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Investigating scapula positioning in individuals with non-specific lower back pain: A preliminary study

Darryl Cochrane *, Cara Leyten

School of Sport, Exercise & Nutrition, Massey University, New Zealand

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ABSTRACT

Introduction: Low back pain (LBP) is an economic and physically disabling burden on individuals and society. With 70% of cases classed as non-specific, there is a need for further research into the causes and consequences associated. The involvement of postural balance in musculoskeletal conditions is gaining increasing interest in research and health practice. However, there is a lack of literature surrounding LBP and posture in distal segments of the body.
Objective: The current study investigated scapula positioning in those with non-specific LBP.
Methods: Scapula angle of rotation, scapula protraction, and scapula elevation were assessed in nine participants with chronic non-specific LBP and compared with that of nine asymptomatic controls (aged 18–60 years). The degree of pelvic tilt was assessed across both groups as a secondary outcome measure.
Results: No difference was identified between the two sample groups for scapula angle of rotation ($p = 0.707$), protraction ($p = 0.755$), or elevation ($p = 0.691$). Anterior pelvic tilt was greater in those with LBP ($p = 0.046$), supporting previous literature.
Conclusion: The findings for the scapula position are novel, given that research in this field is limited. It is concluded that there is no change in scapula positioning in those with non-specific LBP, but there is an increased anterior pelvic tilt.

1. Introduction

Low back pain (LBP) is a highly prevalent and disabling health condition, affecting 80% of the world's population in their lifetime (Kendall et al., 2014; Pongsthorn et al., 2012). LBP is an economic and disabling burden on individuals and society, numerous comorbidities include depression, rheumatoid arthritis, osteoarthritis, osteoporosis, cardiovascular disease, and cerebrovascular disease (Bletzer et al., 2017; Buchbinder et al., 2018; Hartvigsen et al., 2018; Ramanathan et al., 2018; Schneider et al., 2007; Wolter et al., 2011). While risk factors such as individual and family history of spinal problems, occupational workloads, trauma, emotional stress, hypertension, and lifestyle influences have been determined, the exact causes of most individual cases are unknown (Ganesan et al., 2017; Zafar et al., 2018). Seventy percent of LBP cases are classified as non-specific, with 27% classed as mechanical or having structural deformities, and a small percentage being due to rare causes (Last and Hulbert 2009). Therefore, current protocols in the health sector focus predominantly on management or surgical repair, often failing to correct the root cause (Maher et al., 2017). With prevalence continuing to rise, current methods and literature are considered insufficient (Foster et al., 2018; Hung et al., 2015; Hurwitz et al., 2018; Richmond 2012).

The spinopelvic region has a significant role in stabilising the body and remaining an upright posture; being the most central, misalignment in any of these structures can impair the body's equilibrium and overall functioning (Wang et al., 2016). Specifically, imbalance results in a shift in structural integrity and altered workloads on the intervertebral discs and joints, which are common contributors to LBP (Bassani et al., 2019). Due to its proximity, this region is heavily researched regarding posture and LBP. A correlation has been identified between LBP and reduced thoracic kyphosis (TK), lumbosacral angle, pelvic incidence, sacral slope, and a forward thoracic tilt (Chaléat-Valayer et al., 2011). In support of this Król et al. (2017) reported reduced lumbar lordosis and increased anterior pelvic tilt, with lumbar lordosis dependent on pelvic tilt. Similarly, Lim et al. (2013) reported an increased anterior pelvic tilt with LBP.

In contrast, Masaki et al. (2017, 2018) found no relationship between static or dynamic spinal alignment and LBP. Masaki et al. (2017)

* Corresponding author.
E-mail address: D.Cochrane@massey.ac.nz (D. Cochrane).

