that the function of the upper body was evaluated by using surface EMG electrodes (not part of this study). The alignment measurements were conducted before the subject elevated the arm several times.

Data Analysis

The R version 2.8.0 (R Foundation for Statistical Computing) was used for statistical analysis. The age, weight, and height between the three groups were compared by ANOVA. The main parameter of interest was the alignment of the shoulder girdle and cervical and thoracic spine with the arms resting by the side. The data for the alignment of the shoulder girdle was described using two clavicle rotations—elevation/depression and retraction/protraction, and by three scapular rotations—upward/downward rotation, internal/external rotation, and anterior/posterior tilt, as dependent variables (Figure 1). A software program (KINE, Hafnarfjordur, Iceland) calculated the orientation of each clavicle and scapular rotation.

Three variables were related to the alignment of the cervical and thoracic spine: cranial angle, cervical angle, and midthoracic curve (Figure 2 and 3). The calculation for the alignment of the cervical and thoracic spine was performed automatically by the use of an Excel software program (Bullock et al., 2005).

For each group, means and standard deviations were calculated for the five dependent variables on each side demonstrating alignment of the shoulder girdle and the three dependent variables demonstrating cervical and thoracic alignment. As the Shapiro test did not reject normal distribution of the data, parametric tests were used for statistical analysis. Initial analyses were performed to test for possible group differences, in the dependent measures, by using general linear model one-way ANOVA, and the Tukey honest significant difference method was used to determine the main effects of the ANOVA. The correlation between the dependent variables and the scores on the NDI and VAS was also assessed. The significance level for all tests was set at 0.05.

Results

There was no significant difference in age, weight, and height among the three groups or between the results of men and women within each group (Table 1). The ANOVA revealed on the right side a significant difference in clavicle retraction ($p < .03$) and on the left side a significant difference in clavicle elevation ($p = .01$), scapular tilt ($p < .01$), and scapular upward rotation ($p < .03$) among the three groups. A significant difference was also observed in the cranial angle ($p < .01$) and a tendency in the cervical angle ($p = .07$), but no difference was found in the midthoracic curve ($p = .99$) among the three groups.

The reduced clavicle retraction and cranial angle observed in the asymptomatic group correspond to those of former studies, where clavicle elevation and retraction is typically reduced on the dominant side compared with the nondominant side (Sobush et al., 1996) and scapular upward rotation is increased on the nondominant side compared with the dominant side (Crosbie et al., 2008). As the majority of patients that participated in this study had bilateral symptoms in the neck area, the side-to-side differences cannot be related to increased symptoms on the left side but rather to less usage and less awareness of the nondominant arm compared with the dominant arm (Sandlund et al., 2006).

The reduced clavicle retraction and cranial angle observed in the symptomatic groups are consistent with previous reports that a forward head posture and a combination of lower cervical flexion, upper cervical extension, and reduced clavicle retraction are more common in patients with neck pain compared with asymptomatic subjects (Braun, 1991; Szeto et al., 2002; Yip et al., 2008). This may lead to increased compressive forces in the articulations of the cervical and thoracic spine, inducing tension in the muscles in the area (Harrison et al., 2004; Szeto et al., 2002; Yip et al., 2008) and affecting the muscle activity of the trapezius and the serratus anterior (Weon et al., 2010). Reduced median nerve sliding and...
Figure 5 — Columns demonstrating the mean and the 95% confidence intervals of the cranial angle, cervical angle, clavicle elevation and retraction, and scapular anterior tilt, upward rotation and internal rotation in the three groups. *p < 0.05.
The combination of reduced clavicle elevation and reduced scapular anterior tilt demonstrated in the IONP group might be associated with forward head posture (Thigpen et al., 2010) and short overactive pectoralis minor muscle associated with inefficiency in the serratus anterior and lower trapezius muscles that fail to control the anterior tilt of the scapula (Borstad & Ludewig, 2000; Sahrmann, 2002).

