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Relation between Thoracic Angle and Costochondritis in Postmenopausal Women

Rovan M. Elbesh[1], Reda Sayed Ashour[2], Eman Jamal Hassan[3]

1.Lecturer of Physical Therapy – Women's Health, Faculty of Physical Therapy, Misr University for Science and Technology, Giza, Egypt.

2.Lecturer of Biomechanics, Faculty of Physical Therapy, Cairo University, Giza, Egypt.

3. Lecturer in Department of Physical Therapy for Women's Health Faculty of Physical Therapy, Egyptian Chinese University.

Abstract:

Background: Hyperkyphosis of the thoracic spine is frequently observed in the musculoskeletal system of women after menopause. It may also impact anterior chest wall discomfort, such as costochondritis. In addition, the inflammation of the costochondral joints and the thoracic curvature are associated; however, the association is not well established.

Objective: Determine the association between the angle of thoracic kyphosis and the degree of costochondritis among postmenopausal women.

Methods: The cross-sectional observational study included 270 participants, aged between 50 and 60 years, who were screened for kyphosis. The curvature was evaluated with an inclinometer. An orthopedist diagnosed osteochondritis clinically using established criteria, and pain severity was assessed using the Visual Analog Scale (VAS). The linear relationships and multiple regressions were also done with adjustments for

Results: There was a meaningful, strong positive relationship between the angle of thoracic kyphosis and the severity of costochondritis ($r=0.852$, $p<0.001$). VAS scores were also higher in subjects with hyperkyphosis. The relation was unconditional of confounding factors, such as BMI.

Conclusion: The amount of costochondral pain increases with the degree of thoracic kyphosis in postmenopausal women.

Keywords: Thoracic Kyphosis, Costochondritis, Postmenopausal Women, Spinal Deformities, Musculoskeletal Pain In The Chest

Conflicts of Interest: The author has no conflicts of interest to declare.

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Introduction:

Costochondritis is an inflammatory disorder of the costal cartilages, resulting in localized and reproducibly tender pain in the anterior chest wall[1]. Costochondritis is a common non-cardiac chest pain among women over 50, with clinical prevalence estimates between 13% and 36%[2]. It is responsible for most chest pains and discomfort in adults aged 40 to 50, especially women. As in hospital practice and primary care, reported costopain and other skeletal-muscular chest pains are at times accompanied by an overlap diagnosis that may include trauma to the heart, such as myocardial infarction[2]. As a nod to musculoskeletal diseases, once they are safely identified, costochondritis profiles encompass a range of conditions, including trauma or strain, overuse syndromes (such as sports-related), arthritis, fibromyalgia, neoplastic, infectious, post-herpetic, Tietze syndrome, painful wind-fingered xiphoid syndrome, and sliding rib syndrome[3]. Diagnosis of costochondritis is based on clinical examination, which includes reproducible pain on palpation, the crowing rooster snap test, and the adduction test of the cross-chest. While evidence is scant, modalities such as heat application, non-steroidal anti-inflammatory drugs, Lidocaine patches, capsaicin cream, physiotherapy, and acupuncture are used to manage the illness. Patients are generally easier to manage and settle with conservatively

intractable patients who persist in steroid injection therapy and suffer from managing development[2,3]. However, costochondritis may significantly limit function and cause disproportionate anxiety in patients[4].

Epidemiological studies suggest that postmenopausal women have a 20% to 40% prevalence of thoracic hyperkyphosis, which is due to vertebral compression fractures, osteoporosis, and altered aging hormones. Thoracic hyperkyphosis was defined as having a thoracic kyphotic angle greater than 50° in the sagittal plane[5]. This spinal deformity can cause alterations in biomechanics and respiration or generate musculoskeletal pain, including pain at the anterior chest wall[6]. A handful of clinical and biomechanical studies have suggested an association between musculoskeletal pain in the chest and increased thoracic curvature. It has been proposed that excessive kyphotic angulation alters rib position, increases the stress at the costochondral junction, and predisposes these structures to inflammation[6,7]. However, concrete pieces of evidence that support the link between thoracic kyphosis and costochondritis in postmenopausal women, who often have greater strut and hormonal risk, are still lacking.

Most prior research has analyzed spinal posture or chest pain in isolation. For example, Katzman et al.[6] associated osteoporotic women with thoracic hyperkyphosis and reduced mobility, while Winzenberg et al.[8] discussed the pain and musculoskeletal disorders. Still, there is a lack of research that examines the correlation between the curvature of the thoracic spine and inflammation of the costal cartilage.

