

Article

A Single Thoracopelvic Exercise Intervention Is Associated with Short-Term Changes in Dynamic Scapular Dyskinesis and Shoulder Mobility in Computer-Based Office Workers

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Abstract

Background: Scapular Dyskinesis (SD) is common in computer-based office workers, yet its short-term response to thoracopelvic exercise intervention is unknown. This quasi-experimental exploratory pre–post study examined the primary outcome of short-term change in SD grade and the secondary outcomes of static scapular position and passive glenohumeral (GH) rotational range of motion (ROM). **Methods:** Forty office workers with obvious SD in the dominant arm were assessed at baseline, immediately post-intervention, and at 24 h follow-up using the Scapular Dyskinesis Test (SDT), the Lateral Scapular Slide Test (LSST), and electronic goniometry for passive GH internal (IR) and external rotation (ER). Each completed a single thoracopelvic exercise intervention session targeting pelvic neutrality, thoracic orientation, and respiration-based core activation. **Results:** SDT grades fell on both sides at post-intervention and follow-up (dominant, $p = 0.001$, $W = 0.766$; non-dominant, $p = 0.001$, $W = 0.250$), shifting from obvious to subtle SD. LSST decreased only at position 2 (dominant, $p = 0.014$, $\eta^2 = 0.101$; non-dominant, $p = 0.011$, $\eta^2 = 0.107$). Dominant IR increased ($p = 0.001$, $\eta^2 = 0.462$) and ER decreased ($p = 0.001$, $\eta^2 = 0.163$); non-dominant ER increased ($p = 0.015$) while IR was unchanged ($p = 0.847$). The dominant SDT change correlated inversely with the IR change ($r = -0.35$, $p = 0.03$). **Conclusions:** A single thoracopelvic exercise intervention session was associated with selective short-term changes in SD grade and dominant-side passive GH ROM, whereas static scapular changes were limited. These findings represent preliminary response patterns rather than evidence of clinical effectiveness. **Trial Registration:** Clinical Research Information Service (CRIS), Korea KCT0011747 (registered retrospectively on 19 March 2026; study start date on 4 August 2025).

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1. Introduction

Scapular dyskinesia (SD) refers to abnormal scapular position and/or motion and is a major contributor to shoulder dysfunction [1], increasing the risk of shoulder pain by up to 43% [2,3]. SD has also been associated with neck pain, as altered scapular alignment or movement is more frequent in individuals with cervical symptoms than in asymptomatic individuals [4]. The scapula lies against the posterior thoracic wall, so variations in

thoracic curvature or posture can alter its kinematics and contribute to shoulder dysfunction [5]. Thoracic alignment has also been associated with neck pain [6]. Excessive thoracic kyphosis may promote forward head posture and increase cervical loading, thereby potentially eliciting pain [7]. Thoracic kyphosis may alter rib cage mechanics and diminish thoracic mobility [5]. Dysfunctional breathing patterns, characterized by reduced diaphragmatic excursion and altered timing of activation of scapular stabilizers, such as the serratus anterior and lower trapezius, have been observed in individuals with excessive thoracic kyphosis [8]. Respiratory retraining improved scapular muscle recruitment and postural control, suggesting that impaired breathing may contribute to the development and persistence of SD [9]. This association has a mechanical basis: diaphragmatic contraction lowers the central tendon and stabilizes the lower rib cage, and the associated rise in intra-abdominal pressure provides proximal stabilization that fixes the thoracic base on which the serratus anterior and lower trapezius act. Improved thoracic mobility then allows the scapula to follow rib cage orientation during arm elevation, linking breathing mechanics to scapular upward rotation and posterior tilt through the kinetic chain [9].

SD is commonly observed in overhead athletes and is frequently attributed to repetitive movements such as throwing, with a reported prevalence of approximately 61% [10,11]. From a clinical perspective, SD has been associated with an increased risk of shoulder pain. Salamh et al. (2023) reported that up to 57% of symptomatic individuals exhibited SD [12]. This supports its classification as a functional impairment rather than a purely static postural deviation. Conversely, office workers, despite the absence of repetitive overhead loading, exhibit a markedly higher prevalence of SD, reaching 89.9% [4]. This high prevalence has been associated with prolonged forward head posture during work tasks [13], a postural pattern that, in turn, is associated with excessive thoracic kyphosis [14]. Altered thoracic alignment affects scapular kinematics, including upward rotation and posterior tilt [15], while spinal deformities have been implicated in the development or exacerbation of SD. Because the scapula lies on the posterior thorax, thoracic malalignment and restricted mobility may impair scapular positioning and muscular coordination [16], emphasizing the importance of thoracic-scapular interactions in office workers.

