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Possible Relationship between the Spine Curvatures and the Presence of Scapular Dyskinesis: A Possible Association

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SUMMARY

Background. Scapular dyskinesia is defined as an abnormality in the static or dynamic position of the scapula during movements of the shoulder complex, being classified as dysrhythmia, winging or mixed. It is speculated that this abnormality may be associated with the positioning of the spine, pain in the shoulders or cervical spine, as several muscles cross these same joints.
Objective. The study aims to verify the relationship between spinal curvatures and the presence of scapular dyskinesia.
Methods. Participants were 28 young adults (15 males and 13 females) who were evaluated using the scapular dyskinesia test, resisted by dumbbells during shoulder abduction, scaption and flexion movements and by evaluating cervical and thoracic curvatures using the flexicurve method. The angulations were calculated using the "Biomec Flex" software and statistical analysis was performed using the SPSS v26.0 software using the t test for independent samples and chi-square test.
Results. Participants with scapular dyskinesia have greater angulations in the curvatures of the cervical spine and there was an association between the variables, indicating that participants classified as having normal curvatures or with cervical hyperlordosis had a higher prevalence of scapular dyskinesia, while those with rectification curvatures had a lower prevalence.
Conclusions. There is relationship between spine curvatures and presence of scapular dyskinesis, therefore, a broader perspective on the evaluation of individuals with scapular dyskinesis is important.

KEY WORDS

Cervical spine; kyphosis; scapular dyskinesis; spine; thoracic spine.

INTRODUCTION

Scapular dyskinesis is a term given to alterations in scapular position, movement, and biomechanics (1). It can be classified as winged types (I and II), dysrhythmic (type III), or both. In type I, the inferior angle of the scapula becomes prominent; in type II, the entire medial border is displaced; and in type III, there is excessive elevation or insufficient upward rotation of the scapula (2). These changes impact the scapulohumeral rhythm and the biomechanical function of the scapular and glenohumeral joints (1).

Studies suggest some factors related to the causes of scapular dyskinesis, including muscle imbalances in the scapular girdle. This imbalance can manifest as hyperactivity of muscles like the upper trapezius, middle trapezius, and pectoralis minor (3, 4), or as hypoactivity of the lower trapezius and serratus anterior (4-6). Additionally, the most common kinematic alterations are increased scapular internal rotation and decreased upward rotation (4). Scapular dyskinesis can also be a consequence of neurological injuries, as the accessory spinal and long thoracic nerves are affected, resulting in a loss of function in parts of the trapezius and serratus. It may be symptomatic or asymptomatic or generate a series of crepitations, as articular friction occurs during scapular movement, which is strongly related to shoulder injuries such as impingement syndrome, rotator cuff tears, and joint instabilities (7).

Considering that scapular muscles have proximal insertion points on the cervical and thoracic spine (8), it is important for the spine to be in a proper position and mobility to maintain functionality and the absence of pain, directly influencing scapular movements (9-11). However, in some cases, there may be angular changes in the spinal curvatures, referred to as straightening, hyperkyphosis, and hyperlordosis. In many cases, these alterations can be asymptomatic, depending on the degree of alteration and the individual's lifestyle habits, affecting the distribution of biomechanical loads across the shoulder and spinal complex (11). Nevertheless, few studies have investigated the alterations in spinal curvatures and their relationship with the presence of scapular dyskinesis.

Given the above, it is speculated that changes in scapular and glenohumeral joint movements, as well as in cervical and/or thoracic spinal angulations, could result in mechanical overloads on structures and contribute to symptoms in the cervical region (8, 12). Understanding this interrelationship is essential for developing effective assessment and intervention strategies. Therefore, the objective of the study was to investigate the relationship between spinal curvatures and the presence of scapular dyskinesis. Secondarily, it aimed to compare cervical and thoracic curvature angles between individuals with and without scapular dyskinesis.

