Acute effects of chest binding on respiratory mechanics and cervicothoracic kinematics in healthy females: a randomized crossover study

Efectos agudos del vendaje torácico sobre la mecánica respiratoria y la cinemática cervicotorácica en mujeres sanas: un ensayo cruzado aleatorizado

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Abstract

Introduction: Chest binding is widely used for gender affirmation, yet its acute biomechanical impacts remain unclear.
Objective: This study aims to investigate the immediate effects of a commercial chest binder on respiratory mechanics and cervicothoracic kinematics.
Methodology: Thirty-two healthy females completed a randomized crossover study comparing a control condition (no bra) to a chest binder. Outcome measures included pulmonary function (spirometry), regional chest expansion, thoracic kyphosis, and cervical range of motion (CROM).
Results: Chest binding significantly reduced FEV1 ($p < 0.001$) and the FEV1/FVC ratio ($p = 0.038$). Chest expansion was severely restricted at the middle (-3.87 cm, $p < 0.001$) and lower lobes (-2.35 cm, $p < 0.001$). Additionally, the anterior compression significantly increased thoracic kyphosis from 34.52 degrees to 36.54 degrees ($p = 0.032$), which subsequently reduced CROM across all six anatomical planes (all $p < 0.05$).
Conclusion: The acute application of a chest binder significantly limits regional chest wall excursion and dynamic pulmonary function. Concurrently, it induces a hyper-kyphotic posture that restricts cervical mobility, highlighting the need for safe binding guidelines and targeted postural rehabilitation.

Keywords

Chest binding; pulmonary function; chest expansion; cervical kinematics; thoracic kyphosis.

Resumen

Introducción: El vendaje torácico (*chest binding*) se utiliza ampliamente para la afirmación de género; sin embargo, sus impactos biomecánicos agudos aún no están del todo claros.
Objetivo: Este estudio tiene como objetivo investigar los efectos inmediatos de un vendaje torácico comercial sobre la mecánica respiratoria y la cinemática cervicotorácica.
Metodología: Treinta y dos mujeres sanas completaron un ensayo cruzado aleatorizado en el que se comparó una condición de control (sin sostén) con el uso de un vendaje torácico. Las medidas de resultado incluyeron la función pulmonar (espirometría), la expansión torácica regional, la cifosis torácica y el rango de movimiento cervical (CROM, por sus siglas en inglés).
Resultados: El vendaje torácico redujo significativamente el FEV1 ($p < 0{,}001$) y el cociente FEV1/FVC ($p = 0{,}038$). La expansión torácica se vio severamente restringida a nivel de los lóbulos medios (-3,87 cm, $p < 0{,}001$) e inferiores (-2,35 cm, $p < 0{,}001$). Además, la compresión anterior aumentó de manera significativa la cifosis torácica, pasando de 34,52 grados a 36,54 grados ($p = 0{,}032$), lo que consecuentemente redujo el CROM en los seis planos anatómicos (todos los $p < 0{,}05$).
Conclusión: La aplicación aguda de un vendaje torácico limita de manera significativa la excursión regional de la pared torácica y la función pulmonar dinámica. De forma concurrente, induce una postura hipercifótica que restringe la movilidad cervical, lo que subraya la necesidad de establecer directrices para un vendaje seguro, así como programas de rehabilitación postural dirigida.

Palabras clave

Vendaje torácico; función pulmonar; expansión torácica; cinemática cervical; cifosis torácica.

Introduction

Chest binding is a widely utilized practice among transgender, nonbinary, and gender diverse populations, particularly those assigned female at birth, to flatten the anterior chest wall and align their physical appearance with their gender identity (Julian et al., 2021; Peters et al., 2024). Historically, individuals employed restrictive materials such as elastic bandages or rigid garments, which frequently resulted in dermatological irritation and severe pectoral muscle inflammation (Institute of Medicine Committee on Lesbian et al., 2011). In recent years, commercial chest binders constructed from low elasticity synthetic fabrics have become the standard method for chest compression. While these garments provide substantial psychological benefits by alleviating gender dysphoria, the application of external circumferential pressure imposes significant physiological and biomechanical constraints on the human body (Cumming et al., 2016; Peters et al., 2024). Epidemiological surveys have documented a high prevalence of physical discomforts and musculoskeletal symptoms associated with routine binding, including acute shortness of breath, chronic chest pain, lower back pain, and noticeable postural deviations (Julian et al., 2021; Peitzmeier et al., 2017).

From a rigorous respiratory biomechanics perspective, the application of external compressive forces to the thorax is hypothesized to directly restrict the normal kinematics of the chest wall. The external compression is hypothesized to reduce overall chest wall compliance, which may impede the physiological expansion of the pulmonary system during the inspiratory phase (Marini & Gattinoni, 2021). This mechanical restriction potentially alters the optimal length-tension relationships of the primary respiratory muscles, which could consequently diminish respiratory efficiency. Previous clinical investigations suggest that prolonged chest binding is associated with reductions in key pulmonary function parameters, most notably the forced vital capacity (FVC) and the forced expiratory volume in one second (FEV1) (Akgül et al., 2025; Sintara, 2017).