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assessed spinal alignment muscle stiffness and muscle mass in hospital medical workers with and without LBP. They reported no correlation between LBP and standing or prone sagittal spinal alignment (thoracic kyphosis, lumbar lordosis, and sacral anterior inclination angle), but ultrasonic shear wave elastography identified increased multifidus stiffness in LBP patients. The multifidus findings are in agreement with Murillo et al. (2019), who concluded that stiffness may be due to inactivity of the muscle during dynamic movements. Additionally, Masaki et al. (2018) assessed dynamic thoracic spine flexion and lumbar extension angles in a small group of males with and without LBP during a quadruped upper and lower extremity lift exercise – they concluded no significant difference between the groups. However, they also assessed muscle strain during the exercise and found that with the lower extremity movement, the latissimus dorsi and thoracic erector spinae muscles were under more strain (suggestive of overactivity) in the LBP group, while multifidus and lumbar erector spinae were not. Similarly, Fasuyi et al. (2017) reported that LBP correlates to shortened hamstrings, but it did not influence pelvic tilt. It appears that pelvic tilt is related to LBP, although it may not be an independent variable.

The influence of posture on various health concerns is an increasing field of research. Neutral posture suggests that all components of the human body are aligned in their correct position, providing optimal functioning, and maintaining balance in response to both internal and external forces (Janda et al., 2007; Mehta 2005). Conversely, postural imbalance increases strain and stress on the body and can lead to pain, tensional discomfort, nerve impingement, muscle inhibition, a congested flow system (oxygen delivery, nutrient delivery, waste removal), and inefficient movement patterns (Mehta 2005). With the correction of postural imbalance reducing pain levels, the topic of posture as a potential contributor and therapeutic component of musculoskeletal conditions is gaining research interest (Kim et al., 2017; Mehta 2005). However, despite the significant worldwide prevalence of LBP, the underlying causes, optimal treatments, and preventatives remain unclear. Postural imbalance as a contributor to LBP has been considered as a possible cause. The majority of research has focused on the spinopelvic-hip region, suggesting a relationship (Bassani et al., 2019; Król et al., 2017).

In contrast, other research reported no postural misalignment in the spinopelvic-hip region, despite identifying abnormalities in soft tissue structure and function (Masaki et al., 2018). Therefore, postural imbalance may be occurring elsewhere in the body. For example, Cadar and Pop (2015) suggest that the cervical spine can promote LBP by compressing the spinal column. Exercise protocols for correcting forward head posture have been shown to significantly reduce LBP and associated sciatica (Cadar and Pop, 2015). More recently, a case study determined that lumbar nerve pain was a direct result of compression on the cervical spine due to stenosis of the cervical vertebrae, with surgical correction significantly reducing LBP (Mansfield, 2019). Cadar and Pop (2015) and Mansfield (2019) identify causation despite the distance between the lower back and cervical spine.

In individuals with LBP, the current literature highlights abnormality in either postural alignment or muscle structure or activity. With muscle stiffness and overactivity suggestive of postural misalignment, there is interest in whether such tensional imbalance would present postural imbalance elsewhere other than the spinopelvic-hip region. The current literature remains unclear regarding scapula positioning, despite the known physiological connection between the two regions. Investigating scapula alignment in non-specific LBP will provide new information to inform practice. It will contribute to the current literature and promote continued research into causal relations.

Therefore, this study aimed to determine scapula positioning in individuals with non-specific LBP that may provide new insight as a potential contributor to LBP when considering treatment and rehabilitation. Based on previous research that increased latissimus dorsi stiffness was associated with scapular dyskinesia (Laudner and Williams 2013) and scapula upward rotation was observed in LBP patients (Taghizadeh et al., 2017), it was hypothesised that non-specific LBP would display asymmetrical and/or significantly greater scapula angle (upward rotation), protraction, or elevation when compared to asymptomatic controls.

2. Methods

2.1. Experimental approach

A case-control design was used to determine a difference between scapula positioning in those with LBP compared to asymptomatic controls. The primary outcome measure assessed the scapula angle of rotation, scapula elevation, and scapula protraction from the frontal plane. The secondary outcome measure assessed the degree of pelvic tilt from the sagittal plane.

2.2. Participants

Low back pain and control participants were recruited from the local community through advertisements on social media, and community and clinical notice boards. Eighteen participants volunteered for the study; nine participants in each group (LBP, control) of which four females and five males were represented. The two groups were matched for age (LBP 32.7 ± 14.2, control 34.0 ± 16.7 years, $p = 0.858$), weight (LBP 83.1 ± 14.9, control 81.4 ± 16.0 kg, $p = 0.816$), and height (LBP 174.4 ± 10.3, control 178.8 ± 8.7 cm, $p = 0.342$). From the control group, two of the nine participants indicated that they were left limb dominant compared with the LBP group of which all nine participants were right limb dominant.