MATERIALS AND METHODS

Participants

The study included 28 young adults (15 men, 13 women, aged 22.1 ± 4.1 years, weight 64.8 ± 10.7 kg, and height 1.71 ± 0.10m), students at the Centro Universitário da Serra Gaúcha (FSG) who were invited to participate via social media. Healthy participants aged 18 to 35 years were included. Participants who presented shoulder or spinal pain, paresthesia, or diagnosed injury, a history of fractures or surgeries in the spinal or scapular region, or diagnosed scoliosis with a curvature > 20 degrees (moderate or severe) were excluded. All participants signed an informed consent form, approved by the Ethics and Research Committee of the Centro Universitário da Serra Gaúcha under opinion no. 6.582.706 – date of approval: December 13, 2023.

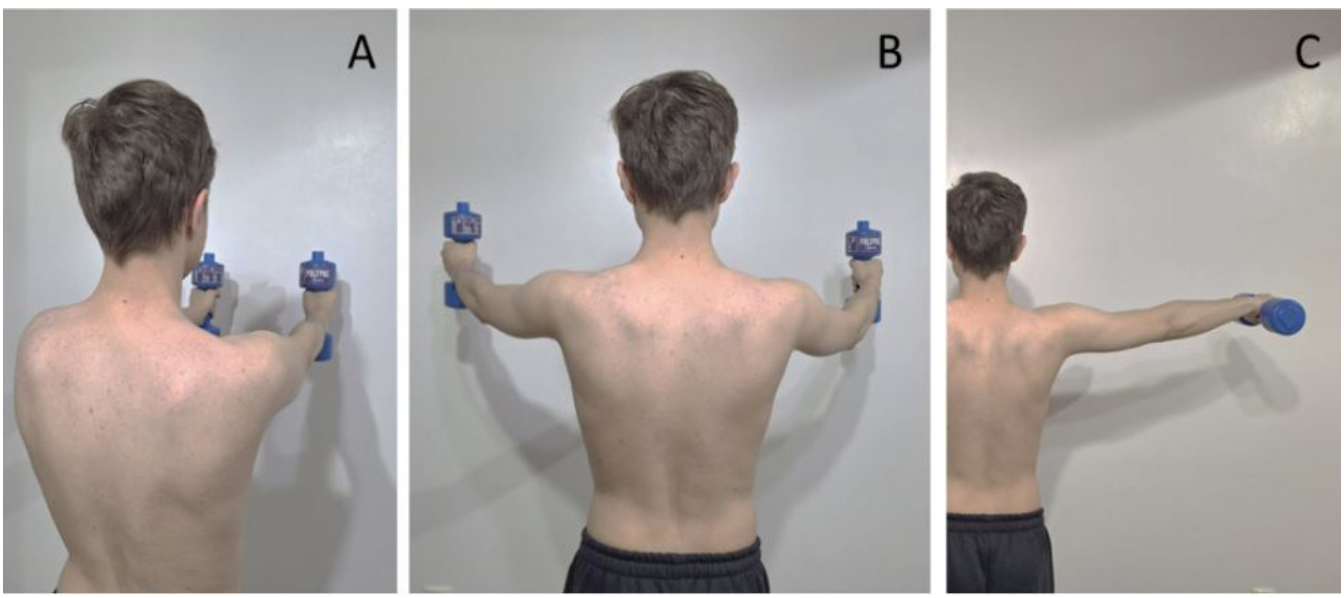

Figure 1. Scapular Dyskinesis Test for flexion **(A)**; elevation in the scapular plane **(B)**; and shoulder abduction **(C).**