Beyond the immediate alterations in respiratory mechanics, chest binding introduces substantial biomechanical perturbations to the musculoskeletal system through the kinetic chain principle. The continuous anterior compressive force alters the center of mass of the upper trunk, inducing a series of compensatory postural adaptations (Attali et al., 2019). To mitigate anterior soft tissue tension and alleviate localized discomfort, individuals frequently adopt a flexed spinal posture, leading to a clinically observable increase in the thoracic kyphosis angle (Peitzmeier et al., 2017). Biomechanically, an exaggerated thoracic curve shifts the load distribution across the intervertebral discs and triggers a cascade of compensatory kinematic adjustments upward along the cervical spine, frequently resulting in a forward head posture. This structural malalignment alters the resting length of the cervical musculature, increases posterior fascial tension, and modifies the normal gliding mechanics of the cervical facet joints. Consequently, the altered cervical arthrokinematics restrict the active cervical range of motion across multiple anatomical planes, leading to joint stiffness and potential neuromuscular pain (Audette et al., 2010).

Despite the growing recognition of the adverse effects associated with prolonged chest binding, the current literature is predominantly limited to retrospective survey based studies and long term physiological assessments. There remains a critical lack of empirical, quantitative data regarding the immediate biomechanical and physiological responses following the acute application of a chest binder. Previous studies have primarily relied on the subjective reporting of clinical symptoms, such as perceived dyspnea and feelings of restricted chest expansion (Peitzmeier et al., 2017). This leaves a substantial knowledge gap concerning the acute, measurable alterations in multi segmental biomechanics. Specifically, the immediate impact of modern chest binders on the regional excursion of the chest wall at specific anatomical levels (upper, middle, and lower lobes), coupled with the acute kinematic adaptations of the cervical spine and the thoracic posture, remains unexplored. Understanding these acute physiological and biomechanical deviations is essential for elucidating the underlying pathomechanical mechanisms of binder related injuries.

Therefore, the primary objective of this pilot study was to investigate the immediate effects of wearing a commercial chest binder on pulmonary function, regional chest expansion, cervical range of motion, and thoracic kyphosis in healthy female participants. Based on the principles of respiratory and structural biomechanics, it was hypothesized that the acute application of a chest binder would significantly reduce dynamic pulmonary function parameters, specifically FEV1 and FVC, while maintaining a normal

FEV1 to FVC ratio above the standard clinical threshold (Moore, 2012). Furthermore, it was hypothesized that chest expansion would be significantly restricted, particularly at the middle and lower anatomical lobes where the magnitude of diaphragmatic excursion is most prominent (Marini & Gattinoni, 2021). Additionally, the restrictive intervention was expected to induce an immediate postural deviation characterized by an increased thoracic kyphosis angle and a concurrent reduction in the active cervical range of motion across all primary movement directions. The empirical findings derived from this study aim to provide robust biomechanical evidence to inform clinical screening protocols, guide targeted physical therapy interventions, and promote safe binding practices for individuals utilizing chest compression garments.

Method

Study Design and Ethical Approval

A randomized, controlled, crossover study was conducted to investigate the immediate effects of wearing a chest binder on pulmonary function, chest expansion, cervical kinematics, and thoracic spinal posture in healthy females. The experimental protocol was reviewed and approved by the Human Research Ethics Committee of Mae Fah Luang University (Certificate of Approval No: 229/2024; Project Code: EC 24138-25). The study was conducted in strict accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants prior to data collection.

Participants

Thirty-two healthy female participants were recruited for this study. The sample size was determined a priori based on a pilot study using an established sample size calculation framework for crossover designs (Viechtbauer et al., 2015), ensuring 80% statistical power and an alpha level of 0.05.

The inclusion criteria were: (1) biological females aged between 18 and 25 years; (2) chest circumference between 32 and 36 inches; (3) normal body mass index (BMI) ranging from 18.5 to 24.9 kg/m^2; and (4) no prior experience wearing chest binders. Participants were excluded if they presented with musculoskeletal injuries affecting the respiratory muscles (diaphragm, intercostals, abdominals, or pectorals) lasting more than three weeks, or if they reported a Visual Analog Scale (VAS) pain score greater than 3 during maximum inhalation and exhalation. Further exclusion criteria included cervical pain limiting the full range of motion, severe spinal pathologies (e.g., cervical spondylosis, herniated discs), cardiovascular diseases (e.g., uncontrolled hypertension, recent myocardial infarction), respiratory conditions (e.g., asthma, chronic obstructive pulmonary disease), or contraindications for spirometry testing (e.g., recent eye or thoracic surgery, aneurysms, active respiratory infections). The baseline demographic and anthropometric characteristics of the participants are summarized in Table 1.