This study aims to fill this gap by assessing the relationship between the kyphosis angle of the thoracic vertebrae and the degree of costochondritis in postmenopausal women. Understanding this relationship deepens knowledge and facilitates precise physical therapy planning for this specific group of patients. We hypothesized that there is a significant positive correlation between the thoracic kyphosis angle and the severity of costochondral pain.

Methodology:

Study Design and Setting: This cross-sectional observational study was conducted from June 2023 to March 2025 at the outpatient clinics of the musculoskeletal and women's health clinics and the Faculty of Physical Therapy, Misr University for Science and Technology, Giza, Egypt. The study has ethical references from Sinai University with a number [SU.REC.2025 (52 H)], and consent from all participants has also been appropriately documented.

Participants: This study recruited 290 postmenopausal women aged between 50 and 60 years. Participants were assessed for costochondritis based on a clinical examination by an orthopedist, using standard criteria that included localized tenderness over the costosternal junctions and the exclusion of cardiac causes. Out of the recruited 290 participants, 270 met the inclusion criteria who were subdivided into two groups: Group A (the costochondritis group), comprising 146 women clinically diagnosed with costochondritis, and Group B (the control group), comprising 124 women without symptoms of chest wall pain (Fig. 1).

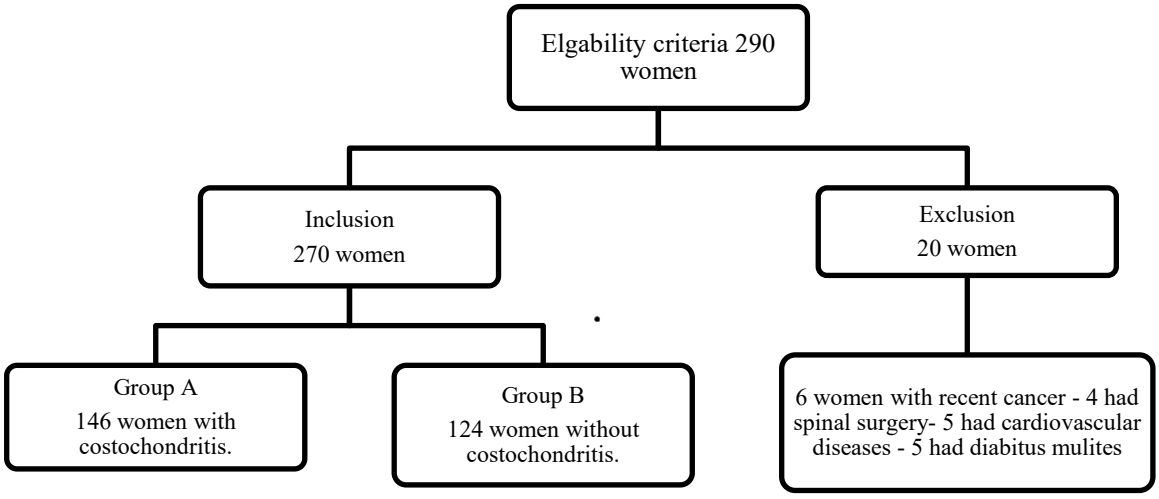

Fig. 1: Flow chart of the study

Inclusion Criteria: Females aged 50–60 years with at least 12 months of natural menopause. Participants could stand unaided and had no history of surgery to the thorax or spine. The body mass index (BMI) ranged from 25.0 to 29.9 kg/m².

Exclusion Criteria: Patients with a history of cardiovascular, pulmonary, or other systemic inflammatory conditions that could mask present chest pain. Patients with spinal fractures or any recent trauma, past blasts of rib or thoracic trauma, surgical procedures involving the thorax, or significant operations on the chest wall. Autoimmune disorders like rheumatoid arthritis and rheumatoid spondylitis are accompanied by osteoporotic vertebral deformities, as well as osteoporotic vertebral fractures with considerable spinal alignment deformities. Also excluded were patients with marked neuromuscular disorders affecting posture or mobility about the thorax, or those who are unable, due to noncompliance, to follow study procedures or complete study assessments. Women with diagnosed fibromyalgia or other generalized musculoskeletal disorders. Women are diagnosed with any form of malignancy.