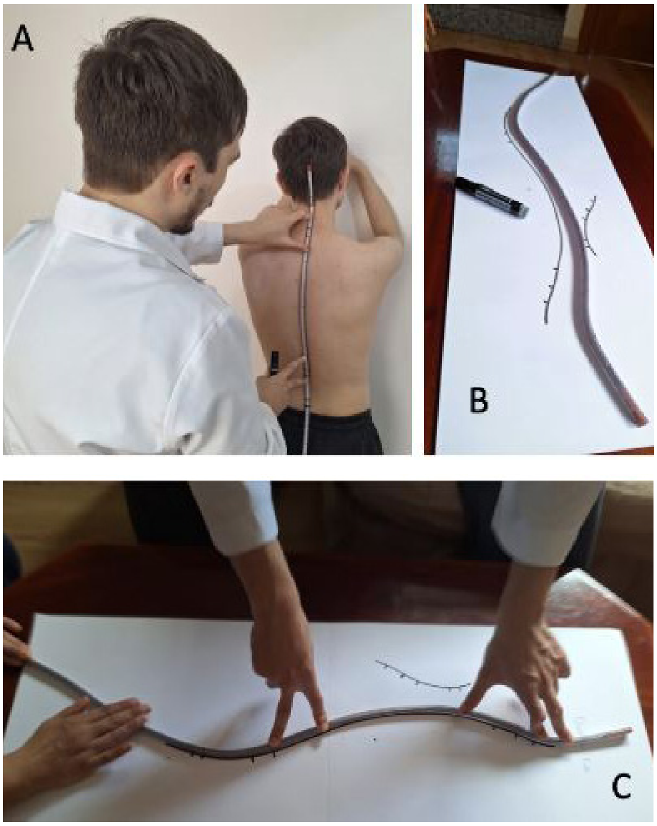

Figure 2. Molding **(A)**; marking **(B)**; positioning of the flexicurve **(C)**.

Procedures

The data collection was conducted at the Integrated Health Center of the Centro Universitário da Serra Gaúcha, according to the availability of researchers and study participants. It consisted of evaluating the presence of scapular dyskinesis using a validated clinical test (13, 14) and assessing cervical, thoracic, and lumbar spinal curvatures in the sagittal plane with the flexicurve method (15, 16).

Scapular Dyskinesis Test

The scapular dyskinesis test (13, 14) was performed with participants undressed, shoulders in a neutral rotation, elbows straight, and arms at their sides. Participants were asked to perform 5 bilateral repetitions of flexion, scaption, and active, resisted, and weighted shoulder abduction, with the evaluator observing from the posterior view and recording a video.

During execution, participants held dumbbells according to their body weight: for participants under 68.1 kg, a 1.4 kg dumbbell; for participants 68.1 kg or above, a 2.3 kg dumbbell. These weights were provided by plastic dumbbells calibrated with sand and water to achieve the specified load (**figure 1**).

As the participants performed these movements, researchers observed scapular movements, especially noting the presence of dysrhythmia (altered scapulohumeral rhythm) and winging (prominent inferior angle and/or medial border) or normality. Researchers recorded their assessments, and if there was disagreement, the video was reviewed later.

Flexicurve

The flexicurve is a flexible ruler that can be molded and marked along the spinous processes, allowing for the measurement of spinal curvatures (cervical, thoracic, and lumbar) in the sagittal plane (15, 16).

After palpating and marking (using a demographic pencil) specific anatomical points and correctly positioning the participant, the flexicurve should be molded over the spinous processes in the area of the spine being evaluated, with the marks transferred directly onto the flexicurve. The flexicurve is then carefully repositioned onto an A3 sheet, where the contours of the participant's spinal curvature are transcribed (**figure 2**).

In the cervical spine evaluation (15), the occipital protuberance (C0), posterior tubercle of atlas (C1), and the spinous processes of C2, C7, T1, and T2 should be marked. Immediately afterward, the individuals should sit down, close their eyes, flex and extend the head twice, and then stop in a neutral position with open eyes and no movement.

In the thoracic and lumbar curvature evaluation (16), the spinous processes of vertebrae C7, T1, T12, L1, L5, and S1 should be marked. The participants should stand with feet parallel and bare, in their usual posture, with shoulders and elbows flexed at 90° and the back uncovered, supported against a wall to avoid possible movements during the flexicurve molding (**figure 2**).

Data and Statistical Analysis

Flexicurve data were analyzed using Biomec Flex software. The contours of the cervical, thoracic, and lumbar curvatures were captured via digital photographs and imported. All points were identified by region (cervical or thoracolumbar) and, through trigonometric equations, the software generated a plot with the equations, curvatures, flexicurve angles, and Cobb angles.

