Comparative Effects of Manual Physical Therapy and Manual Physical Therapy Combined with Home Exercises for Thoracic Mobility on Range of Motion, Respiratory Function, and Health-Related Quality of Life Following Shoulder Surgery

https://doi.org/10.32337/KACPT.2026.14.1.47
대한심장호흡물리치료학회지 제14권 제1호 2026. PP.47-53

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Purpose: This study aimed to investigate the effects of manual physical therapy and manual physical therapy combined with home exercises for thoracic mobility on shoulder joint range of motion, respiratory function, and quality of life in patients following surgical repair of rotator cuff tears. **Methods:** Thirty-two participants who underwent rotator cuff repair were randomly allocated to either the manual physical therapy combined with home exercises for thoracic mobility group or the manual physical therapy group. Interventions were administered twice per week for eight weeks. Shoulder range of motion was assessed with a goniometer, respiratory function was evaluated using a spirometer (forced vital capacity, forced expiratory volume in one second, and peak expiratory flow), and quality of life was assessed using the short form-36. Data were collected at baseline, the 4th week, and the 8th week. Statistical analyses were performed using two-way repeated-measures ANOVA, and the significance level was set at $\alpha=0.05$. **Results:** Both groups demonstrated significant improvements in shoulder range of motion, respiratory function, and quality of life over time($p<.001$). Significant group × time interactions were observed for shoulder flexion($p=.007$), FVC($p=.002$), FEV_1 ($p=.002$), and PEF($p=.002$), indicating greater improvements in the manual physical therapy combined with home exercises for thoracic mobility group compared with the manual physical therapy group. No significant interaction effects were found for abduction, external rotation, or short form-36 scores, suggesting similar improvements across both groups in these outcomes. **Conclusion:** Manual physical therapy, either with or without home exercises for thoracic mobility, effectively improved shoulder mobility, respiratory function, and quality of life in post-surgical patients. The addition of home exercises for thoracic mobility provided specific benefits for shoulder flexion and respiratory function, supporting their inclusion in comprehensive rehabilitation protocols.

Key words: Exercise therapy, Physical therapy modalities, Quality of life, Range of motion, Respiratory function

Received: September 18, 2025 / **Revised:** October 17, 2025 / **Accepted:** October 21, 2025

Ⅰ. Introduction

Following shoulder surgery for rotator cuff tears, patients frequently encounter various complications and physical challenges that can impede their recovery and diminish their health-related quality of life(HRQoL)(Mazzocca et al., 2017). One of the most prevalent issues is postoperative stiffness, which significantly limits shoulder range of motion(ROM), particularly in abduction(lifting the arm to the side) and external rotation(Jackins, 2004). This stiffness often results from scar tissue formation and the natural healing process, which both restrict joint mobility(Itoi et al., 2016).

Additionally, muscle weakness in the shoulder is a common consequence of the initial injury and the subsequent immobilization during recovery. Regaining strength in the rotator cuff and surrounding shoulder muscles can be slow, often failing to return to pre-injury levels without extensive rehabilitation(Nilamdeen and Edirimanne, 2022). Persistent or recurrent shoulder pain following rotator cuff surgery has been reported to be associated with postoperative inflammation, reduced

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vascularity, and impaired tendon healing, which may lead to prolonged discomfort and delayed functional recovery (Mazuquin, 2019).

These complications can impair patients' ability to perform daily activities, especially those requiring overhead, lifting, or rotational movements, such as reaching for objects on shelves, dressing, or carrying items. Such limitations can negatively affect HRQoL and reduce independence(Tan et al., 2024). Moreover, postoperative changes in shoulder and thoracic posture particularly forward head and rounded shoulder positions have been reported to increase mechanical load on the neck and shoulder muscles, leading to musculoskeletal strain and reduced thoracic mobility(Wong et al., 2014). The rounded shoulder posture, which commonly develops after rotator cuff repair due to pain avoidance and prolonged immobilization, contributes to restricted scapular movement and decreased thoracic expansion. These postural alterations may limit effective ventilation and may hinder the recovery of both shoulder and respiratory functions.