Thoracic Kyphosis Angle Measurement: The angle was measured using a Baseline Bubble Inclinometer (Fabrication Enterprises Inc., USA). The bubble inclinometer is considered a valid and reliable tool for measuring the thoracic kyphosis angle with good to excellent intra-rater reliability. It has an ICC of 0.89, with a 95% confidence interval of 0.73 to 0.96[9,10]. Each participant was instructed to take off their shoes and stand upright. Two skin markers were applied to the participant's skin above the C7 and T12 spinous processes while the physiotherapist stood behind them. The therapist requested that the patient extend forward and place their finger on both the C6 and C7 spinous processes to palpate the position of the C7 spinous process. While the C6 spinous process moved anteriorly and the thoracic spinous processes were recognized by palpating the spinous processes to T12, the C7 spinous process shouldn't have moved. The inclinometer's caudal end was then positioned on the C7 skin markers, and the process was repeated for the lower thoracic spine T12 to determine the thoracic inclination. The difference between the two earlier measurements from the inclinometer readings was used to calculate the thoracic kyphotic angle[11]. This procedure was done three times, and the mean value calculated was used. All measurements were performed in a quiet, temperature-regulated room. The room had blinds that allowed for privacy curtains, providing the participants with a comfortable and relaxed environment conducive to rest. In the sagittal plane, the T1 and T12 vertebral bodies are separated by the thoracic kyphosis angle. The typical range of the thoracic kyphotic angle was 20° to 45°. The kyphotic angle of more than 50° is known as hyperkyphosis[11]

Visual Analog Scale (VAS) for Pain: Assessing pain severity for the costochondritis group was done with the Visual Analogue Scale (VAS), a 10-centimetre line ranging from “0 = no pain” to “10 = worst imaginable pain.” They were asked to indicate the level of pain they experienced, and it was recorded in centimeters from the left side of the line. We considered benchmarks outlined in clinical pain research to determine the severity of costochondral pain when assigning basic thresholds to pain severity on the visual analog scale (VAS). A VAS score of 0 to 3 cm is regarded as mild pain, 4 to 6 cm as moderate pain, and 7 to 10 cm as severe pain. For this study, as Boonstra et al. (2008) suggested, classifying clinically significant costochondral pain using a cutoff of ≥ 4 cm was beneficial, as their findings indicated that scores of 4 or greater tend to reflect moderate to severe pain and functional impact on daily activities[12]. Regarding pain fluctuation, participants were instructed to rate their average pain level over the past three days, rather than a single moment, to minimise the impact of daily variability[13].

Procedure and Environment: To minimize the risk of inter-rater bias, all measurements were conducted in a single session by the same physical therapist. Every subject had a rest period between the measurements. The room's design was psychologically designed to ensure both physical and psychological comfort, enabling the subjects to achieve a preferred neutral position and minimize extraneous factors.

Sample size:

The sample size calculation was conducted using G*Power software program (version 3.1.9.7). The power analysis revealed that at least 111 women were needed for the t-tests family (correctional: biserial model), a power (1-β error probability) = 95%, α error level probability = 0.05 and an effect size = 0.3. The current study included 270 women; Group A (the costochondritis group), comprising 146 women and Group B (the control group), comprising 124 women.

Statistical Analysis:

Descriptive statistics (mean ± SD) were calculated for thoracic angle, VAS, and BMI values. Independent t-tests were employed to determine the difference in means for the two groups. The relationship between the two variables, thoracic

angle and VAS, was tested for Pearson correlation. A multiple linear regression model was devised to ascertain the determinants of costochondral pain severity. Statistical significance was accepted at $p < 0.05$.

Results:

The unpaired t-test revealed non-significant differences between the two groups regarding participants' age, body mass, and height (Table 1).

Table 1. Demographic data for postmenopausal women with and without Costochondritis

	Costochondritis group (A)	Control group (B)	t-value	p-value
Age (years)	55.411 ± 3.247	55.00 ± 3.169	1.048	0.296
Body mass (kg)	72.823 ± 7.161	72.439 ± 7.269	0.436	0.663
Height (cm)	162.60 ± 6.903	162.04 ± 7.407	0.645	0.519

* Significant at alpha level< 0.05. Data are represented as Mean ± SD

By comparing the measured variables between the two groups, the results showed significant increases ($p < 0.001$) in the mean values of the VAS score and thoracic angle in group A compared with group B. However, there was no significant difference ($p > 0.05$) in the mean BMI value of participants between the two groups (Table 2).