Statistical analysis was performed in SPSS v26.0. Initially, data normality was verified using the Shapiro-Wilk test. Associations between nominal variables were analyzed with

Table I. Results of the Scapular Dyskinesis Test.

Shoulder Flexion			
Yes - 50% (16 mild e 12 obvious)		No - 50% (28 normal)	
Normal 50% (n = 28)	**Dysrhythmia** 28.6% (n = 16)	**Winging** 14.3% (n = 8)	**Both** 7.1% (n = 4)
Elevation in the Scapular Plane			
Yes – 46.4% (20- mild e 6 obvious)		No – 53.6% (30 normal)	
Normal 53.6% (n = 30)	**Dysrhythmia** 28.6% (n = 16)	**Winging** 10.7% (n = 6)	**Both** 7.1% (n = 4)
Shoulder Abduction			
Yes – 39.3% (18 mild e 4 obvious)		No – 60.7% (34 normal)	
Normal 60.7% (n = 34)	**Dysrhythmia** 25.0% (n = 14)	**Winging** 7.1% (n = 4)	**Both** 7.1% (n = 4)

Table II. Classification of spinal curvatures in the sagittal plane (n = 56).

Variables	Normality	Hyperlordosis or Hyperkyphosis	Rectification
Flexicurve Angle CC	42.9% (n = 24)	32.1% (n = 18)	25.0% (n = 14)
Cobb Angle CC	21.4% (n = 12)	3.6% (n = 2)	75% (n = 42)
Flexicurve Angle CT	14.3% (n = 8)	46.4% (n = 26)	39.3% (n = 22)
Cobb Angle CT	21.4% (n = 12)	50% (n = 28)	28.6% (n = 16)

CC: Cervical Spine; CT: Thoracic Spine.

Table III. Comparison of spinal curvature values between individuals with and without scapular dyskinesis in flexion, elevation, and abduction movements.

Variables		Abduction	Elevation	Flexion
Flexicurve Angle CC	Yes	45.7 ± 6.5°	42.3° ± 6.8°	42.2° ± 6.8°
	No	36.3° ± 9.8°	38.0° ± 11.5°	29.2° ± 8.6°
	p	< 0.0001*	0.05*	0.049*
Cobb Angle CC	Yes	34.1° ± 5.4°	32.8° ± 4.3°	32.8° ± 4.4°
	No	29.0 ± 7.3°	29.4° ± 8.4°	29.2° ± 8.6°
	p	0.002*	0.018*	0.016*
Flexicurve Angle CT	Yes	38.8° ± 6.9°	37.5°± 8.9°	37.2° ± 9.8°
	No	36.6° ± 9.4°	37.5° ± 8.2°	37.7° ± 7.1°
	p	0.460	0.768	0.693
Cobb Angle CT	Yes	40.2 ± 5.8	39.1° ± 7.0°	38.9° ± 8.4°
	No	38.2 ± 8.1	38.9° ± 7.7°	39.1° ± 6.1°
	p	0.420	0.818	0.742

*Significant difference ($p < 0.05$); CC: Cervical Spine; CT: Thoracic Spine.

Pearson's Chi-Square test (X^2). Comparisons were made using the t-test for independent samples (parametric), with a 95% significance level.

RESULTS

The study included 28 young adults (15 men and 13 women) with an average age of 22.2 ± 4.1 years, height of 171.4 ± 10.7 cm, and weight of 64.8 ± 11.3 kg, with 56 shoulders analyzed. **Table I** shows the results of the scapular dyskinesis test for flexion, scaption, and shoulder abduction movements. **Table II** presents the classification of spinal curvatures, while **table III** shows a comparison of the curvature values measured with the flexicurve between participants with and without scapular dyskinesis. It can be observed that participants with scapular dyskinesis had higher flexicurve and Cobb angles in the cervical region compared to those without dyskinesis for abduction ($p < 0.001$; 0.002), scaption ($p = 0.05$; 0.018), and flexion ($p = 0.049$; 0.016).
It can be observed that participants with scapular dyskinesis had higher flexicurve and Cobb angles in the cervical region compared to those without abduction dyskinesis ($p < 0.001$; 0.002), scaption ($p = 0.05$; 0.018), and flexion ($p = 0.049$; 0.016). Additionally, there was an association between the presence of scapular dyskinesis and cervical curvature classification (hyperlordosis, normality, and rectification) for abduction ($X^2 = 6.297$; $p = 0.047$), scaption ($X^2 = 9.796$; $p = 0.007$), and flexion ($X^2 = 10.032$; $p = 0.07$), indicating that individuals with rectification values typically did not exhibit dyskinesis, while those classified as normal or with cervical hyperlordosis had a higher prevalence of scapular dyskinesis.