Scapular-focused interventions, such as stabilization exercises, taping, and manual therapy, have been commonly employed to address SD [17–19]. A recent meta-analysis found that these interventions produced limited effects on scapular positioning despite observed improvement in SD-related symptoms [20]. These exercises were not more effective than general exercise programs in individuals with chronic shoulder pain and SD [21]. This limited effectiveness is likely attributable to the influence of thoracic morphology and periscapular muscles on scapular motion [22,23]. Traditional scapular-focused interventions may be less effective in clinical contexts where scapular mechanics are influenced by integrated trunk movements and postural asymmetries [20]. Recent studies have supported the adoption of a broader, more integrative perspective. Previous studies have shown that trunk endurance, pelvic alignment, and pelvic repositioning influence scapular control and shoulder Range of Motion (ROM) [24–26]. Pelvic alignment may influence shoulder function through muscular sling connections within the proximal kinetic chain [27]. This relationship is also relevant in individuals with SD, who commonly demonstrate diminished upward rotation and increased anterior scapular tilt during shoulder flexion. Similar kinematic patterns have been reported in patients with Glenohumeral Internal Rotation Deficit (GIRD), particularly when SD coexists [28]. From this perspective, exercise approaches targeting thoracopelvic alignment may provide a biomechanically relevant strategy for influencing scapular control beyond isolated scapular-focused rehabilitation. This rationale reflects biomechanical plausibility rather than demonstrated clinical effectiveness, because controlled trials testing whether thoracopelvic interventions reduce SD or improve shoulder outcomes remain scarce. Before longer con-

trolled rehabilitation trials can be justified, it is necessary to determine whether clinical measures of SD show measurable short-term responses after a standardized thoracopelvic exercise intervention session.

Although local scapular strengthening remains common, its efficacy has been questioned because symptomatic improvements may occur without corresponding changes in scapular kinematics [20]. The thorax and pelvis influence scapulothoracic control through proximal alignment and kinetic-chain mechanisms [29,30], and pelvic alignment may indirectly affect scapular orientation and kinematics through spinal posture [25]. No prior study has tested whether a single standardized thoracopelvic exercise intervention session produces measurable short-term change in dynamic SD grade, static scapular position, and passive glenohumeral (GH) rotational ROM in computer-based office workers with clinically evident SD. This study addresses scapular control through a proximal thoracopelvic method and tests the immediate response of clinically assessed measures rather than symptom-based or laboratory kinematic outcomes. A single session cannot alter the structural contributors to SD, such as thoracic morphology and habitual posture, whereas the neuromuscular component, scapular stabilizer timing, and proximal postural tone can respond acutely to altered pelvic and thoracic alignment and breathing-based core activation. The design, therefore, identifies immediate response patterns and provides preliminary data for future controlled trials rather than establishing efficacy. This quasi-experimental, exploratory pre–post study examined the immediate and 24 h responses of the Scapular Dyskinesis Test (SDT) grade as the primary outcome, and the Lateral Scapular Slide Test (LSST) distance and passive GH internal rotation (IR) and external rotation (ER) as secondary outcomes. We hypothesized that the intervention would be associated with short-term changes in dynamic SD grade, static scapular position, and passive GH rotational ROM.

2. Methods

2.1. Study Design

This study was designed as a quasi-experimental, single-group, pre-post, exploratory study with three repeated assessments at baseline, immediately after the intervention, and at 24 h follow-up. The 24 h follow-up was selected to determine whether the immediate post-exercise response persisted across one overnight rest period and a single return to habitual computer-based work, without the confounding of a repeated session or accumulated training. This interval reflects short-term retention of an acute response rather than a training adaptation. The purpose of this design was to examine short-term response patterns in SD rather than to establish intervention efficacy. Because the study involved group-level repeated-measures data from multiple participants, within-subject statistical analyses were applied to evaluate changes over time. A no-control condition was not included because the study was intended to provide preliminary data for future controlled rehabilitation trials. Methodological reporting incorporated relevant elements of the CONSORT checklist, as applicable, to improve transparency and reproducibility. This study was approved by the Institutional Review Board of CHA University (1044308–202506–HR–264–02) on 28 July 2025. Participant recruitment and data collection began on 4 August 2025 and ended on 25 September 2025.

2.2. Participants

The participants were office workers employed at a corporation in Seoul and were recruited between August 4 and September 25, 2025. Before enrollment, eligibility was confirmed using the SDT, and written informed consent was obtained after a full explanation of the study's purpose and procedures. Inclusion criteria were adults aged 20–50

years, which was selected to include working-age adults while minimizing the influence of age-related degenerative changes in the shoulder and cervical spine, engagement in full-time (≥ 40 h/week) computer-based office workers [31] individuals demonstrating obvious SD on the dominant arm according to the three-grade SDT classification by McClure et al. [32] thereby ensuring enrollment of participants with clearly observable SD, and participants with full, pain-free, passive bilateral shoulder ROM. Exclusion criteria were a history of cervical or upper extremity fracture or surgery within the previous 6 months; traumatic upper extremity injury, fibromyalgia; systemic disease, soft-tissue disorders; scoliosis; central neurological disorders; engagement in structured upper-body resistance exercise two or fewer times per week within the previous 6 weeks [13], and any condition that prevented accurate performance of SDT or LSST [4].

2.3. Protocol

A total of 40 eligible participants were recruited and completed the study. No adverse events were reported during or after the intervention session. Prior to baseline testing, all participants provided demographic information, including age, sex, height, and body weight. Thereafter, the three-grade SDT classification was applied to both shoulders to identify the presence and laterality of SD. Eligible participants then completed baseline SDT, LSST, and passive glenohumeral internal and external rotation measurements. These assessments were repeated immediately after the intervention and 24 h later to capture short-term changes (Figure 1).