The Pearson correlation coefficient revealed a strong positive correlation between the VAS score and the thoracic kyphosis angle in postmenopausal women ($r = 0.852$, $p < 0.01$). Conversely, there was an extremely low, non-significant negative correlation between the VAS score and BMI in postmenopausal women ($r = -0.021$, $p = 0.365$).

The multiple linear regression analysis revealed that the independent variables, thoracic angle and BMI, strongly predict the severity of costochondral pain (as measured by the VAS score) in postmenopausal women ($F(2,267) = 354.093$, $p < 0.001$). Additionally, R^2 0.726 depicts that the model explains 72.6% of the variance in the VAS score.

Moreover, the coefficients were studied to detect the impact of each variable (thoracic angle and BMI) on the VAS score in postmenopausal women. The results showed that the thoracic kyphosis angle had a substantial and positive impact on the VAS score ($B = 0.555$, $t = 26.604$, $p < 0.001$). However, BMI does not affect the VAS score ($B = 0.043$, $t = 0.551$, $p = 0.582$).

Table 2. Comparison of all measured variables between postmenopausal women with and without Costochondritis

	Costochondritis group (A)	Control group (B)	Mean difference (95% CI)	t-value	p-value
VAS	7.657± 1.735	1.330±1.124	6.326 (5.969 to 6.684)	34.849	0.001*
Thoracic Kyphosis angle (degrees)	54.809± 2.154	45.401±3.034	9.408 (8.784to 10.033)	29.684	0.001*
BMI (kg/m²)	27.493± 1.361	27.548±1.503	-0.054 (0.398 to 0.288)	- 0.314	0.754

VAS: Visual Analog Scale, BMI: Body Mass Index, CI: Confidence Interval, *Significant at alpha level < 0.05. Data are represented as Mean±SD

Discussion:

According to the significant difference ($p < 0.001$) between the two groups in the VAS score, it is explained that costochondritis elevates the VAS score as it significantly increases chest wall pain, which is what the VAS seeks to quantify or measure[14]. Additionally, there was a significant increase ($p < 0.001$) and a substantial rise ($p < 0.001$) in thoracic kyphosis angle in the costochondritis group compared with the control group. It should be taken into consideration that causality cannot be drawn between the increased thoracic kyphosis angle in an individual and the severity of costochondral pain due to the cross-sectional design of the current study.

The significant increase in the VAS score in the costochondritis group may be explained by the reduction in back extensor muscle strength and endurance associated with thoracic hyperkyphosis. The endurance of the back extensor muscles has been previously studied as a potential risk factor for thoracic pain[15]. It has also been noted as a characteristic that increases the likelihood of experiencing low back pain[16,17] and chronic neck pain[18]. While the relationship between upper back extensor muscle endurance and thoracic pain remains ambiguous, suggesting that the functionality of back muscles can influence the compressive loading of the thoracic spine, potentially contributing to the onset of thoracic pain[19]. The impact of spinal loading due to inadequate back muscle endurance and its implications for spinal pain has been a longstanding topic in low back pain research[20]. Given that the upper back extensor muscles primarily serve a postural role[18], it is reasonable to assume that a lack of endurance could adversely affect spinal loading over time, potentially leading to symptoms. Enhancing back muscle function to alleviate the compressive loading on the thoracic spine can improve thoracic posture.

The difference in the thoracic angle between both groups is explained by the normal thoracic kyphosis angle for women, which is considered to range from 20° to 40° when measured with any radiographic or clinical instruments, such as Cobb's X-ray or an inclinometer[9,21]. A kyphosis angle of 40° to 50° is considered normal, while an angle greater than 50° is classified as hyperkyphosis. This value can change slightly based on the thoracic kyphosis angle, which is known to increase with age, especially after menopause, due to reductions in bone density and changes in spinal alignment[5]. Osteoporosis, lack of discipline in maintaining correct posture, and spinal deformities such as hyperkyphosis have led to increased spinal curvature beyond normal limits[5-7]. Hyperkyphotic posture not only increases postural back pain but also increases the risk of falls, thereby increasing the risk of bone fractures[21].

Furthermore, this study's findings showed a strong positive correlation between thoracic kyphosis angle and thoracic spine pain in postmenopausal women. According to Strong, hyperkyphosis in the thoracic region is associated with greater pain, regardless of its one-dimensional measurement in the form of the VAS score. A biomechanical explanation can be offered for the sharp pain of costochondritis. It is reasonable to postulate that chronic postural alterations can contribute to the development of pain and deformity, thereby exacerbating the disease. In this situation, a massive muscle imbalance due to improper posture may be a feature of the disability syndrome, which is responsible for the reduction of the patient's functional abilities.