All volunteers were pre-screened to ensure they met the inclusion criteria of the study. The inclusion criteria for the LBP group were consistent bone, muscle, or nerve pain in the lower back region for three consecutive months; the cause unknown, with non-existent traumatic or structural damage, deformity, or disease confirmed by a health professional. The exclusion criteria for the control group included current or historical pain or impairment regarding the lower back or a history of significant trauma to the back or hip region. The exclusion criteria for all participants included: a history of spinal trauma or other significant musculoskeletal condition, such as arthritis in the related joints or scoliosis; known cardiovascular (e.g., hypertension, cardiovascular disease), respiratory (e.g., asthma), or other significant health condition; a known leg length discrepancy, surgical intervention in the back or shoulders, or history of neck or shoulder pain or disability and abnormal mobility or function of the scapula.

To ensure adequate sample size a priori *t*-test analysis was completed before data collection. Taghizadeh et al. (2017) who analysed upward scapula rotation, detected a change of 18% in the distance between the inferior angle and the thoracic vertebrae between experimental and control groups with a standard deviation of 13.3. Based on the above result the current study was designed to have 80% power, $\alpha = 0.05$ therefore a sample size of nine participants was required for each group (G*Power 3, version 3.1.9.2, Heinrich-Heine University, Dusseldorf, Germany).

2.3. Procedure

Before testing, all participants provided written informed consent and the study was approved by the University Human Ethics Committee (SOA, 20/39). Participants completed a health questionnaire that inquired about date of birth, limb dominance, and shoulder and back pathology. Height and weight were measured, and testing occurred in a consultancy room. Participants wore attire that allowed the assessor to access the posterior thoracic region while covering the front of the torso. Participants were instructed to stand in a relaxed position, with their arms by their sides and heads in a comfortable position while looking forward at the wall. Bilateral measurements were obtained for all measurements.

The study involved one assessor. To reduce the risk of bias influence and predisposed expectations, pre-screening information was only partially disclosed to the assessor; details relating specifically to low back pain status were completed discreetly and participants were grouped after the testing had been performed. As no intervention was involved, and the postural variable was not expected to be easily manipulated, participant blinding was deemed unnecessary.

2.3.1. Scapula angle of rotation (θ)

The Lennie method has been previously described in earlier research to assess scapula rotation and horizontal alignment (Sobush et al., 1996; Taghizadeh et al., 2017). The superior angle, root of the scapula spine, and inferior angle were palpated and marked with a dot using a black marker pen. The spinous process horizontal to each scapula landmark was palpated and marked. An anthropometric tape measure recorded the distance between the root of the spine of the scapula and its respective vertebrae, and the distance between the inferior and superior angles and its respective vertebrae (Fig. 1). The distance of the medial border of the scapula was measured from the superior angle to the inferior angle.

The scapula angle of rotation (θ) was determined by the above scapula landmarks, the distance of the medial border of the scapula (Side A), and the horizontal distance between the inferior angle and superior angle of the scapula (Side B, Fig. 2). Scapula rotation was calculated using the following formula (Fig. 2).

$$\theta = \sin^{-1} \times (Side\ B \div Side\ A)$$

Where, side A = medial border distance and side B = the inferior angle distance to the midline subtracted from the superior angle distance to the midline. θ = angle of scapula rotation.

All palpations and markings were repeated at least three times for accurate landmarking.

2.3.2. Scapula elevation and protraction

The protractor method was used to identify elevation and protraction. This is a reliable assessment of vertical scapula position (O'Shea et al., 2016). Using a black marker, the assessor palpated and marked a crosshatch on the eighth thoracic spinous process (T8). A crosshatch was then placed to the inferior angle landmark from the Lennie test markings. The protractor was placed in a vertical alignment along the vertebrae, with the base placed on the horizontal marking of the inferior angle crosshatch. The vertical distance between the base of the protractor to the T8 crosshatch was measured (Fig. 3). All palpations and markings were repeated at least three times for accurate landmarking.