While prior studies have documented improvements in shoulder joint ROM, pain, and upper limb muscle strength through physical therapy after rotator cuff repair(Du Plessis et al., 2011), postoperative limitations in thoracic mobility can reduce lung volumes and restrict effective ventilation, which may negatively affecting overall recovery and quality of life. However, no research has yet examined the specific effects of home exercise programs designed to enhance thoracic mobility on the restoration of respiratory function in these patients. Therefore, this study aims to examine the combined effects of manual physical therapy and home exercises for thoracic mobility on shoulder ROM, respiratory function, and HRQoL in patients following shoulder surgery for a rotator cuff tear.

Ⅱ. Materials and Methods

1. Participants

Participants were recruited from the Department of Orthopedic Surgery at C Hospital in Chungnam, South Korea, following surgical repair of rotator cuff tears. All participants were fully informed about the study’s purpose and procedures, and those who voluntarily agreed to participate provided written informed consent. The study protocol was reviewed and approved by the Hoseo University Institutional Review Board(Approval No: 1041231-241112-HR-188). Eligibility criteria required that participants had undergone rotator cuff surgery at least two weeks prior, possessed a physician-prescribed manual physical therapy plan, demonstrated restricted shoulder joint mobility and muscle weakness, and exhibited rounded shoulder posture. Exclusion criteria included a postoperative pain score of 9–10 on the visual analog scale, a history of two or more rotator cuff surgeries, the necessity of additional surgical procedures beyond rotator cuff repair, contraindicating comorbidities such as diabetes, or medical conditions that precluded physical therapy. A priori power analysis was conducted using G*Power 3.1.9.7 software for a two-way repeated measures ANOVA(2 groups × 3 time points). Assuming a medium effect size($f = 0.25$) according to Cohen(1988), with an alpha level of 0.05 and a statistical power of 0.80, the required sample size was calculated to be 28. Considering an anticipated dropout rate of 20%, 32 participants were recruited. Participants who met the eligibility criteria were randomly assigned to either the manual physical therapy group or the manual physical therapy combined with home exercises for thoracic mobility group, while maintaining gender balance between groups. Random allocation was conducted separately for each gender using a simple randomization method to ensure comparable distributions of male and female participants. All participants completed the study and were included in the final analysis. The general characteristics of the participants are summarized in Table 1.

2. Measurement Tools and Methods

1) Range of Motion

Shoulder joint ROM was measured using a goniometer. For shoulder flexion, participants were positioned in the supine position with the knee extended. The axis of the goniometer was aligned with the lateral aspect of the greater tubercle, the stationary arm was parallel to the midaxillary line of the thorax, and the movable arm was aligned with the lateral midline of the humerus, referencing the lateral epicondyle. For shoulder abduction, participants were placed in the supine position with the shoulder in the anatomical position. The axis was positioned at the anterior aspect of the acromion process, the stationary arm was parallel to the midline of the sternum, and the movable arm was aligned with the anterior midline of the humerus. For shoulder external rotation, participants were positioned in the supine position with the elbow flexed to 90° and the arm kept close to the trunk, as full 90° abduction was not achievable during the initial evaluation. The axis of the goniometer was aligned with the olecranon process, the stationary arm was kept perpendicular to the floor, and the movable arm followed the ulnar border of the forearm toward the ulnar styloid process. All measurements were performed by the same examiner, and the mean value of three trials was used for analysis.

2) Respiratory Function

Respiratory function was assessed using a portable spirometer(Pony FX, COSMED, Italy) to measure forced vital capacity(FVC), forced expiratory volume in one second(FEV_1), and peak expiratory flow(PEF).

Participants were seated upright with a straight back, wearing a nose clip to prevent air leakage, and were instructed to seal their lips tightly around the mouthpiece. After a full inhalation to total lung capacity, participants exhaled as forcefully, rapidly, and completely as possible to measure FVC, while the volume exhaled during the first second was recorded as FEV_1, PEF was automatically calculated by the device as the highest airflow achieved during forced expiration. All measurements were performed at least three times, and the highest value among the reproducible trials was recorded for analysis(Graham et al., 2019).