This conclusion was challenged by the research conducted by Petronilla et al. (2024), which indicated that an increase in thoracic spine posture, such as hyperkyphosis, does not correlate with thoracic spine pain in postpartum women[22]. The discrepancy in findings may stem from the fact that a significant portion of their sample consisted of postpartum women exhibiting normal thoracic spine posture values, which are not typically associated with pain, as only 16% reported experiencing pain. Among those with hyperkyphotic postures, there was uncertainty regarding the duration and permanence of these deformities. The current study can't determine the duration of such postural deformities due to its cross-sectional design. Prolonged deformities, such as hyperkyphosis, are likely to result in more adverse effects, including pain, as evidenced by other studies that have explored similar relationships in different populations and yielded comparable results[21,23]. For example, Kado et al.[23] demonstrated an association between thoracic kyphosis and interscapular pain in postmenopausal women.

According to kyphotic posture, in some cases, supporting evidence has been reported to be associated with pain, which some studies claim may be because of increased thoracic kyphosis. This suggests that such postural deviations may affect discomfort levels. NADIA et al. (2021) found that patients having thoracic hyper-kyphosis showed an exacerbated head forward posture and increased pain levels as well[24]. This suggests that thoracic kyphosis may also contribute to pain in adjacent areas, such as the chest region.

Additionally, Kupeli et al. (2021) observed that patients with chronic obstructive lung disease and kyphotic deformity of the thoracic vertebrae also experienced higher rates of back pain[25]. Although the primary focus of the study was back pain, it underscores the fact that other changes in the thorax may influence the perception of pain.

The current study findings revealed that BMI is not a risk factor for the development of thoracic pain in postmenopausal women with costochondritis. On the other hand, Contradictory Evidence, other research has placed greater focus on the presence of group elements like BMI, size of the breasts, and the working posture regarding the development of pain, where thoracic kyphosis did not present a considerable direct association, as a study conducted on dentists found no significant relationship between the thoracic kyphosis angle and the intensity of low back pain. The authors suggested that other factors, such as work posture or body mass index (BMI), may contribute to the development of pain[7].

Also, Spencer and Briffa's (2013) research found that greater breast size, along with increased BMI, did accompany an increase in thoracic pain[26]. However, the authors found no dominant association between thoracic kyphosis and pain. This suggests that other mechanical factors may have a greater influence on how pain is perceived.

Limitation:

1. It is important to note that the thoracic kyphosis angle in an individual and the severity of costochondral pain cannot be regarded as causal due to the cross-sectional design of the study.
2. Generalizability is limited due to the study's reliance on a singular population sample.
3. Other unexplored confounding components for measurement.
4. This study did not assess physical activity.
5. This study is limited by the use of VAS pain reporting, which we subjectively categorized without consideration of possible daily or weekly cycles in pain perception that could influence the variability of the outcomes.
6. The lack of blindness.

Clinical Impacts:

The critical correlation between anatomical hyperkyphosis of the thoracic spine and the severity of costochondral pain underscores the need for refinement of posture during clinical assessment. Including spinal curvatures in routine checks promotes early detection and treatment of problems. Pain management in the costochondral region through physiotherapy can be achieved through non-invasive measures, such as corrective posturing, strengthening the thoracic extensors, and ergonomic training. Prompt treatment may improve physical capacity and functioning for the affected population.

Recommendation:

To delineate the association between thoracic kyphosis and pain from costochondritis
Specialized investigations are required for patients with costochondritis to evaluate the effect of thoracic kyphosis and assess the impact of thoracic kyphoscoliosis on pain. To hone in on the effects of kyphosis, compare and control extraneous variables such as body mass index, occupation's posture, and breast size. Develop and maintain studies to determine the relationship between changes in posterior thoracic alignment over time and the course of pain improvement.

Conclusion:

Costochondral pain severity increases with the degree of thoracic kyphosis in postmenopausal women. Thoracic hyperkyphosis could be viewed as a risk factor for the development of costochondral pain in postmenopausal women.

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Conflict of Interest:

author. The author declares no conflicting interests. The author declares no conflicting interests. The author declares no contradictory interests.

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