Table 1. General characteristics of the participants (N = 32)

Characteristics	Mean ± SD
Age (years)	20.5 ± 0.94
Height (cm)	161.03 ± 1.78
Weight (kg)	54.81 ± 4.81
Body Mass Index (kg/m^2)	21.12 ± 1.78
Chest circumference (cm)	32.78 ± 1.11

Experimental Protocol and Randomization

Following screening and enrollment, participants were randomly allocated into one of two testing sequences. To prevent selection bias, the randomization sequence was generated by an independent research assistant who was not involved in the clinical assessments. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes. Participants randomly drew an envelope to determine their initial testing sequence. Sequence 1 began with the control condition followed by the chest binding condition, whereas Sequence 2 performed the conditions in the reverse order.

For the control condition, participants were instructed to wear no bra (utilizing silicone nipple covers) underneath a loose-fitting outer shirt. For the intervention condition, participants wore a half-body chest binder constructed from breathable, low-elasticity Tero fabric featuring side-adjustable hooks to compress and flatten the breast tissue. A minimum washout period of 24 hours was strictly implemented between the two testing sessions to eliminate any potential neuromuscular or physiological carryover effects (Talwar et al., 2024). Prior to testing, resting blood pressure and heart rate were monitored to ensure participant safety.

Data Collection and Outcome Measures

To ensure high inter-rater reliability, all clinical assessments were conducted by a single trained female assessor (Intraclass Correlation Coefficient, ICC = 0.94). Four primary biomechanical and physiological assessments were performed in a standardized sequence. For the chest binding condition, measurements were taken immediately after the binder was applied.

Chest Expansion

Chest wall excursion was measured using a standard anthropometric measuring tape (Padkao & Boonla, 2020; Reddy et al., 2019). Measurements were performed with participants in a seated position with hips and knees at 90 degrees. Data were collected at three distinct anatomical levels: the upper lobe (mid-axillary line at the sternal angle/T4-T5 intervertebral disc), the middle lobe (level of the xiphoid process/7th rib), and the lower lobe (level of the 10th rib). The raw data consisted of the chest circumference recorded at the peak of a maximal inhalation and the end of a maximal forced exhalation. The analytical variable (chest expansion) was mathematically extracted by calculating the absolute difference (in cm) between these two raw values. Three repetitions were performed with a 1-minute rest interval between each, and the average difference was used for statistical analysis.

Cervical Range of Motion (CROM)

Cervical kinematics were assessed using a standardized Cervical Range of Motion (CROM) device (Audette et al., 2010). Participants were seated with their backs supported. Active range of motion was recorded in six anatomical directions: flexion, extension, right lateral flexion, left lateral flexion, right rotation, and left rotation. Compensatory movements, such as trunk rotation or shoulder elevation, were strictly monitored and prevented. Three valid trials were recorded for each direction, separated by a 1-minute rest period, and the mean values (in degrees) were extracted for analysis.

Thoracic Kyphosis

The postural alignment of the thoracic spine was evaluated using a flexible ruler, a valid and reliable non-invasive tool for measuring spinal curvature (Seidi et al., 2009). While the participant stood in a relaxed posture, the spinous processes of C7 and T12 were palpated and marked. The flexible ruler was molded to the exact contour of the thoracic spine between these two anatomical landmarks. The molded ruler was then carefully transferred to a flat sheet of paper to trace the raw spinal curve. From this raw geometric tracing, a straight vertical line connecting the C7 and T12 marks was drawn to represent the length (L). A second perpendicular line was drawn from L to the deepest point (apex) of the curve to determine the height (H). The final variable, the thoracic kyphosis angle (θ), was calculated using the following mathematical equation:

$$\theta = 4 \arctan\left(\frac{2H}{L}\right)$$

This procedure was repeated three times with a 1-minute rest interval, and the calculated angles were averaged.

Pulmonary Function Test

Following a 15-minute rest period, pulmonary function was evaluated using a digital spirometer (Fernández-Villar et al., 2018). Participants were seated, fitted with a nose clip, and instructed to seal their lips tightly around the mouthpiece. The testing protocol required participants to inhale maximally and subsequently perform a forced, maximal exhalation lasting at least 6 seconds. Raw spirometric flow-volume curves were generated during each maneuver. To prevent performance bias, visual feedback from the computer monitor was concealed from the participants. A minimum of three acceptable and reproducible curves were required, with a maximum limit of eight attempts permitted to ensure safety.

The final physiological variables extracted from the optimal flow-volume curve included the Forced Vital Capacity (FVC, %), Forced Expiratory Volume in 1 second (FEV1, %), and the FEV1/FVC ratio (%).