3. Procedure

The study followed a standardized protocol for physical therapy and data collection, which was explained to all participants prior to study initiation. Demographic information, including gender and age, was obtained through a questionnaire, and anthropometric data, such as height and weight, were measured using a stadiometer (BSM330, InBody, Korea). The ROM of the shoulder joint was assessed with a goniometer. Respiratory function was assessed with a spirometer, focusing on FVC, FEV_1, and PEF. HRQoL was evaluated using the short form-36(SF-36) questionnaire. All measurements were collected at baseline, the 4th week, and the 8th week of the intervention.

Manual physical therapy was administered twice weekly for 30 minutes following a structured protocol. All interventions were consistently delivered by a licensed physical therapist with over five years of clinical experience

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

	MT	M	t	p
Male/Female	9/7	9/7		1.000
Age(year)	56.19±9.54a	56.13±9.44	0.019	0.985
Height(cm)	166.38±7.88	168.13±6.47	-0.687	0.498
Weight(kg)	69.13±10.87	69.69±9.55	-0.155	0.877
BMI(kg/m^2)	24.86±2.31	24.54±1.85	0.420	0.677
Flexion(°)	68.13±29.49	74.69±26.92	-0.657	0.516
Abduction(°)	64.38±32.40	57.19±23.87	0.714	0.480
External Rotation(°)	25.00±21.45	19.38±9.98	0.951	0.352
FVC(ℓ)	3.70±0.33	3.76±0.34	-0.475	0.638
FEV_1(ℓ)	2.96±0.26	3.01±0.27	-0.475	0.638
PEF(ℓ/sec)	5.18±0.46	5.26±0.48	-0.475	0.638
SF-36(scores)	48.69±2.39	48.69±2.47	0.000	1.000

[a]mean±SD

MT, manual physical therapy combined with home exercises for thoracic mobility; M, Manual Physical Therapy; BMI, body mass index; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; PEF, peak expiratory flow in manual therapy. Pre-treatment evaluation included assessments of joint ROM and pain. Standard soft tissue mobilization techniques and muscle energy techniques were applied to promote relaxation of the rotator cuff, latissimus dorsi, pectoralis major, and levator scapulae prior to joint mobilization. Joint mobilization targeted the sternoclavicular, acromioclavicular, and glenohumeral joints, followed by active-assisted mobilization to enhance shoulder ROM. Furthermore, sling exercise device training was implemented to promote shoulder joint relaxation and increase flexion angle.

In the group that received both manual physical therapy and home exercises for thoracic mobility, patient understanding of the shoulder joint self-exercise program was assessed, and feedback was provided accordingly. In addition, participants were given supplementary education on home exercises for thoracic mobility. These exercises were performed twice daily for 10 minutes each session and were continued throughout the intervention period. Adherence to the home exercise program was regularly monitored, and feedback was provided based on the participants' performance.

In the group that received only manual physical therapy, patient education focused on the shoulder joint self-exercise program. Understanding of the exercises was evaluated, and individualized feedback was provided to ensure correct performance.

4. Statistical Analysis

Statistical analyses were performed using SPSS Version 20.0 software(SPSS Inc., Chicago, IL, USA). The normality of the data was assessed using the Shapiro–Wilk test. A two-way repeated-measures ANOVA with one between-subjects factor and one within-subjects factor was employed to evaluate the effects of the intervention. When a significant group × time interaction was found, simple main effect analyses with Bonferroni-adjusted post-hoc comparisons were conducted to identify specific differences between time points within each group or between groups at each time point. The level of statistical significance was set at α=0.05.

Ⅲ. Results

1. Shoulder Joint Range of Motion

Flexion showed a significant main effect of time (F=298.523, p<.001) and a significant group × time interaction(F=5.373, p=.007)(Table 2). Bonferroni-corrected post hoc analysis revealed significant within-group improvements across all time points(baseline, 4th week, and 8th week; all p<.001). Between-group comparisons showed no significant differences at baseline or the 4th week(p>.05), whereas the experimental group demonstrated significantly greater flexion ROM than the control group at the 8th week(p<.001).