2.3.3. Pelvic tilt

As a secondary outcome measure, pelvic tilt was measured in the sagittal plane using a custom-made inclinometer. The manual method of this device made it difficult to determine calibration. The PSIS (posterior superior iliac spine) and ASIS (anterior superior iliac spine) were palpated and the PSIS was marked using a black marker pen three times for accurate landmarking; the ASIS landmark was not marked due to its location underneath the participant's undergarments. The participant stood side-on in a relaxed position; the upper arm remained at the participant's side, the elbow was bent to 90° and the forearm was placed across the body. From the sagittal plane, the two ends of the inclinometer were aligned to the PSIS and ASIS landmarks (Fig. 4). The reading from the inclinometer recorded the degree of pelvic tilt (Fig. 5).

2.4. Statistical analysis

Data was analysed using Statistical Package for Social Sciences (SPSS, Statistics v24, IBM New York, USA), with the level of significance set at $p < 0.05$. The normality of the data was analysed by the Shapiro-Wilk test. A one-way analysis of variance (ANOVA) determined any significant difference between the mean sex, age, weight, and height of each group. A two-way ANOVA was performed to examine a group effect (LBP, control), limb effect (right side, left side), and interaction effect (group x limb) for measures of scapula angle of rotation, scapula protraction, scapula elevation, and pelvic tilt. When a significant F-value was achieved, post-hoc comparisons were performed using the Bonferroni correction. Effect sizes are reported as partial eta squared (η_p^2), where 0.01, 0.06, and 0.14 represent small, medium, and large effects, respectively. The odds ratio of the group (LBP vs. control) on scapula angle, scapula protraction, scapulae elevation, pelvic tilt, and limb was calculated using binary logistic regression (see Table 2). Interclass correlation coefficient (ICC) and coefficient of variation were used to evaluate the reliability of landmark distances, the protractor method, and pelvic tilt. Before testing the measurement reliability was determined by the assessor performing the testing protocol measurements on five individuals who were not involved in the study and were separated by at least three days between test and retest. All data is represented as mean ± standard deviation (SD).

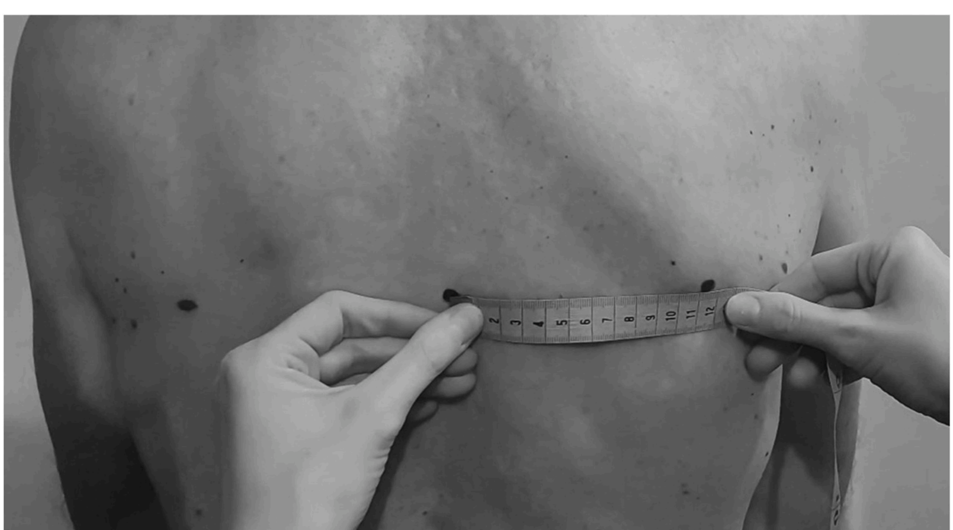

Fig. 1. The Lennie method. The distance between each scapula landmark and the respective thoracic vertebrae was determined using an anthropometric measuring tape.