Statistical Analysis

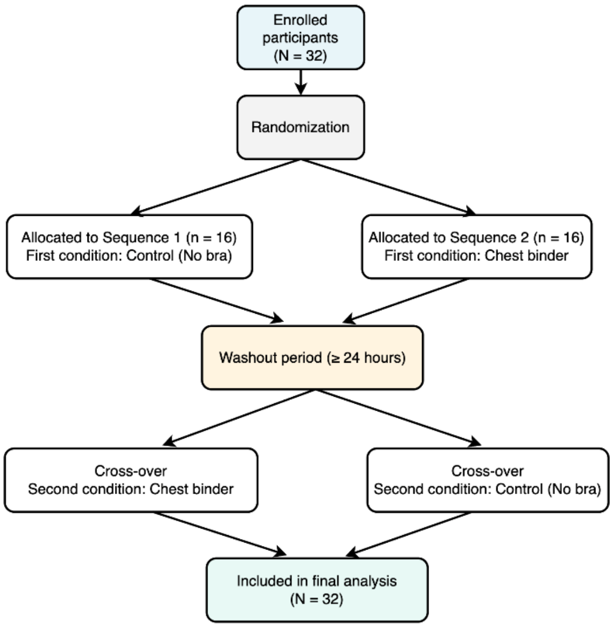
All statistical analyses were performed using IBM SPSS version 21 Statistics software (SPSS Inc., Chicago, IL, USA). Descriptive statistics were utilized to summarize the demographic and anthropometric data. The Shapiro-Wilk test was applied to assess the normality of data distribution for all calculated variables. For continuous variables demonstrating a normal distribution (chest expansion at the middle and lower lobes; CROM extension, right rotation, and bilateral lateral flexions; thoracic kyphosis; and FVC), Paired-samples t-tests were employed to analyze the mean differences between the pre-binding (control) and post-binding conditions. For variables violating the assumption of normality (FEV1/FVC, FEV1, CROM flexion, and left rotation), the non-parametric Wilcoxon signed-rank test was utilized. The level of statistical significance was set a priori at $p < 0.05$.

Results

Demographic characteristics of the participants

Thirty-two healthy female participants successfully completed the crossover study. The participant recruitment, screening, and testing sequence are illustrated in Figure 1. The baseline demographic and anthropometric characteristics, including age, height, weight, body mass index (BMI), and chest circumference, are summarized in Table 1. All participants were within a normal BMI range.

Figure 1. Flow diagram of the randomized controlled crossover study.



Note: thirty-two healthy female participants were enrolled and randomly assigned to one of two testing sequences (n = 16 per sequence). Sequence 1 began with the control condition (no bra) followed by the chest binding condition, whereas Sequence 2 began with the chest binding condition followed by the control condition. A minimum washout period of 24 hours was implemented between the two testing sessions to eliminate potential carryover effects. All participants successfully completed both testing phases and were included in the final analysis.

Immediate effects of chest binding on pulmonary function

The pulmonary function parameters assessed via spirometry before and immediately after wearing the chest binder are presented in Table 2. The analysis revealed a statistically significant reduction in both the FEV1/FVC ratio ($p = 0.038$) and the FEV1 parameter ($p < 0.001$) following the application of the chest binder. However, there was no significant difference observed in the FVC parameter between the two conditions ($p = 0.052$).

Table 2. Pulmonary function parameters before and after wearing the chest binder

Variables	Pre-binding (N = 32)	Post-binding (N = 32)	95% CI	p-value
FEV1/FVC (%)	93.43 (90.18, 95.96)†	93.11 (85.87, 95.30)†	-	0.038*
FEV1 (%)	97.63 ± 2.16	91.88 ± 2.37	3.43, 8.07	< 0.001***
FVC (%)	94.75 ± 12.58	92.03 ± 13.11	-0.02, 5.46	0.052

Note: Data are presented as Mean ± SD or †Median (Q1, Q3) due to non-normal distribution (Wilcoxon signed-rank test); 95% CIs of the mean difference are not applicable for non-parametric variables. * $p < 0.05$, *** $p < 0.001$.

Immediate effects of chest binding on chest expansion

Table 3 displays the changes in chest expansion measured at three anatomical levels. While chest expansion at the upper lobe showed no significant alteration ($p = 0.781$), a substantial and statistically significant restriction was observed at both the middle lobe (mean difference = 3.87 cm; $p < 0.001$) and the lower lobe (mean difference = 2.35 cm; $p < 0.001$) immediately after wearing the chest binder.

Table 3. Chest expansion (cm) before and after wearing the chest binder

Anatomical Level	Pre-binding	Post-binding	Mean Difference	95% CI	p-value
Upper lobe	6.18 ± 1.24	6.12 ± 1.64	0.05	-0.36, 0.47	0.781
Middle lobe	6.08 ± 1.26	2.20 ± 0.65	3.87	3.47, 4.26	< 0.001***
Lower lobe	6.05 ± 1.27	3.71 ± 1.38	2.35	1.73, 2.96	< 0.001***

Note: Data are presented as Mean ± SD. *** $p < 0.001$.