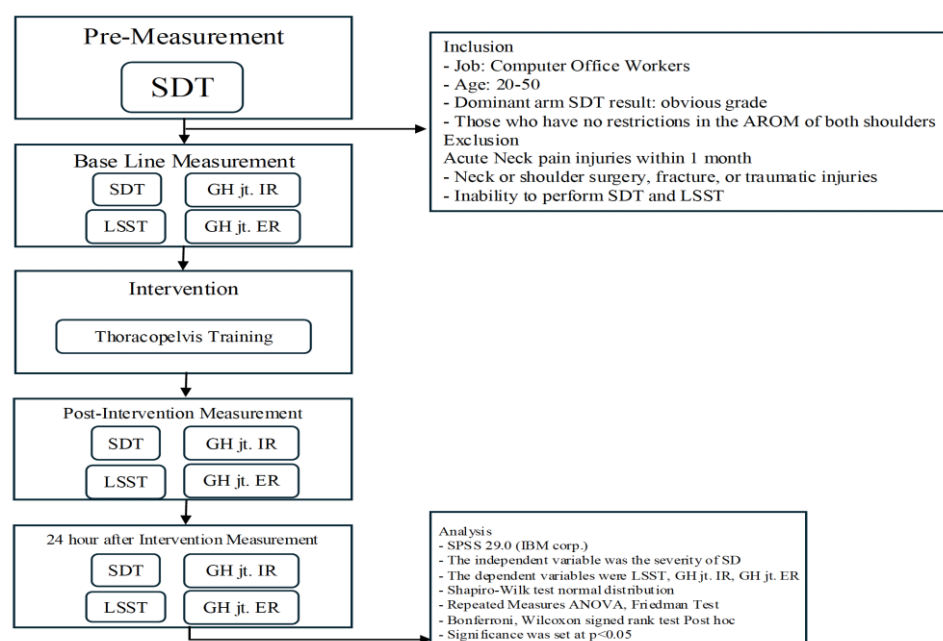


Figure 1. CONSORT flow diagram of the study. SD: Scapular Dyskinesia, SDT: Scapular Dyskinesia Test, LSST: Lateral Scapular Slide Test, GH jt.: Glenohumeral joint, IR: Internal Rotation, ER: External Rotation.

2.4. Intervention

Participants completed a single-session thoracopelvic exercise intervention program consisting of three corrective exercises targeting asymmetric thoracopelvic mechanics and respiration-mediated deep-core activation. The intervention was performed in the same order for all participants. The intervention was administered face-to-face, one-on-one, at the Graduate School of Sports Medicine, CHA University (Pocheon, Republic of Korea). A stable wall surface, a 15 cm foam ball, a plyometric box for heel support, and a yoga

mat were employed during the session. The total intervention time was approximately 40 min, including exercise instruction, set completion, and rest intervals. The intervention was performed in the same order for all participants and followed a standardized protocol without individual tailoring or modification. The intervention was administered by two experienced clinicians: a musculoskeletal rehabilitation specialist with 15 years of clinical practice and a certified athletic trainer with 25 years of experience. Throughout the session, participants received continuous verbal cueing and tactile feedback to ensure accurate alignment and breathing mechanics. Verbal cues focused on heel pressure, pelvic position, abdominal tension, rib cage control, and controlled breathing. Tactile feedback was provided to guide pelvic alignment, thoracic orientation, and maintenance of the target exercise position.

2.5. Procedures

The intervention comprised three biomechanically grounded exercises aimed at correcting asymmetrical pelvic and thoracic alignment patterns and improving deep core stability through regulated breathing [33]. The detailed procedures were as follows. The first exercise involved a 90–90 wall bridge performed with a ball. Participants were positioned supine with their hips and knees flexed to 90° and the heels supported on a box. A ball was placed between the knees to facilitate adductor activation, whereas the dominant arm was positioned at 180° shoulder flexion and the non-dominant arm at 90° flexion. Participants were instructed to apply downward heel pressure to activate the hamstrings and induce a posterior pelvic tilt. While maintaining this position, participants performed controlled deep breathing with 4 s end-inspiratory and end-expiratory holds, followed by inhalation and exhalation while maintaining abdominal tension. This breathing cycle was repeated four times for a total of 4 sets (Figure 2a) [26,33]. The second exercise was performed in a dominant-side-lying position and followed procedures analogous to those used in the first exercise. Adductor activation was facilitated by posterior translation of the femur along its long axis (Figure 2b) [26,34]. The third exercise was performed in a non-dominant side-lying position. Participants maintained the hips and knees in the 90–90 position with feet supported against a wall. ER of the dominant hip was emphasized to activate the gluteus maximus, and the same procedures used in the preceding exercises were applied (Figure 2c). The same breathing cycle and set structure were used for all three exercises [26]. Exercise intensity was determined by this breathing protocol rather than by external load, with each hold performed at a submaximal, non-fatiguing effort under continuous verbal cueing to maintain consistent breathing effort across participants (Table 1).

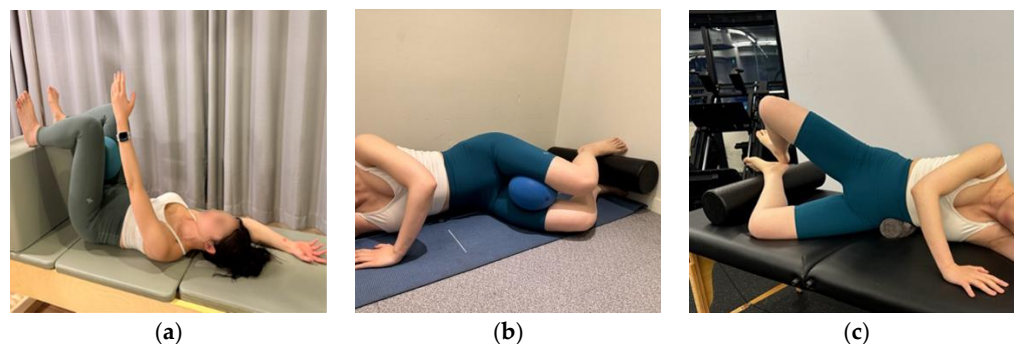


Figure 2. (a) A 90–90 wall bridge with a ball; (b) Adductor Pullback; (c) Gluteus Maximus Abduction.