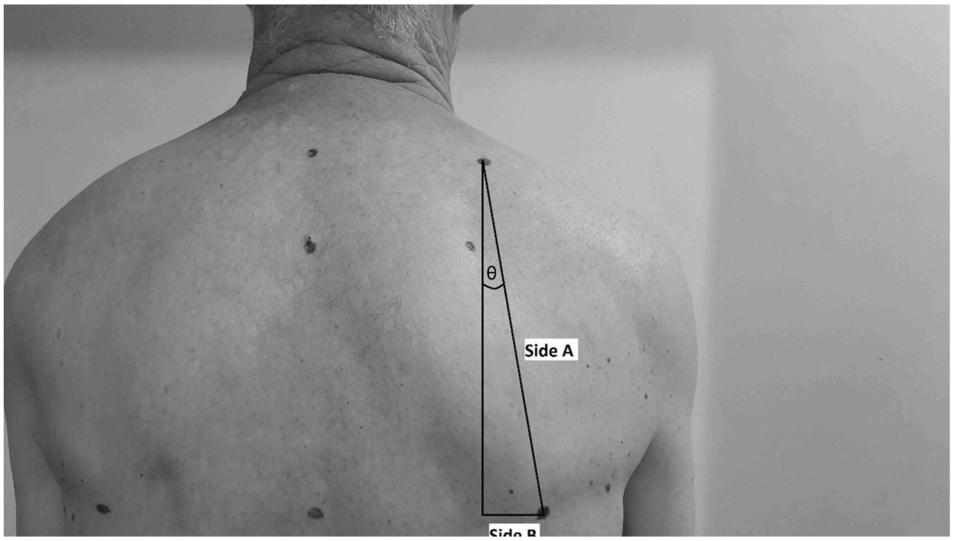

Fig. 2. The Lennie method. The length of the scapula medial border and the horizontal distance between the inferior angle and superior angle of the scapula determined the angle of scapula rotation.

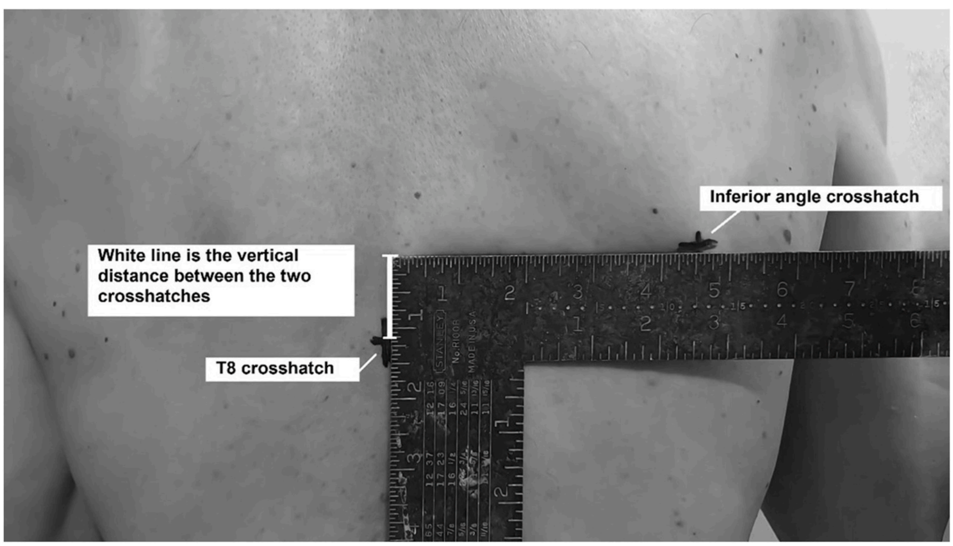

Fig. 3. The protractor method. The vertical distance between the two crosshatches (the inferior angle of the scapula and T8) is represented by the white box along the protractors vertical edge.

3. Results

The intraclass coefficient and coefficient of variation were 0.95 and 3.2% for landmark distances, 0.87 and 3.8% for the protractor method, 0.85 and 6.3% for the scapula angle, and 0.88 and 5.2% for pelvic tilt, respectively.

All data were normally distributed according to the Shapiro-Wilk test and sphericity was not violated. For the scapula angle of rotation, there was no significant group ($p = 0.707$), limb ($p = 0.140$), or interaction effect ($p = 0.592$) (Table 1). For scapula protraction, there was no significant group ($p = 0.755$), limb ($p = 0.081$) or interaction effect ($p = 1.000$). For elevation, there was no significant difference for group ($p = 0.691$) or limb ($p = 0.165$). However, there was an interaction effect of group x limb ($p = 0.012$), indicating that in the control group, the left scapula was located significantly higher than the right ($p = 0.005$). For pelvic tilt, there was a significant difference between the two groups ($p = 0.046$), but there was no significant limb difference ($p = 0.848$) and no interaction effect ($p = 0.861$) (see Table 1).