Immediate effects of chest binding on cervical range of motion

The immediate impact of chest binding on cervical kinematics is detailed in Table 4. Participants exhibited a statistically significant decrease in the cervical range of motion across all six anatomical directions (flexion, extension, right/left rotation, and right/left lateral flexion) while wearing the chest binder compared to the baseline condition (all $p < 0.05$).

Table 4. Cervical range of motion (degrees) before and after wearing the chest binder

Movement Direction	Pre-binding	Post-binding	Mean Difference	95% CI	p-value
Flexion	67.67 (58.58, 70.67)†	62.34 (56.42, 67.92)†	-	-	< 0.001***
Extension	56.59 ± 9.19	54.00 ± 9.40	2.59	0.72, 4.46	0.008**
Right rotation	46.46 ± 11.15	41.25 ± 10.13	5.21	3.20, 7.23	< 0.001***
Left rotation	50.84 (35.67, 56.25)†	41.67 (35.83, 50.00)†	-	-	< 0.001***
Right lateral flexion	39.55 ± 5.85	37.70 ± 5.41	1.84	0.90, 2.78	< 0.001***
Left lateral flexion	41.58 ± 6.98	39.88 ± 6.56	1.70	0.59, 2.82	0.004**

Note: Data are presented as Mean ± SD or †Median (Q1, Q3) due to non-normal distribution (Wilcoxon signed-rank test); Mean difference and 95% CIs are not applicable for non-parametric variables. $p < 0.01$, *** $p < 0.001$.

Immediate effects of chest binding on thoracic kyphosis

As shown in Table 5, the application of the chest binder induced an immediate postural alteration in the thoracic spine. The thoracic kyphosis angle significantly increased from a baseline mean of 34.52 degrees to 36.54 degrees while wearing the chest binder ($p = 0.032$).

Table 5. Thoracic kyphosis angle (degrees) before and after wearing the chest binder

Variable	Pre-binding	Post-binding	95% CI	p-value
Thoracic kyphosis	34.52 ± 5.91	36.54 ± 7.28	-3.87, -0.18	0.032*

Note: Data are presented as Mean ± SD. * $p < 0.05$.

Discussion

The primary objective of this randomized crossover pilot study was to investigate the immediate biomechanical and physiological effects of commercial chest binding on pulmonary function, regional chest expansion, cervical kinematics, and thoracic posture in healthy females. While chest binding is a crucial practice for affirming gender identity, epidemiological data consistently report adverse physical symptoms, including dyspnea and musculoskeletal pain (Julian et al., 2021). The findings of the current study provide empirical evidence supporting these reports, demonstrating that the acute application of a chest binder significantly restricts chest wall expansion at the middle and lower lobes, impairs dynamic pulmonary function (FEV1 and FEV1/FVC), alters structural posture by increasing thoracic kyphosis, and consequently restricts the cervical range of motion across all anatomical planes.

From a respiratory biomechanics perspective, the significant reduction in chest expansion observed at the middle (mean difference = 3.87 cm) and lower lobes (mean difference = 2.35 cm) reflects a direct mechanical constraint imposed by the circumferential pressure of the binder. External compression applied to the thoracic wall substantially decreases total chest wall compliance (Marini & Gattinoni, 2021). The middle and lower thoracic regions are highly dynamic, relying on the "pump-handle" and "bucket-handle" kinematic movements of the ribs, synchronized with the descent of the diaphragm, to facilitate lung inflation (Wilson, 2016; Zhao et al., 2022). The binder's low-elasticity fabric effectively acts as a restrictive exoskeleton, impeding these physiological excursions (Illi et al., 2012). Interestingly, chest expansion at the upper lobe remained unaffected. This lack of significant change can be explained anatomically. The upper thoracic region is situated above the primary horizontal force vector of the binder, allowing the accessory muscles of respiration (such as the sternocleidomastoid and scalenes) to maintain apical lung expansion without direct mechanical obstruction.

Furthermore, the baseline chest expansion values recorded in this cohort were generally higher than standard reference values previously reported for the general Thai population (Songsorn et al., 2014). This elevated baseline is attributable to the participants' age demographic (18 to 25 years), a period characterized by peak elasticity of the costovertebral joints and maximal diaphragmatic strength (Sharma & Goodwin, 2006). The restriction in chest wall kinematics directly translates to the observed impairments in pulmonary function. The statistical analysis revealed a significant acute decline in FEV1 (Forced Expiratory Volume in 1 second) and the FEV1/FVC ratio, although the ratio remained above the clinical threshold of 70% indicating normalcy (Moore, 2012). The reduction in FEV1 can be elucidated through the neuromuscular length-tension relationship. The inability to fully expand the thorax prevents the inspiratory and expiratory muscles from reaching their optimal functional length. This mechanical limitation causes an excessive overlap of actin and myosin filaments within the sarcomeres, reducing the number of available cross-bridges and subsequently diminishing the maximal contractile force the muscles can generate during a forced exhalation (Sherwood, 2015). These acute physiological alterations are consistent with recent literature highlighting decreased FEV1 and FVC in transgender youth utilizing chest binders (Akgül et al., 2025) , as well as in adolescent populations subjected to rigid spinal orthoses (Yurt et al., 2021). Although the statistical analysis revealed significant acute declines in FEV1 and the FEV1/FVC ratio, these parameters remained within normal clinical thresholds. From a clinical perspective, this indicates that the acute restriction is physiologically compensated at rest. However, this diminished functional respiratory reserve suggests that during physical exertion or increased ventilatory demand, the mechanical constraint could significantly increase the work of breathing, thereby explaining the exertional dyspnea frequently reported by users. If such mechanical restrictions are sustained, they may predispose individuals to long-term respiratory function impairment (Perossi et al., 2025).