The reduced clavicle elevation observed in the IONP group is consistent with previous reports in patients with tension-type headache for whom an intermediate lateral projection of an X-ray spinogram was used to determine the position of the shoulder girdle. The lower cervical and upper thoracic spine is generally obscured by the projection of an X-ray spinogram was used to determine the position of the shoulder girdle. The term low-set shoulder was used to refer to cases where the first thoracic vertebra (mild cases) and upper third or more of the second thoracic vertebra (severe cases) were clearly visualized. In the controls (n = 225), a mild low-set shoulder was observed in 38% (n = 86) of the subjects but severe in only 3.8% (n = 8). In patients with tension-type headache (n = 372), 48% (n = 180) had mild low-set shoulders and 9.1% (n = 34) severe (Nagasawa et al., 1993). The reduced clavicle elevation may reflect inefficiency of the upper trapezius, which fails to control normal clavicle elevation against gravity (Mottram et al., 2009; Sahrmann, 2002) or an imbalance between the upper and lower trapezius muscles such that the activity of the lower trapezius may dominate the activity of the upper trapezius (Ludewig et al., 1996).

The increased anterior tilt of the scapula in the WAD group might be associated with forward head posture (Thigpen et al., 2010) and short overactive pectoralis minor muscle associated with inefficiency in the serratus anterior and lower trapezius muscles that fail to control the anterior tilt of the scapula (Borstad & Ludewig, 2000; Sahrmann, 2002).

The reduced clavicle elevation observed in the IONP group is consistent with previous reports in patients with tension-type headache for whom an intermediate lateral projection of an X-ray spinogram was used to determine the position of the shoulder girdle. The lower cervical and upper thoracic spine is generally obscured by the projection of an X-ray spinogram was used to determine the position of the shoulder girdle. The term low-set shoulder was used to refer to cases where the first thoracic vertebra (mild cases) and upper third or more of the second thoracic vertebra (severe cases) were clearly visualized. In the controls (n = 225), a mild low-set shoulder was observed in 38% (n = 86) of the subjects but severe in only 3.8% (n = 8). In patients with tension-type headache (n = 372), 48% (n = 180) had mild low-set shoulders and 9.1% (n = 34) severe (Nagasawa et al., 1993). The reduced clavicle elevation may reflect inefficiency of the upper trapezius, which fails to control normal clavicle elevation against gravity (Mottram et al., 2009; Sahrmann, 2002) or an imbalance between the upper and lower trapezius muscles such that the activity of the lower trapezius may dominate the activity of the upper trapezius (Ludewig et al., 1996).

The combination of reduced clavicle elevation and reduced scapular anterior tilt demonstrated in the IONP group might be associated with forward head posture (Thigpen et al., 2010) and short overactive pectoralis minor muscle associated with inefficiency in the serratus anterior and lower trapezius muscles that fail to control the anterior tilt of the scapula (Borstad & Ludewig, 2000; Sahrmann, 2002).

The reduced clavicle elevation observed in the IONP group is consistent with previous reports in patients with tension-type headache for whom an intermediate lateral projection of an X-ray spinogram was used to determine the position of the shoulder girdle. The lower cervical and upper thoracic spine is generally obscured by the projection of an X-ray spinogram was used to determine the position of the shoulder girdle. The term low-set shoulder was used to refer to cases where the first thoracic vertebra (mild cases) and upper third or more of the second thoracic vertebra (severe cases) were clearly visualized. In the controls (n = 225), a mild low-set shoulder was observed in 38% (n = 86) of the subjects but severe in only 3.8% (n = 8). In patients with tension-type headache (n = 372), 48% (n = 180) had mild low-set shoulders and 9.1% (n = 34) severe (Nagasawa et al., 1993). The reduced clavicle elevation may reflect inefficiency of the upper trapezius, which fails to control normal clavicle elevation against gravity (Mottram et al., 2009; Sahrmann, 2002) or an imbalance between the upper and lower trapezius muscles such that the activity of the lower trapezius may dominate the activity of the upper trapezius (Ludewig et al., 1996).

The combination of reduced clavicle elevation and reduced scapular anterior tilt demonstrated in the IONP group might be associated with forward head posture (Thigpen et al., 2010) and short overactive pectoralis minor muscle associated with inefficiency in the serratus anterior and lower trapezius muscles that fail to control the anterior tilt of the scapula (Borstad & Ludewig, 2000; Sahrmann, 2002).