4. Discussion

The purpose of this study was to determine scapula positioning in individuals with chronic non-specific LBP. The findings of this study do not support the hypothesis that scapula angle, scapula protraction, and scapula elevation are greater in those with non-specific LBP when compared to asymptomatic controls.

The current finding of no change in the scapula angle of rotation differs to Taghizadeh et al. (2017) observed excessive upward rotation in individuals with LBP. This may be due to the application of the Lennie method. Taghizadeh et al. (2017) applied a partial Lennie method whereby measures were taken between three scapula landmarks (superior angle, root of the spine of the scapula, and inferior angle) and their respective vertebrae. The author's conclusion of excessive upward rotation was based on the inferior scapula landmark (the inferior angle) being located further from the vertebral column in those with LBP while the superior landmarks (superior angle and root of the spine of the scapula) did not. Additionally, the study did not involve a calculation for the angle of rotation. In the present study, the full Lennie method was

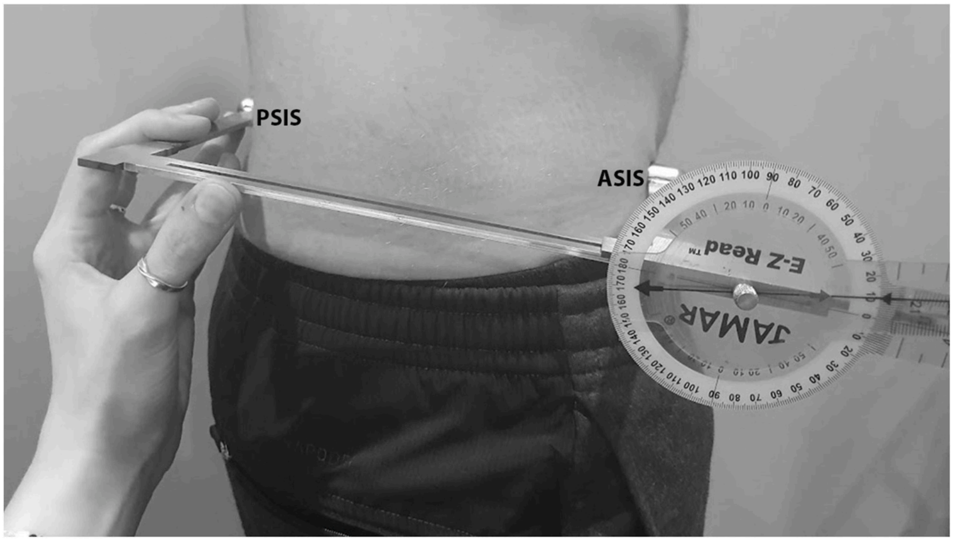

Fig. 4. Pelvic tilt assessment. The two ends of the custom-made pelvic inclinometer are aligned with the PSIS and ASIS of the pelvis.