Beyond the respiratory system, the acute application of the chest binder induced immediate structural deviations in the spinal column. The current study observed a significant increase in the thoracic kyphosis angle ($p = 0.032$). Biomechanically, the continuous anterior compressive force generated by the binder alters the center of mass of the upper trunk. To alleviate the concentrated tension on the anterior soft tissues and chest wall, the neuromuscular system initiates a compensatory postural adaptation, naturally shifting the thoracic spine into a hyper-kyphotic position (Briggs et al., 2007). This finding provides quantitative validation for prior survey-based research where individuals reported subjective postural changes and upper back discomfort associated with binding practices (Peitzmeier et al., 2017).

This primary deviation in the thoracic spine triggers a secondary biomechanical cascade affecting the cervical region, governed by the kinetic chain principle. An increased thoracic kyphosis inevitably alters the foundational alignment of the cervical spine. To maintain a horizontal visual gaze, the cervical spine must adopt a compensatory forward head posture, which involves lower cervical flexion and upper cervical extension. This structural alteration in the thoracic spine concurrently occurs with a secondary biomechanical cascade affecting the cervical region. An increased thoracic kyphosis alters the foundational alignment of the cervical spine, which is a possible biomechanical mechanism contributing to the observed reductions in the active Cervical Range of Motion (CROM) across all six directions (flexion, extension, bilateral rotation, and bilateral lateral flexion) (Audette et al., 2010). While an acute increase of approximately 2 degrees in thoracic kyphosis and minor reductions in cervical mobility may appear clinically negligible in the short term, their biomechanical implications are significant under chronic conditions. Prolonged maintenance of this altered posture exposes the posterior spinal ligaments and musculature to continuous tensile stress, leading to viscoelastic creep. Over time, this constant mechanical strain can result in muscular fatigue and the development of myofascial pain, providing a pathomechanical rationale for the chronic back and neck discomfort reported by regular binder users. To counteract these postural adaptations, future clinical management should consider incorporating functional exercise interventions. Recent evidence demonstrates that functional training programs significantly reduce thoracic kyphosis and improve postural alignment in young adults (Bogdani et al., 2026). Implementing such targeted core and multi-planar strengthening protocols could serve as a vital conservative strategy to mitigate the spinal biomechanical side effects induced by chronic chest binding.

Given the acute mechanical restriction and potential for muscular fatigue observed in this study, future clinical guidelines for habitual chest binder users should integrate targeted respiratory rehabilitation. Previous research has demonstrated that respiratory rehabilitation programs, particularly when combined with adjunctive therapies such as non-invasive neuromodulation, significantly enhance pulmonary function parameters, including FEV1 and FVC, in populations with compromised ventilatory muscle performance (Fergany et al., 2026). Adapting similar respiratory strengthening protocols could be a viable non-invasive strategy to mitigate the restrictive pulmonary effects and exertional dyspnea associated with chronic chest binding.

While this pilot study provides critical quantitative insights, certain limitations must be acknowledged. First, the sample was restricted to healthy biological females without prior binding experience. The physiological and biomechanical responses inhabitual chest binder users, transgender individuals, or those undergoing testosterone therapy may differ significantly due to chronic tissue remodeling, altered chest wall compliance, and changes in muscle mass. Second, the exact mechanical interface pressure (in mmHg) exerted by the chest binder was not instrumentally quantified using pressure sensors. This limits the reproducibility of the specific compressive force and prevents the establishment of a dose-response relationship between the magnitude of external compression and the degree of biomechanical or respiratory restriction. Future longitudinal investigations with larger, diverse cohorts are warranted to evaluate the cumulative long-term effects of chest binding. Incorporating wearable pressure sensors and dynamic electromyography (EMG) would provide a deeper understanding of the neuromuscular control strategies and muscular fatigue associated with this practice.