Abduction demonstrated a significant main effect of time(F=350.322, p<.001), with Bonferroni-corrected post hoc comparisons indicating significant differences between all time points(baseline, 4th week, and 8th week; all p<.001). No significant group or interaction effects were observed(p>.05).

External rotation showed significant main effects of both time(F=185.013, p<.001) and group(F=4.299, p=.047). Bonferroni-corrected post hoc tests indicated significant differences among all time points(p<.001). No significant interaction was detected(p>.05).

2. Respiratory Function

FVC showed significant main effects of time(F=169.725, p<.001) and group × time interaction(F=7.118, p=.002). Bonferroni-corrected post hoc analysis revealed significant improvements across all time points within both groups(all p<.001). Between-group comparisons showed no significant differences at any time point(p>.05)(Table 2).

FEV_1 demonstrated a significant main effect of time(F=213.324, p<.001) and a significant group × time interaction(F=7.138, p=.002). Both groups showed significant within-group improvements across all measurement points(all p<.001), but no between-group differences were found at any time point(p>.05).

PEF exhibited significant main effects of time(F=476.407, p<.001) and group × time interaction(F=7.088, p=.002). Post hoc comparisons revealed significant within-group improvements across all time points(all p<.001); however, there were no significant between-group

Table 2. Changes in Shoulder Joint Range of Motion, Respiratory Function, and Quality of Life Across Groups and Time Points

		baseline	4 week	8 week	group		group x time		time	
					F	p	F	p	F	p
Flexion(°)	MT	68.13±29.49	124.38±25.29	173.75±5.00	1.314	0.261	5.373	0.007*	298.523	0.000*
	M	74.69±26.92	115.00±17.51	155.63±12.10						
Abduction(°)	MT	64.38±32.40	117.50±24.08	170.63±7.72	3.516	0.105	.914	0.397	350.322	0.000*
	M	57.19±23.87	105.63±21.28	153.13±15.80						
External Rotation(°)	MT	25.00±21.45	53.44±16.71	77.50±5.77	4.299	0.047*	1.147	0.321	185.013	0.000*
	M	19.38±9.98	48.75±9.92	65.63±8.14						
FVC(ℓ)	MT	3.70±0.33	3.91±0.39	4.21±0.35	0.017	0.897	7.118	0.002*	169.725	0.000*
	M	3.76±0.34	3.91±0.38	4.10±0.40						
FEV_1(ℓ)	MT	2.96±0.26	3.13±0.31	3.41±0.29	0.018	0.894	7.138	0.002*	213.324	0.000*
	M	3.01±0.27	3.13±0.31	3.32±0.33						
PEF(ℓ/sec)	MT	5.18±0.46	5.47±0.55	6.31±0.53	0.022	0.883	7.088	0.002*	476.407	0.000*
	M	5.26±0.48	5.48±0.54	6.14±0.61						
SF-36 (scores)	MT	48.69±2.39	53.44±2.37	61.63±3.30	0.607	0.442	2.370	0.102	850.647	0.000*
	M	48.69±2.47	52.81±2.26	60.31±2.33						

*p<0.05
MT, manual physical therapy combined with home exercises for thoracic mobility; M, Manual Physical Therapy; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; PEF, peak expiratory flow

differences(p>.05).

3. Health-Related Quality of Life

SF-36 scores showed a significant main effect of time(F=850.647, p<.001). Bonferroni-corrected post hoc tests revealed significant improvements between baseline, 4th week, and 8th week(all p<.001). No significant group or interaction effects were observed(p>.05)(Table 2).

Ⅳ. Discussion

The present study demonstrated that both manual physical therapy and manual physical therapy combined with home exercises for thoracic mobility significantly improved shoulder joint mobility, respiratory function, and HRQoL in post-surgical patients over an eight-week intervention period. Consistent with previous research, these findings highlight the therapeutic benefits of physical therapy interventions in post-surgical rehabilitation, particularly for improving joint ROM(Conti et al., 2009), respiratory outcomes(Pennisi, 2024), and overall patient well-being.