Table 1. Standardized thoracopelvic exercise intervention protocol.

Exercise	Starting Position	Main Target	Sets/Breathing Cycles	Key Instruction
90–90 wall bridge with a ball	Supine, hip/knee 90° flexion, heels on box	Hamstrings, adductors, posterior pelvic tilt, breathing control	4 sets x 4 breathing cycles	Heel pressure, ball squeeze, abdominal tension
Left adductor pullback	Dominant side-lying	Adductor activation, pelvic repositioning	4 sets x 4 breathing cycles	Posterior femoral translation, maintain abdominal tension
Right gluteus maximus abduction	Non-dominant side-lying, feet on wall	Dominant hip ER, gluteus maximus activation	4 sets x 4 breathing cycles	Maintain 90-90 position, controlled breathing

2.6. SDT

The SDT was used as the primary outcome measure to assess dynamic SD grade. Participants were instructed to hold a dumbbell selected according to their body weight. Participants weighing less than 68.1 kg used a 1.4 kg dumbbell, whereas those weighing more than 68.1 kg used a 2.3 kg dumbbell, in accordance with the standardized SDT protocol by McClure et al. [32]. Participants were instructed to flex the shoulder to 180° and then return to a neutral position with the thumb oriented upward, performing both flexion and extension at a controlled pace of 3 s per movement. This sequence was repeated 5 times to assess the presence of SD [32]. SDT was performed using a palpation-based method [35]. A three-grade classification system was used to categorize scapular motion as normal, subtle dyskinesia, or obvious dyskinesia [32]. Scapular motion was classified as normal when no abnormality was observed, subtle dyskinesia when a mild or questionable abnormality was present, and obvious dyskinesia when a clear deviation in scapular movement was observed [32]. Measurements were obtained at baseline, immediately post-intervention, and 24 h after the intervention. The inter-rater reliability of the SDT has been reported as moderate to high ($\kappa = 0.57$ – 0.64) [35].

2.7. LSST

The LSST was used as a secondary outcome measure to quantify static scapulothoracic distance. Participants were instructed to stand upright while scapular position was assessed in three standardized postures: (1) arms relaxed with the hands placed on the waist, (2) shoulders abducted to 90° with IR, and (3) shoulders abducted to 90° with IR in an elevated position. In each posture, the linear distance from the T7 spinous process to the inferior angle of the scapula was measured using a caliper (CAS; Yangju City, Gyeonggi-do, Republic of Korea) [36]. All measurements were obtained twice, and the mean values were used for subsequent analysis. Although the LSST protocol was employed, it was used solely to quantify the scapulothoracic distance rather than to classify SD. Because the LSST provides a two-dimensional linear measure of static scapular position, it was interpreted as a clinical index of scapular distance rather than a comprehensive measure of scapular kinematics. Measurements were collected at three time points: pre-intervention, immediately post-intervention, and 24 h post-intervention. The intra-rater and inter-rater reliability of the LSST has been reported as high ($ICC = 0.87$) [37].

2.8. Shoulder IR/ER ROM

Passive GH IR and ER ROM were used as secondary outcome measures to assess GH rotational mobility during standardized scapular stabilization. Passive ROM was selected to reduce the influence of voluntary movement strategy and to standardize GH rotational mobility assessment. Passive GH ROM of the dominant and non-dominant shoulders was

measured with participants in the supine position. Dominance was determined by the hand used to control the computer mouse [4]. IR and ER were evaluated with the shoulder positioned at 90° of abduction and the elbow flexed to 90°, using a digital inclinometer (Ex-Power, Cheonan City, Chungcheongnam-do, Republic of Korea) placed at the mid-point of the forearm. For both IR and ER, one examiner stabilized the participant's shoulder against the table, while a second examiner applied maximal passive rotation by grasping the distal forearm [38]. After two practice trials, two test measurements were recorded and averaged for analysis. The intra-rater and inter-rater reliability of IR and ER measurements has been reported as high (ICC = 0.85–0.99) [39].

2.9. Reliability of the Examiner Assessments

To ensure measurement consistency, examiner reliability was established before data collection through a pilot assessment involving 10 individuals. The intra-rater reliability coefficients were as follows: SDT ($\kappa = 0.78$), LSST (ICC = 0.76), and IR/ER ROM (ICC = 0.82). Examiner YK performed the SDT and GH IR measurements, whereas Examiner SM performed the LSST and GH ER assessments. To reduce measurement bias, the examiners responsible for the SDT and LSST were blinded to each other's results throughout data collection.