Conclusions

This study provides biomechanical evidence suggesting that the acute application of a commercial chest binder is associated with immediate alterations across multiple physiological systems. The external compressive force restricts regional chest expansion at the middle and lower lobes, which appears to alter neuromuscular length-tension dynamics and moderately reduce dynamic pulmonary performance, particularly FEV1. Concurrently, the anterior mechanical load triggers a kinematic chain reaction, characterized by an immediate increase in the thoracic kyphosis angle that subsequently restricts the cervical range of motion in all planes. These findings elucidate the underlying pathomechanical mechanisms responsible for the respiratory and musculoskeletal symptoms frequently reported by individuals who bind their chests. This evidence highlights the necessity for developing safe clinical guidelines, targeted respiratory muscle training, and postural rehabilitation protocols to minimize injury risk and support the physical well-being of individuals utilizing chest compression garments.

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Conflicts of Interest

All authors declare that they have no conflict of interest.

References

Akgül, S., Tüzün, Z., Pehlivantürk Kızılkan, M., Alboğa, D., Yalçın, E., Özçelik, U., Kanbur, N., & Başar, K. (2025). The Impact of Chest Binding on Pulmonary Functions of Trans and Gender Diverse Youth. *Journal of Adolescent Health*, *76*(1), 37-43. https://doi.org/10.1016/j.jadohealth.2024.07.031

Attali, V., Clavel, L., Rouch, P., Rivals, I., Rémy-Néris, S., Skalli, W., Sandoz, B., & Similowski, T. (2019). Compensation of Respiratory-Related Postural Perturbation Is Achieved by Maintenance of Head-to-Pelvis Alignment in Healthy Humans [Original Research]. *Frontiers in Physiology*, *Volume 10 - 2019*. https://doi.org/10.3389/fphys.2019.00441

Audette, I., Dumas, J.-P., Côté, J. N., & De Serres, S. J. (2010). Validity and Between-Day Reliability of the Cervical Range of Motion (CROM) Device. *Journal of Orthopaedic & Sports Physical Therapy*, *40*(5), 318-323. https://doi.org/10.2519/jospt.2010.3180

Bogdani, A., Pano, G., & Lile, A. (2026). Comparative effects of functional and traditional exercise training on thoracic kyphosis in 19–22 years. *Retos*, *77*, 164-175. https://doi.org/10.47197/retos.v77.117741

Briggs, A. M., van Dieën, J. H., Wrigley, T. V., Greig, A. M., Phillips, B., Lo, S. K., & Bennell, K. L. (2007). Thoracic Kyphosis Affects Spinal Loads and Trunk Muscle Force. *Physical Therapy*, *87*(5), 595-607. https://doi.org/10.2522/ptj.20060119

Cumming, R. J. M., Sylvester, K., & Fuld, J. (2016). P257 Understanding the effects on lung function of chest binder use in the transgender population. *Thorax*, *71*(Suppl 3), A227. https://doi.org/10.1136/thoraxjnl-2016-209333.400

Fergany, L. A., Abdelmoneam, H., El-Sayed, S. A. E. A., Heneidy, W. E., Shaban, S. M., Zaid, A. A. A. A., & Mohamed, M. A. R. (2026). Noninvasive neuromodulation as an adjunct rehabilitation strategy for respiratory dysfunction in individuals with low-level spinal cord injury. *Retos*, *75*, 698-706. https://doi.org/10.47197/retos.v76.118409

Fernández-Villar, A., Represas-Represas, C., Mouronte-Roibás, C., Ramos-Hernández, C., Priegue-Carrera, A., Fernández-García, S., & López-Campos, J. L. (2018). Reliability and usefulness of spirometry performed during admission for COPD exacerbation. *PLOS ONE*, *13*(3), e0194983. https://doi.org/10.1371/journal.pone.0194983

Illi, S. K., Held, U., Frank, I., & Spengler, C. M. (2012). Effect of respiratory muscle training on exercise performance in healthy individuals: a systematic review and meta-analysis. *Sports Med*, *42*(8), 707-724. https://doi.org/10.1007/bf03262290

Institute of Medicine Committee on Lesbian, G. B., Transgender Health, I., Research, G., & Opportunities. (2011). The National Academies Collection: Reports funded by National Institutes of Health. In

The Health of Lesbian, Gay, Bisexual, and Transgender People: Building a Foundation for Better Understanding. National Academies Press (US) Copyright © 2011, National Academy of Sciences. https://doi.org/10.17226/13128

Julian, J. M., Salvetti, B., Held, J. I., Murray, P. M., Lara-Rojas, L., & Olson-Kennedy, J. (2021). The Impact of Chest Binding in Transgender and Gender Diverse Youth and Young Adults. *Journal of Adolescent Health*, *68*(6), 1129-1134. https://doi.org/10.1016/j.jadohealth.2020.09.029

Marini, J. J., & Gattinoni, L. (2021). Improving lung compliance by external compression of the chest wall. *Critical Care*, *25*(1), 264. https://doi.org/10.1186/s13054-021-03700-8

Moore, V. C. (2012). Spirometry: step by step. *Breathe*, *8*, 232 - 240.