DISCUSSION

The objective of this study was to investigate the relationship between spinal curvatures and the presence of scapular dyskinesis. It was found that individuals with scapular dyskinesis exhibited significantly greater cervical curvature angles and a higher prevalence of cervical hyperlordosis and angles in normality compared to individuals without dyskinesis, who tended to have straighter cervical curves. These results highlight the relationship between the evaluated structures during different movements, showing possible postural adaptations that increase cervical curvature or lead to scapular dyskinesis as an attempt to stabilize or adapt movement and positioning. On the other hand, thoracic spine analysis showed no significant differences between the groups, which may reflect the lower functional impact of the thoracic region on scapular mechanics.

The literature includes various studies investigating the cervical spine in patients with cervical pain and scapular dyskinesis (8, 9, 17). Kaaragaç *et al.* (17) found that individuals with nonspecific chronic cervical pain show a higher prevalence of scapular dyskinesis and reduced muscle strength in the cervical and scapulothoracic regions than asymptomatic individuals. Another study by Ludewig and Braman suggests that scapular compensations may serve as adaptive mechanisms to protect adjacent structures, such as cervical and thoracic muscles, especially during high-demand physical movements. These findings emphasize the importance of scapular biomechanics as a fundamental component of postural rehabilitation, suggesting that interventions focused on reducing cervical curvature and restoring scapular control could provide significant benefits in preventing dysfunctions and associated pain.
These aspects are supported by Castelein *et al.* (8), who demonstrated that individuals with cervical pain and scapular dyskinesis showed reduced EMG activity in the middle trapezius during elevation in the scapular plane and increased activity in the pectoralis minor during the towel wall slide. This muscle activity imbalance suggests that the scapula increasingly relies on muscles that contribute to internal rotation and anterior tilt, such as the pectoralis minor, resulting in compensations that can influence cervical posture. These findings reinforce the importance of the relationship between the structures due to their similar muscular attachments, which may vary depending on the type of scapular dyskinesis described by Wannaprom *et al.* (18), demonstrated that the group with cervical pain and scapular dyskinesis of the scapular winging type showed decreased clavicular retraction and increased internal rotation and anterior tilt. Additionally, it was found that individuals with scapular dyskinesis and dysrhythmia showed reduced scapular upward rotation (9). Thus, by examining the biomechanical relationship of these aspects, we can speculate that individuals with scapular dyskinesis who show greater EMG activity in the pectoralis minor and lower activity in the middle trapezius may experience kinematic changes in the scapula, leading to internal rotation and clavicular protraction (8). If we consider that the upper trapezius has a proximal attachment to the external occipital protuberance, the nuchal ligament, and a distal attachment to the lateral clavicle and acromial end, while the middle trapezius has a proximal attachment to the nuchal ligament and the first thoracic vertebrae with a distal attachment on the acromion, it can be speculated that changes in scapular kinematics may be related to increased cervical lordosis angles due to these attachments.

However, it is important to acknowledge that the associations observed in this study do not allow for establishing a causal relationship between scapular dyskinesis and cervical curvature alterations. Factors such as chronic pain, mechanical overload, and compensatory patterns may contribute to these postural adaptations without one phenomenon being the direct cause of the other. Longitudinal studies are needed to clarify the causes and effects of this relationship, which could aid in more targeted and effective therapeutic interventions.