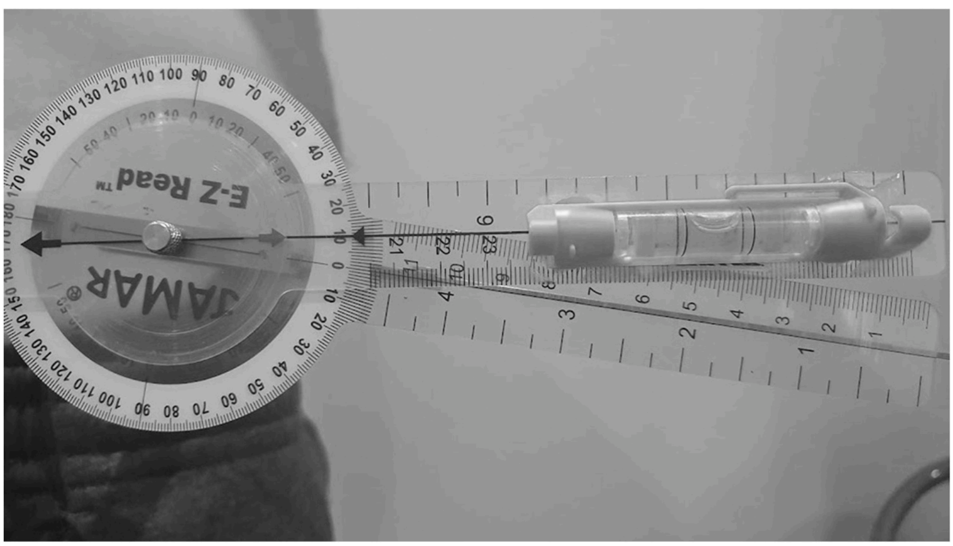

Fig. 5. The inclinometer measures the degree of pelvic tilt. A leveller attached to the measuring arm of the inclinometer indicates when the arm is horizontal and ready to provide a reading.

implemented to provide specific angles of rotation; measurements of the horizontal distances between two scapula landmarks (superior angle, inferior angle) and their respective thoracic vertebrae, and the length of the medial border of the scapula were used to calculate angle of rotation. Therefore, it is plausible this may explain the dissonance between the present results and Taghizadeh et al. (2017) finding.

The current findings of scapula protraction are in agreement with Taghizadeh et al. (2017) who concluded that the scapula (measured from the root of the spine of the scapula) is not located any further or closer to the spine in those with LBP when compared to asymptomatic controls. This suggests LBP is not present with excessive protraction (a distance further from the spine) as hypothesised. Furthermore, the current results in LBP revealed a distance of 7.85 cm from the thoracic vertebrae indicating normal horizontal positioning (Frank et al., 2013; Sobush et al., 1996).

Due to the novelty of the current study, it is not possible to directly compare scapula elevation or depression (scapula height). However, the present results support what is considered normal height for the inferior angle of the scapula, which is a height aligning with the spinous processes of the seventh thoracic vertebrae (T7) to the ninth thoracic vertebrae (T9) (Haneline et al., 2008). An abnormal elevation is considered a location superior to that of T7 (Kunkel et al., 2011). Given that T7 is normally located at least 1.4 cm above T8, the elevation of 1.16 cm identified in the current study for the LBP group is negligible and indicates that excessive elevation is not evident in those with LBP. While the current study indicated no difference in scapula elevation between the LBP and control groups, asymmetry was identified in the positioning of the right and left scapulae in the control group, but not in the LBP group. This contrasts previous research that showed no limb difference in scapula height in healthy participants (Oyama et al., 2008; Sobush et al., 1996).

Contrary to the reported scapula findings, the current results indicate that individuals with non-specific LBP have an excessive anterior pelvic tilt when compared to the control. A mean of 14.2° in the LBP group was almost two-fold the normal degree of tilt (8°) suggested in clinical settings (Falk Brekke et al., 2020). This finding is supported by previous research by Król et al. (2017) and Lim et al. (2013) but contrasts with Chaléat-Valayer et al. (2011). With no significant difference between the left and right side of the pelvis, the anterior pelvic tilt was unrelated to the location of back pain.

Table 1
Mean ± SD of scapula angle of rotation, scapula protraction, scapula elevation, and pelvic tilt for group, limb, and interaction (group x limb) effects.

Group				
Measure	LBP	Control	η_p^2	p-value
Scapula angle of rotation (°)	2.82 ± 6.71	2.05 ± 6.05	0.005	0.707
Scapula protraction (cm)	7.85 ± 1.60	7.68 ± 1.41	0.004	0.755
Scapula elevation (cm)	1.16 ± 1.15	1.33 ± 1.04	0.008	0.691
Pelvic tilt (°)	14.22 ± 6.70*	6.83 ± 5.49	0.114	0.046

Limb				
Measure	**Right**	**Left**	η_p^2	**p-value**
Scapula angle of rotation (°)	3.71 ± 7.36	1.16 ± 4.93	0.042	0.243
Scapula protraction (cm)	7.45 ± 1.70	8.08 ± 1.21	0.047	0.081
Scapula elevation (cm)	1.06 ± 1.25	1.42 ± 0.89	0.030	0.165
Pelvic tilt (°)	10.39 ± 6.98	10.67 ± 7.43	0.001	0.848