2.10. Statistical Analysis

Statistical analyses were performed using SPSS version 29.0 (IBM Corp., Armonk, NY, USA). Sample size estimation was performed using G*Power version 3.1 (Germany) for a repeated-measures analysis of variance across three time points. The primary outcome was the SDT grade. Because no previous study has reported the expected mean difference and standard deviation for short-term changes in SDT grade following thoracopelvic exercise, the sample size was estimated using a conventional medium effect size (Cohen's $f = 0.25$), an alpha level of 0.05, and a statistical power of 0.80. The required minimum sample size was 36 participants. To account for potential dropout, 40 participants were recruited. Statistical significance was set at $p < 0.05$. Prior to analysis, all variables were screened for data completeness, outliers, and distributional assumptions. Because this study included group-level repeated-measures data from multiple participants, within-subject statistical analyses were used to evaluate changes over time. SDT is an ordinal measure; changes across the three time points (baseline, immediate post-intervention, and 24 h follow-up) were analyzed using the Friedman test, followed by pairwise Wilcoxon signed-rank tests with Bonferroni correction when appropriate. Kendall's W was reported as the effect size for the Friedman test. For continuous outcomes, including LSST distances and GH joint ROM, normality was assessed using the Shapiro–Wilk test. Variables that met normality assumptions were analyzed using repeated-measures analysis of variance across the three time points, followed by Bonferroni-adjusted pairwise comparisons when significant main effects were identified. For each repeated-measures ANOVA, sphericity was assessed using Mauchly's test, and the Greenhouse–Geisser correction was applied when the sphericity assumption was violated. Partial eta squared (η^2) was reported as the effect size for repeated-measures ANOVA. Partial eta squared (η^2) values of 0.01, 0.06, and 0.14 were interpreted as small, medium, and large effect sizes, respectively, according to Cohen's guidelines. To examine associations among variables with significant time effects, post-intervention minus baseline change scores were calculated for SDT, LSST position 2, IR, and ER. Because the change scores included ordinal variables and were not assumed to be normally distributed, associations were examined using Spearman's rank-order correlation coefficient. Spearman's rho (ρ) and corresponding p -values were reported. All analyses were conducted separately for the dominant and non-dominant sides. Continuous variables are presented as means and standard deviations, whereas ordinal variables are presented as medians and interquartile ranges.

3. Results

The demographic and clinical characteristics of the 40 participants (19 men and 21 women) who successfully completed all prescribed interventions are summarized in Table 2. All participants completed the baseline, post-intervention, and 24 h follow-up assessments. Overall, the observed responses were selective rather than uniform across outcomes. Differences over time were analyzed separately for the dominant and non-dominant sides.

Table 2. Demographic information of participants.

Variable	Mean $\pm$ Standard Deviation or <i>n</i> (%)
Age	33.2 $\pm$ 3.9 (25–42)
Sex	
Men	19 (48%)
Women	21 (52%)
Height (cm)	169.2 $\pm$ 8.0 (153–190)
Weight (kg)	68.2 $\pm$ 13.1 (46–98)
Dominant Arm	
Right	39 (98%)
Left	1 (2%)

cm = centimeter; kg = kilogram.

On both the dominant and non-dominant sides, SDT grades were significantly lower at post-intervention and follow-up than at baseline ($p = 0.001$), with a large effect on the dominant side (Kendall's $W = 0.766$) and a smaller effect on the non-dominant side (Kendall's $W = 0.250$). These changes represented a shift from obvious to subtle SD rather than complete normalization. No significant differences were observed between post-intervention and follow-up on either side (Table 3).

Table 3. Changes in SDT grades across the 3 time points.

Variable	BL Median (IQR)	PI Median (IQR)	FU Median (IQR)	Chi-Square	<i>p</i>	Kendall's <i>W</i>	Post Hoc
D SDT	3 (3–3)	2 (2–2.5)	2 (2–2)	61.313	0.001	0.766	BL > PI BL > FU
ND SDT	3 (2.5–3)	2 (2–2.5)	2 (2–2)	19.979	0.001	0.250	BL > PI BL > FU

SDT = Scapular Dyskinesia Test; D = Dominant; ND = Non-dominant; BL = Baseline; PI = Post-intervention; FU = 24 h follow-up.

On both the dominant and non-dominant sides, significant time effects were observed only for LSST position 2, with lower post-intervention and follow-up values than baseline (dominant: $p = 0.014$, partial $\eta^2 = 0.101$; non-dominant: $p = 0.011$, partial $\eta^2 = 0.107$). No significant time effects were observed for LSST positions 1 or 3 on either side (Table 4). Thus, static scapular distance changes were limited to one testing position.

Table 4. Changes in LSST distance across the 3 time points.

Variable	BL (95%CI)	PI (95%CI)	FU (95%CI)	F Value	<i>p</i>	η^2	Post Hoc
D LSST 1	9.58 ± 0.41 (9.17–9.99)	9.44 ± 0.34 (9.10–9.78)	9.38 ± 0.36 (9.02–9.75)	0.295	0.745	0.008	
D LSST 2	10.96 ± 0.33 (10.63–11.29)	10.41 ± 0.24 (10.17–10.65)	10.46 ± 0.3 (10.17–10.76)	4.402	0.014	0.101	BL > PI BL > FU
D LSST 3	10.11 ± 0.47 (9.64–10.58)	10.04 ± 0.36 (9.68–10.4)	10.1 ± 0.39 (9.71–10.49)	0.036	0.964	0.001	
ND LSST 1	9.02 ± 0.39 (8.63–9.41)	9.26 ± 0.34 (8.92–9.6)	9.15 ± 0.36 (8.79–9.51)	0.458	0.633	0.012	
ND LSST 2	10.69 ± 0.46 (10.23–11.16)	10.02 ± 0.29 (9.72–10.31)	10.07 ± 0.26 (9.81–10.33)	4.657	0.011	0.107	BL > PI BL > FU
ND LSST 3	10.32 ± 0.32 (10–10.64)	10.26 ± 0.35 (9.92–10.61)	10.28 ± 0.36 (9.92–10.64)	0.032	0.969	0.001	

LSST = Lateral Scapular Slide Test; D = Dominant; ND = Non-dominant; BL = Baseline; PI = Post-intervention; FU = 24 h Follow-up.