Padkao, T., & Boonla, O. (2020). Relationships between respiratory muscle strength, chest wall expansion, and functional capacity in healthy nonsmokers. *J Exerc Rehabil*, *16*(2), 189-196. https://doi.org/10.12965/jer.2040080.040

Peitzmeier, S., Gardner, I., Weinand, J., Corbet, A., & Acevedo, K. (2017). Health impact of chest binding among transgender adults: a community-engaged, cross-sectional study. *Culture, Health & Sexuality*, *19*(1), 64-75. https://doi.org/10.1080/13691058.2016.1191675

Perossi, J., Prudêncio, J. L. G., Wolf, A. E., Belarmino, H. S., dos Santos, D. O., & Gastaldi, A. C. (2025). Influence of Chest Binding on Respiratory Function of Transgender Men. *Archivos de Bronconeumología*, *61*(2), 101-103. https://doi.org/https://doi.org/10.1016/j.arbres.2024.09.010

Peters, M. R., Gross, D. P., & Bostick, G. (2024). Symptoms and Experiences of Chest Binding: A Cross-Sectional Survey Using a Patient-Oriented, Harm Reduction Approach. *Transgender Health*, trgh.2024.0125. https://doi.org/10.1089/trgh.2024.0125

Reddy, R. S., Alahmari, K. A., Silvian, P. S., Ahmad, I. A., Kakarparthi, V. N., & Rengaramanujam, K. (2019). Reliability of Chest Wall Mobility and Its Correlation with Lung Functions in Healthy Nonsmokers, Healthy Smokers, and Patients with COPD. *Canadian Respiratory Journal*, *2019*(1), 5175949. https://doi.org/https://doi.org/10.1155/2019/5175949

Seidi, F., Rajabi, R., Ts, E., & Sj, M. (2009). Iranian Flexible ruler Reliability and Validity in Lumbar Lordosis Measurement. *World Journal of Sport Sciences*, *2*, 95-99.

Sharma, G., & Goodwin, J. (2006). Effect of aging on respiratory system physiology and immunology. *Clin Interv Aging*, *1*(3), 253-260. https://doi.org/10.2147/ciia.2006.1.3.253

Sherwood, L. (2015). *Human Physiology: From Cells to Systems*. Cengage Learning. https://books.google.co.th/books?id=8WVvCgAAQBAJ

Sintara, K., Jangesawang, D., Nakhanakhup, C., Changsri, C., Kumpo, N., Worasarn, C., Sutantikijthaworn, J., & Klumkool, S. (2017). The Effects of Wearing Lingerie Bra on Chest Wall Expansion, Lung Volumes, and Aerobic Capacity of Tomboy, Faculty of Sport Science, Burapha University. The 1st National Conference Research and Innovation Knowledge transformation towards Thailand 4.0,

Songsorn, P., Ariyawongthong, C., & Kensaku, A. (2014). Reference values of chest expansion among Thai healthy people aged 20-70 years. *Thammasat Medical Journal*, *14*, 571-579. https://doi.org/10.70933/2773-9465.1591

Talwar, D., Balamurugan, S., Modi, M., Salvi, S., Lopez, M., Shah, R., Vaidya, A., Barne, M., Madas, S., Kulkarni, N., Sawant, S., & Gogtay, J. (2024). Comparison of a portable, pneumotach flow-sensor–based spirometer (Spirofy™) with the vitalograph alpha Touch™ spirometer in evaluating lung function in healthy individuals, asthmatics, and COPD patients—a randomized, crossover study. *BMC Pulmonary Medicine*, *24*(1), 230. https://doi.org/10.1186/s12890-024-02972-4

Viechtbauer, W., Smits, L., Kotz, D., Budé, L., Spigt, M., Serroyen, J., & Crutzen, R. (2015). A simple formula for the calculation of sample size in pilot studies. *Journal of Clinical Epidemiology*, *68*(11), 1375-1379. https://doi.org/10.1016/j.jclinepi.2015.04.014

Wilson, T. A. (2016). The Chest Wall and the Respiratory Pump. In T. A. Wilson (Ed.), *Respiratory Mechanics* (pp. 19-42). Springer International Publishing. https://doi.org/10.1007/978-3-319-30508-0_2

Yurt, Y., Yatar, İ., Malkoç, M., Yakut, Y., Mıhçıoğlu, S., & Koltak, C. (2021). The effect of brace treatment on pulmonary functions in adolescent idiopathic scoliosis: An 8-month follow-up study. *Journal of Back and Musculoskeletal Rehabilitation*, *34*(5), 887-893. https://doi.org/10.3233/BMR-200195

Zhao, X., Guo, S., Xiao, S., & Song, Y. (2022). Thorax Dynamic Modeling and Biomechanical Analysis of Chest Breathing in Supine Lying Position. *Journal of Biomechanical Engineering*, *144*(10). https://doi.org/10.1115/1.4054346

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