The present study found significant improvements in shoulder range of motion in both groups, with the group performing home exercises for thoracic mobility showing greater gains in flexion over time. All participants exhibited a rounded shoulder posture following rotator cuff repair, which may have contributed to postural limitations during movement.

The addition of home exercises for thoracic mobility appears to have played an important role in alleviating these postural limitations. These exercises appear to have contributed to smoother shoulder flexion by improving upper body movement and postural control. This mechanism is consistent with previous findings that improved thoracic mobility contributes to better shoulder kinematics and reduced compensatory muscular activity(Park et al., 2020; Muth et al., 2012).

These findings also support the notion that enhanced thoracic mobility and posture correction may play a targeted role in flexion recovery, potentially by reducing biomechanical restrictions and enhancing neuromuscular coordination in associated muscle groups(Jensen and

Kannas, 2021). The progressive improvements observed across the 4th and 8th weeks further emphasize the value of sustained therapeutic interventions in shoulder joint rehabilitation. Moreover, maintaining consistent therapeutic input and encouraging patient adherence throughout the intervention period appear essential for optimizing motor relearning and joint mobility restoration, highlighting the importance of continued engagement in rehabilitation programs even after initial improvements are achieved.

In contrast, abduction and external rotation exhibited significant time effects without group × time interactions. These movements primarily depend on glenohumeral joint mechanics, such as capsular elasticity and rotator cuff integrity, rather than thoracic or scapulothoracic motion. Therefore, their improvement is likely attributable to the general effects of manual physical therapy and progressive rehabilitation rather than the additional benefit of thoracic mobility exercises.

Respiratory function outcomes demonstrated robust improvements in both groups, with significant group × time interactions for FVC, FEV_1, and PEF. These results suggest that thoracic mobilization specifically enhanced respiratory recovery beyond the effects of manual physical therapy. Prior studies have shown that thoracic mobility exercises can facilitate pulmonary function, particularly in patients with reduced respiratory capacity following surgery. The greater improvements in FVC, FEV_1, and PEF observed in the combined therapy group may be attributed to improved thoracic cage expansion and decreased muscle tension in the chest wall, leading to more efficient respiratory mechanics.

The significant increases in SF-36 scores across all measurement time points suggest that both interventions had a positive impact on HRQoL over time(Adeyinka, 2021). This outcome reflects the broader benefits of improved physical function and reduced pain or discomfort on overall well-being and daily life. However, the absence of a significant group × time interaction in SF-36 scores indicates that both interventions were equally effective in supporting HRQoL improvements, regardless of the addition of thoracic mobilization exercises.

These findings carry important implications for rehabilitation following shoulder surgery. Incorporating thoracic mobilization exercises into a standard manual physical therapy program may provide additional benefits for shoulder flexion and respiratory function—both of which are critical for restoring independence and improving HRQoL. A combined therapeutic approach may therefore represent a more comprehensive strategy for optimizing post-surgical rehabilitation outcomes(Brantingham et al., 2011).

This study has several limitations. First, the single-center design limits the generalizability of the findings. Future studies involving multiple centers and more diverse populations are needed to confirm these results. Second, the intervention period was limited to eight weeks, which may not fully reflect the long-term effects of combined manual physical therapy and thoracic mobility home exercises. Long-term follow-up studies would help clarify the persistence of the observed improvements. Third, this study relied on self-reported adherence to the home exercise program, which could introduce reporting bias. Objective measures of exercise compliance, such as digital monitoring or wearable sensors, should be considered in future research.

Ⅴ. Conclusion

In conclusion, both groups that received manual physical therapy, either with or without additional home exercises for thoracic mobility, were effective in improving shoulder joint range of motion, respiratory function, and quality of life in post-surgical patients. Adding home exercises for thoracic mobility seems to offer specific benefits for shoulder flexion and respiratory outcomes, supporting their inclusion in comprehensive rehabilitation protocols. Further research is needed to confirm these findings and to explore their long-term effects.

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