Corroborating our findings, Akodu *et al.* (19) found that undergraduate students with excessive smartphone use exhibited a similar posture. Like our study, the sample comprised asymptomatic young adults, raising the possibility that scapular dyskinesis may be a relatively common finding in asymptomatic populations. For athletes, especially those involved in overhead activities such as tennis and swimming, the prevalence of scapular dyskinesis is even higher and often associated with symptoms of pain and functional limitations (20, 21). Thus, individuals with increased cervical angles show a higher prevalence of dyskinesis, reinforcing the relationship between the shoulder girdle muscles, which attach to both the scapula and the cervical and occipital regions.

Regarding the thoracic region, Welbeck *et al*. (12) show no relationship between the presence of scapular dyskinesis and thoracic spinal curvature in swimmers with and without shoulder pain. Another study reports that patients with cervical region pain, shoulder issues, and scapular protrusion should investigate thoracic spinal curvature, as they may have reduced shoulder range of motion (22). Although muscles such as the rhomboids, middle, and lower trapezius have proximal attachments on the thoracic vertebrae and distal attachments on the scapular spine, our results did not reveal differences in thoracic curvature angle between individuals with and without scapular dyskinesis. This suggests that the lower mobility of the thoracic spine, compared to the cervical spine, may limit the biomechanical adaptations resulting from scapular alterations. The literature indicates a possible relationship between the presence of stiffness in the latissimus dorsi and scapular dyskinesis in swimmers (23). Despite the muscle attaching to both the thoracic and lumbar regions, there is still limited investigation in the literature, with no apparent relationship between the regions; however, an increased anterior pelvic tilt is observed in individuals with dyskinesis (24).

The practical application of this study suggests that movement professionals should consider the relationship between spinal curvatures, with special attention to the cervical region, in individuals with scapular dyskinesis. Integrating this evaluation into the protocol for patients with scapular dyskinesis can facilitate the development of more specific prevention and rehabilitation programs, including scapular stabilization exercises and strengthening of cervical muscles, which can reduce postural compensations and improve shoulder complex functionality (25). It is also important to mention that there is a difference between the functional stability of the upper limb and perception of strength and sense of joint position between subjects with and without scapular dyskinesis. Physical therapist involved in the treatment needed to evaluate impaired posture, glenohumeral joint mobility and neuromuscular control or performance of the shoulder (26). Assessment of posture and biomechanics of the cervical spine and scapular kinematics should be an integral part of treatment to reduce compensations and enhance the overall function of the shoulder complex.

The study presents some limitations that should be mentioned. The first limitation is the lack of a larger sample size across all classifications of scapular dyskinesis, which may influence the extrapolation results to the population. The second limitation is potential human error in palpating anatomical structures, testing dyskinesis, and transferring curvature to paper; however, to minimize these errors, each researcher was assigned a specific stage of the evaluation. The third limitation is the sample profile, as it only included young adults without musculoskeletal complaints or pathologies, so future studies should include these assessments across different age groups and populations. Nonetheless, the results in young adults showed that even without symptoms or pathologies, there are biomechanical relationships between scapular dyskinesis and the cervical region.

CONCLUSIONS

It can be concluded that individuals with scapular dyskinesis exhibit greater cervical spinal curvature angles than those without scapular dyskinesis. There was an association between scapular dyskinesis and cervical spine classifications, demonstrating that individuals with straightened cervical spines did not exhibit scapular dyskinesis, while those classified with normal or cervical hyperlordotic curvatures had a higher prevalence of scapular dyskinesis. Thus, the biomechanical relationship between the scapular and cervical regions is important for a broader approach to the rehabilitation of individuals with scapular dyskinesis.

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DATA AVAILABILITY
Data are available within the article.

CONTRIBUTIONS
GFP: conceptualization, methodology, writing – original draft, formal analysis. EB: data collection, writing – original draft. WRO: writing – original draft, supervision. WD: investigation, resources, writing – review & editing, supervision.

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CONFLICT OF INTERESTS
The authors declare that they have no conflict of interests.

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