Significant time effects were observed for dominant-side IR and ER and for non-dominant-side ER, whereas no significant time effect was found for non-dominant-side IR. Dominant-side IR was significantly higher at post-intervention and follow-up than at baseline ($p = 0.001$, partial $\eta^2 = 0.462$), whereas dominant-side ER was significantly lower at post-intervention than at baseline ($p = 0.001$, partial $\eta^2 = 0.163$). On the non-dominant side, ER was significantly higher at post-intervention than at baseline ($p = 0.015$, partial $\eta^2 = 0.100$), whereas IR did not change significantly over time ($p = 0.847$, partial $\eta^2 = 0.004$) (Table 5). These findings indicate side-specific ROM responses, with the largest effect observed for dominant-side IR.

Table 5. Changes in glenohumeral internal and external rotation angles across the 3 time points.

Variable	BL (95%CI)	PI (95%CI)	FU (95%CI)	F Value	<i>p</i>	η^2	Post Hoc
D IR	21.36 ± 0.91 (20.45–22.27)	26.15 ± 0.82 (25.33–26.97)	24.61 ± 0.83 (23.77–25.44)	33.43	0.001	0.462	BL < PI BL < FU
D ER	100.39 ± 1.76 (98.62–102.15)	96.395 ± 1.28 (95.12–97.67)	98.14 ± 1.32 (96.82–99.46)	7.574	0.001	0.163	BL > PI
ND IR	28.295 ± 1.59 (26.7–29.89)	28.78 ± 1.05 (27.74–29.84)	28.43 ± 1.12 (27.3–29.55)	0.166	0.847	0.004	
ND ER	91.19 ± 1.53 (89.66–92.72)	94.18 ± 1.39 (92.78–95.57)	92.5 ± 1.44 (91.06–93.93)	4.343	0.015	0.100	BL < PI

IR = Internal Rotation; ER = External Rotation; D = Dominant; ND = Non-dominant; BL = Baseline; PI = Post-intervention; FU = 24 h Follow-up.

Among the examined change scores, only the dominant-side change in SDT was significantly correlated with the dominant-side change in internal rotation ROM ($q = -0.35$, $p = 0.03$), indicating a weak inverse association. No other significant correlations were observed among the dominant-side change scores, and no significant associations were found among any of the non-dominant-side change scores (Table 6). These results suggest limited coherence among dynamic SD grade, static scapular distance, and passive GH rotational ROM changes.

Table 6. Correlation between changes in scapular measures and shoulder rotation ROM.

Variable	Spearman's ρ	p -Value
Δ D SDT (post-pre)- Δ D LSST 2 (post-pre)	0.17	0.31
Δ D SDT (post-pre)- Δ D ER (post-pre)	0.28	0.08
Δ D SDT (post-pre)- Δ D IR (post-pre)	−0.35	0.03
Δ D LSST 2 (post-pre)- Δ D ER (post-pre)	−0.24	0.13
Δ D LSST 2 (post-pre)- Δ D IR (post-pre)	−0.19	0.24
Δ ND SDT (post-pre)- Δ ND LSST 2 (post-pre)	0.12	0.46
Δ ND SDT (post-pre)- Δ ND ER (post-pre)	0.16	0.34
Δ ND SDT (post-pre)- Δ ND IR (post-pre)	0.16	0.33
Δ ND LSST 2 (post-pre)- Δ ND ER (post-pre)	0.12	0.47
Δ ND LSST 2 (post-pre)- Δ ND IR (post-pre)	0.21	0.19

Correlation coefficients are presented as Spearman's rho (ρ); D = Dominant; ND = Non-dominant; SDT = Scapular Dyskinesia Test; LSST = Lateral Scapular Slide Test; IR = Internal Rotation; ER = External Rotation.

4. Discussion

The purpose of this quasi-experimental exploratory pre–post study was to examine the immediate and 24 h responses of dynamic SD grade, static scapular position, and passive glenohumeral rotational ROM following a single-session thoracopelvic exercise intervention in computer-based office workers with obvious SD. The main findings were that SDT grades changed on both sides, LSST changes were limited to position 2, and passive GH IR and ER changed selectively, primarily on the dominant side. However, changes in SD grades were limited to a transition from obvious to subtle SD, and complete resolution was not achieved following a single-session intervention. The initial response to the thoracopelvic exercise intervention may involve short-term changes in movement coordination and kinetic chain function rather than structural modification of scapular alignment. These findings should be interpreted as short-term response patterns within a single-group design rather than evidence of intervention effectiveness, because the absence of a control group precludes causal inference.