The reduced clavicle elevation observed in the IONP group is consistent with previous reports in patients with tension-type headache for whom an intermediate lateral projection of an X-ray spinogram was used to determine the position of the shoulder girdle. The lower cervical and upper thoracic spine is generally obscured by the projection of an X-ray spinogram was used to determine the position of the shoulder girdle. The term low-set shoulder was used to refer to cases where the first thoracic vertebra (mild cases) and upper third or more of the second thoracic vertebra (severe cases) were clearly visualized. In the controls (n = 225), a mild low-set shoulder was observed in 38% (n = 86) of the subjects but severe in only 3.8% (n = 8). In patients with tension-type headache (n = 372), 48% (n = 180) had mild low-set shoulders and 9.1% (n = 34) severe (Nagasawa et al., 1993). The reduced clavicle elevation may reflect inefficiency of the upper trapezius, which fails to control normal clavicle elevation against gravity (Mottram et al., 2009; Sahrmann, 2002) or an imbalance between the upper and lower trapezius muscles such that the activity of the lower trapezius may dominate the activity of the upper trapezius (Ludewig et al., 1996).

The combination of reduced clavicle elevation and reduced scapular anterior tilt demonstrated in the IONP group might be associated with forward head posture (Thigpen et al., 2010) and short overactive pectoralis minor muscle associated with inefficiency in the serratus anterior and lower trapezius muscles that fail to control the anterior tilt of the scapula (Borstad & Ludewig, 2000; Sahrmann, 2002).
group on the left side supports recent suggestions that increased clavicle elevation is coupled with increased scapular anterior tilt and vice versa (Teece et al., 2008). The reduced scapular anterior tilt in the IONP group on the left side may therefore correspond to the decreased clavicle elevation. However, the reduced anterior tilt may also occur due to increased activity in the levator scapulae and the rhomboid muscles, to compensate for inefficient upper trapezius (Ludewig et al., 1996; Sahrmann, 2002).

The reduced scapular upward rotation reflects either long, inefficient upper trapezius and serratus anterior muscles or short overactive levator scapulae and rhomboid muscles, which would simultaneously elevate and retract the clavicle, and downwardly rotate the scapula (Sahrmann, 2002). The reduced clavicle elevation in the IONP group and the reduced scapular upward rotation in the WAD group are concurrent with Sahrmann’s (2002) statement that the most common alignment impairments of the shoulder girdle in patients with shoulder pain is the downwardly rotated alignment of the scapula and the depressed alignment of the clavicle. It should be noted that a reduced clavicle elevation as well as a reduced scapular upward rotation maintains a lengthen position of the upper trapezius, which induces excessive strain on the muscle as well as the levator scapula and the rhomboid muscles. This lengthen position increases tenderness in the muscles (Azevedo et al., 2008) and inflicts compressive, rotational, and shear forces on the cervical and thoracic spine, which may be an important mechanism associated with the maintenance for recurrence or exacerbation of neck pain (Behrns & Maguire, 1986; Jull, 1997; Jull et al., 2004b, 2008; Mottram et al., 2009). This corresponds to studies demonstrating reduced neck symptoms when patients with neck pain rotate the neck when the shoulder girdle is passively elevated (Van Dillen et al., 2007).

The primary limitation of this study is that it describes only the alignment of the spine and the shoulder girdle at rest and therefore the findings cannot be generalized to alignment during functional tasks, especially when the upper limb is moving or loaded. This is also the case when activities are prolonged over time. Secondly, the fact that the measurements were done in sitting may be considered a limitation of the study, since a difference in the sitting position between the three groups may have led to differences observed. However, the sitting position was standardized by adjusting the height of the chair for each subject, by using an obliquely aligned cushion, by ensuring that the sacrum was in contact with the back of the chair, and by placing the feet parallel on the floor. Because the results demonstrate an equivalent alignment of the thoracic spine in all three groups (p = .99), it may be concluded that the sitting position was similar in all three groups and therefore did not affect the results of the study. Thirdly, the results present mean values for each group, but a great variability was observed within each group. Fourthly, evaluating for restriction in extensibility in the pectoralis minor muscle may have provided information about the relationship of a restriction to altered alignment of the shoulder girdle.

**Conclusions**

A reduced clavicle retraction, scapular upward rotation, and cranial angle were observed in patients with neck pain compared with asymptomatic subjects. A different manifestation was observed between patients with IONP and WAD on the left side in clavicle elevation and scapular anterior tilt, suggesting that a difference may exist in impairments between these groups. The WAD group revealed increased anterior tilt of the left scapula compared with the control group and the IONP group, which revealed a reduced clavicle elevation on the left side compared with the control group.

**References**