Group x Limb						
Measure	**LBP right limb**	**LBP left limb**	**Control right limb**	**Control left limb**	η_p^2	**p-value**
Scapula angle of rotation (°)	3.85 ± 8.45	1.79 ± 4.69	3.58 ± 6.61	0.52 ± 5.36	0.010	0.592
Scapula protraction (cm)	7.53 ± 1.76	8.17 ± 1.45	7.37 ± 1.74	8.00 ± 0.98	0.000	1.000
Scapula elevation (cm)	1.23 ± 1.43	1.08 ± 0.86	0.89 ± 1.10	1.76 ± 0.82**	0.294	0.012
Pelvic tilt (°)	14.00 ± 6.91	14.44 ± 6.89	6.78 ± 5.14	6.89 ± 6.13	0.001	0.861

*$p < 0.05$ – The group effect of pelvic tilt was significantly larger in LBP compared to the control.
**$p < 0.05$ – The interaction effect of the control left limb was significantly larger than control right limb.

Table 2
Odds ratio of prevalence of low back pain on scapula angle, scapula protraction, scapulae elevation, pelvic tilt, and limb.

Measure	Odds ratio (95% Confidence Interval)
Scapula angle of rotation	0.91 (0.77–1.09)
Scapula protraction	0.68 (0.34–1.38)
Scapula elevation	1.41 (0.63–3.16)
Pelvic tilt	0.81 (0.69–0.94)
Limb (right/left)	0.97 (0.18–5.22)

The current findings for scapula alignment are novel due to the paucity of research to support them. However, previous research has identified overactivity in the latissimus dorsi muscle in those with LBP, suggesting excessive strain (Masaki et al., 2018). The latissimus dorsi muscle crosses the inferior angle of the scapula which has a role in scapula movements such as protraction and downward rotation. Therefore, excessive latissimus dorsi strain in those with LBP may suggest a change in muscle tension on the inferior angle of the scapula, manipulating the scapula position. This is evidenced by the inferior angle being located further from the vertebral column in those in LBP (Taghizadeh et al., 2017). Latissimus dorsi also originates along the lumbar and sacral spinous processes and the pelvis, acting on trunk extension, trunk lateral flexion, and anterior pelvic tilting (Bhatt et al., 2013). There was no significant difference in scapula position in the current study, this may be attributed to the specific region of latissimus dorsi fibres that are overactive in those with LBP. Latissimus dorsi has multiple groups of muscle fibres of differing actions that are dependent on their location and direction (Brown et al., 2007). For example, the fibres inserted into the humerus influence shoulder function, while the low back is influenced by the thoracolumbar fibres (Bhatt et al., 2013). This may explain why the current study identified a change in pelvic tilt and not scapula alignment.

The major limitation of the current study is that a larger sample size with a cross-sectional design is required to determine its replicability and reproducibility. Additionally, it is important to acknowledge that it is difficult to define chronic non-specific LBP due to the broad scope of pain variables. The intensity and location of pain were not clarified in the present study criteria therefore, the findings are generalised for these variables. Chronic pain was defined as having a duration of at least three consecutive months and it is unknown whether a longer duration of pain would have greater influence on scapula position. It is suggested that future research involve a more defined LBP group that includes the location, and duration of pain and considers activity levels of participants. Having a sample that considers gender bias would be advantageous for future research.

The participants were instructed to stand in a relaxed position, arms by their side, and look forward, however, future studies should consider the individual differences that may occur in the resting position of the scapula. Determining the participant's chronicity of LBP, scapular dyskinesis and scapula static and dynamic stability would strengthen the data collection. Manual methods of tape measurement, protractor, and custom-made inclinometer made it difficult to calibrate equipment, however, previous research has reported good reliability and the current results of the intraclass coefficients support this.

5. Conclusion

To the author's knowledge, this is the second study to have examined scapula position in chronic non-specific LBP. Scapula angle of rotation, scapula protraction, and scapula elevation were no greater in those with non-specific LBP. An increased anterior pelvic tilt was identified, which agrees with previous research. Further research with a change of methodology that simultaneously assesses latissimus dorsi status is recommended.

CRediT authorship contribution statement

Darryl Cochrane: Formal analysis, Supervision, Writing – review & editing. **Cara Leyten:** Conceptualization, Methodology, Project administration, Writing – original draft.

Declaration of competing interest

There is no conflict of interest.

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