Previous exercise-based interventions for SD have primarily focused on isolated training of the periscapular musculature. Although such approaches often yield improvements in pain or function, systematic reviews and meta-analyses reported inconsistent effects on scapular positioning and dynamic scapular control. Previous studies have primarily relied on kinematic or symptom-based outcomes [20], and evidence regarding exercise-associated changes in SD grade, as assessed using the SDT, remains limited. Our data showed a short-term change in dynamic scapular control following an intervention targeting thoracopelvic alignment and breathing-based core stabilization. However, this change was limited to a transition from obvious to subtle SD rather than complete normalization. These results are consistent with previous reports that core stabilization may influence scapular proprioception and muscular performance and that shoulder dysfunction is closely associated with deficits in core stability [40,41]. The observed changes suggest that the thoracopelvic exercise intervention may be associated with altered scapular stabilizer behavior through kinetic chain interactions. Previous studies indicate that scapular motion may be influenced by trunk-generated forces transmitted along the kinetic chain [42]. The thoracopelvic exercise intervention employed in this study facilitated neutral pelvic alignment and deep core activation, thereby potentially influencing proximal stabilization through the thoracolumbar fascia and posterior oblique sling, including the latissimus dorsi and lower trapezius [43,44]. Stephanie et al. reported that conscious abdominal contraction may increase serratus anterior activation [45], and Sungkue et al. observed that lumbar stabilization may advance the activation onset of scapular stabilizing

muscles and improve scapular kinematics in individuals with SD [46]. Kibler et al. suggested that, when considering the integrated relationship among the scapula, trunk, and lower extremities, rehabilitation programs should be designed as functionally integrated units rather than as isolated component-based interventions [22]. Collectively, our findings suggest that thoracopelvic exercise intervention may be associated with short-term changes in scapular control, possibly related to proximal stabilization within the kinetic chain. Periscapular and trunk muscle activity, fascial tension, and three-dimensional scapular motion were not measured, so these mechanistic accounts are hypothetical and are offered as candidate explanations rather than demonstrated pathways. Because participants continued to exhibit residual SD after a single session without direct periscapular training, these findings should be interpreted as preliminary short-term responses rather than evidence of intervention effectiveness. Further studies employing longer interventions are required to determine whether SDT classification can be extended beyond the obvious-to-subtle transition.

The LSST results indicated that static positions did not exhibit uniform responses to the intervention. No significant changes were observed at LSST positions 1 or 3. Kibler (1998) reported that LSST position 1, performed with the shoulder relaxed, induced minimal muscle activation [36], whereas LSST position 3 provoked excessive contraction of the scapular stabilizers [37]. A statistically significant reduction in scapular distance was observed in LSST position 2 performed with the hands placed on the iliac crest. This finding is consistent with previous reports indicating that LSST position 2 may be a clinically useful static index for differentiating SD in office workers with chronic neck pain and that it correlates with the Neck Disability Index score [4]. Anatomically, position 2 transiently creates a closed kinetic chain environment through upper-extremity support of the pelvis [47], thereby increasing reliance on postural tone within the scapular stabilizers. LSST position 2, which demonstrated significant changes, resembled upper-limb-supported working postures commonly adopted by computer-based office workers. Following the thoracopelvic exercise intervention, short-term changes in dynamic scapular control were accompanied by changes in position 2, which required sustained activation of the scapular stabilizers. However, static changes were limited to this single position rather than being observed across all LSST conditions. The lack of a significant association between SDT and LSST position 2 change scores suggests that these measures may capture different aspects of scapular behavior. The SDT classifies dynamic scapular control as normal, subtle, or obvious, whereas the LSST assesses scapular position using linear distance measures [32]. Therefore, a change in dynamic SD grade may occur without a proportional change in static scapular distance. The LSST constitutes a two-dimensional assessment of scapular position and therefore captures only a limited aspect of scapular behavior. It cannot detect three-dimensional scapular kinematics, including tilting and rotation [48]. Accordingly, the selective change observed in LSST position 2 should be interpreted cautiously and not assumed to reflect a global change in static scapular alignment. Previous studies in swimmers differ from our results [49], suggesting that the relationship between dynamic SD and static scapular distance may vary across populations and task demands. Future studies employing three-dimensional motion analysis are required to clarify the effects of thoracopelvic exercise interventions on scapular alignment across all planes of motion.

The thoracopelvic exercise intervention was reflected in the shoulder, as evidenced by changes in GH rotation on the dominant side. However, these changes were selective and were not observed uniformly across both sides or all ROM variables. Baseline differences in GH rotation between the dominant and non-dominant shoulders, likely related to habitual use, may partially explain the ROM changes observed on the dominant side. This side-specific response may also be related to dominant upper-limb use during computer-based work, including mouse control and repetitive task-related positioning. Our

findings align with previous work demonstrating that pelvic repositioning exercises result in acute improvements in GIRD [43] and that hip mobility contributes to trunk rotational mechanics during throwing [50]. Prior studies reported that diaphragmatic breathing increased ribcage mobility and improved thoracic alignment, thereby providing a more favorable scapulothoracic environment for posterior tilt and ER [9,51]. Nonetheless, the observed ROM changes may reflect altered scapulothoracic interactions following a thoracopelvic exercise intervention, including breathing-based core-stabilization mechanisms. The observed changes in GH ROM occurred despite persistent SD within the limited timeframe of a single-session intervention and should therefore be interpreted as short-term passive ROM responses rather than evidence of complete functional restoration. Notably, only passive ROM was assessed, precluding determination of whether these changes translate into meaningful changes in active ROM during functional tasks. Future studies should include active ROM and task-based shoulder assessments to clarify the functional relevance of these findings. Wearable inertial sensors provide objective and reproducible quantification of shoulder mobility and rehabilitation outcomes [52], and inertial-magnetic systems have been validated against optoelectronic reference standards for three-dimensional upper-limb kinematics [53]. Future studies of thoracopelvic exercise in SD should adopt these methods to capture scapular tilt and rotation and to replace conventional clinical instruments with objective motion analysis.

Although SDT and LSST position 2 demonstrated significant pre-post improvements, no significant correlation was observed between their respective post-pre change scores. This finding is consistent with prior reports demonstrating weak correlations between static indices and dynamic performance measures [1,54]. Previous studies examining scapular-focused exercise interventions have shown inconsistent effects on static scapular position and motion in individuals with SD, whereas improvements in pain and functional outcomes have been reported more consistently [55]. Although static measures, such as the LSST, may reflect postural configuration under specific testing conditions, changes in these measures do not necessarily translate into parallel improvements in dynamic scapular control. The qualitative change in SD grade from obvious to subtle observed in our study may not be sufficient to produce proportional changes in static measures such as LSST position 2. Sciascia and Kibler [30] similarly proposed that the clinical relevance of SD lies primarily in its pathophysiological characteristics, particularly neuromuscular coordination, rather than in attempts to restore structural symmetry. From this perspective, the present findings indicate that a thoracopelvic exercise intervention was associated with short-term changes in movement behavior, even in the absence of proportional changes in static scapular distance. Consistent with the view that SD reflects a modifiable motor control strategy rather than a fixed structural deformity, previous studies have shown that symptomatic improvement can occur without scapular kinematic normalization [56] and that kinetic chain-based approaches can influence muscular recruitment patterns across segments [54]. However, the limited correlations suggest that the outcomes reflected different aspects of scapular and shoulder function, and it remains uncertain whether these responses persist under cumulative loading or greater movement demands. Because this study did not include a control condition, the observed changes may also reflect repeated testing, habituation to the assessment, nonspecific mobilization effects, therapist attention, or feedback-related motor learning. Future studies should determine whether these results remain stable across repeated exposures or task-specific functional challenges using controlled designs and broader functional outcome measures.

Limitations

This study has several important limitations. First, the absence of a control group within the single-group pre-post design limits causal inference, and the observed changes

may reflect nonspecific influences such as repeated testing, habituation to the assessment, motor learning, or therapist attention. Repeated administration of the SDT and LSST may have produced practice or familiarization effects that improved performance at later time points, independent of the intervention, and the single-group design cannot separate this contribution from the intervention effect. Because verbal and tactile feedback were provided during the intervention, feedback-related motor learning may also have contributed to the short-term changes. Second, the study examined responses to a single intervention session, limiting conclusions regarding persistence, cumulative effects, or structural adaptation. Intervention studies conducted over several weeks are required. Third, although SDT grades changed significantly, the observed change was limited to a transition from obvious to subtle SD, indicating incomplete normalization. Fourth, although participants exhibited SD, they were asymptomatic computer-based office workers, limiting extrapolation to patient populations with pain, athletic populations, or individuals with structural pathology. In addition, sex-specific responses could not be examined because the study was not powered for subgroup analysis. Habitual physical activity beyond the exclusion criterion for structured upper-body resistance exercise was not objectively monitored. Fifth, the measurement tools have inherent limitations. The SDT is a qualitative clinical measure, whereas the LSST provides only a two-dimensional assessment of static scapular position, without capturing three-dimensional kinematics, such as tilting or rotation. In addition, active ROM, functional outcomes, electromyographic data, and three-dimensional motion analysis were not included. Finally, the clinical relevance of these changes remains uncertain. No minimal clinically important difference has been established for the SDT, LSST, or passive GH rotation in office workers, so whether changes of this magnitude reduce symptom risk or improve work-related shoulder function cannot be determined from the present data. In addition, because all participants were classified as having obvious SD at baseline, the findings may not be generalizable to individuals with subtle dyskinesia or normal scapular control.

5. Conclusions

In computer-based office workers with obvious SD, a single-session thoracopelvic exercise intervention was associated with short-term changes in SD grade, whereas static scapular distance changes were limited, and passive GH ROM responses were mainly observed on the dominant side. These findings should be interpreted as preliminary response patterns within a quasi-experimental exploratory pre–post design, not as evidence of intervention effectiveness. Controlled studies with longer intervention periods, comparison groups, and more comprehensive kinematic and functional assessments are needed to determine the clinical relevance and durability of these findings. Future controlled studies incorporating three-dimensional kinematic analysis and neuromuscular assessments are warranted to clarify the mechanisms underlying these short-term responses.

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Institutional Review Board Statement: This study was registered retrospectively after participant recruitment had begun (Clinical Research Information Service, Korea; KCT0011747; registered on 19 March 2026). Prospective registration was not completed before recruitment because the authors did not fully recognize at the time of study initiation that this single-group interventional design could be subject to clinical trial registration requirements within the current journal and ICMJE

framework. Although the study was subsequently registered in a public trial registry and the registration record was made fully available, retrospective registration should be considered a limitation to methodological transparency because it may raise concerns about reporting integrity and the potential for selective reporting bias.

Informed Consent Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of CHA University (approval no. 1044308-202506-HR-264-02; approval date: 28 July 2025). Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

SD	Scapular Dyskinesis
SDT	Scapular Dyskinesis Test
LSST	Lateral Scapular Slide Test
ROM	Range of motion
IR	Internal Rotation
ER	External Rotation
GH jt.	Glenohumeral joint
GIRD	Glenohumeral internal rotation deficit

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