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EFFECTS OF BREATHING EXERCISES ON PAIN AND FUNCTIONALITY IN ROTATOR CUFF TEARS: A RANDOMIZED CONTROLLED TRIAL

ROTATOR CUFF YIRTIKLARINDA SOLUNUM EGZERSİZLERİNİN AĞRI VE FONKSİYONELLİK ÜZERİNE ETKİSİ: RANDOMİZE KONTROLLÜ ÇALIŞMA

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ABSTRACT

Objective: Rotator cuff tears (RCT) were common shoulder injuries that caused pain, strength loss, and functional impairment. This study assessed the effectiveness of adding breathing exercises to conventional physiotherapy to alleviate pain and improve functionality in individuals with RCT.

Method: In this single-blind, randomized controlled trial, 30 participants aged 30–55 with diagnosed RCT were allocated into two groups: the Conventional Group (CG), receiving standard physiotherapy, and the Breathing Exercise Group (BEG), receiving standard physiotherapy plus breathing exercises for six weeks. Outcome measures included pain intensity assessed by the Numeric Pain Rating Scale (NRS), range of motion (ROM) measured with a goniometer, and shoulder functionality evaluated using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire.

Results: Baseline demographic and clinical parameters did not differ significantly between groups (p>0.05). Both groups demonstrated significant improvements in pain, ROM, and DASH scores post-treatment (p<0.05). However, BEG showed superior improvements in nearly all outcomes, with statistically significant differences in NRS-activity, DASH scores, and ROM (flexion, abduction, internal and external rotation) compared to CG (p<0.05). No significant difference was observed in shoulder extension ROM between the groups.

Conclusion: The integration of breathing exercises into conventional physiotherapy significantly enhances pain relief and functional outcomes in individuals with RCT. These findings support the inclusion of breathing exercises as a complementary approach in conservative rehabilitation programs for rotator cuff injuries.

Key Words: Breathing exercises, Physiotherapy, Rehabilitation, Rotator cuff

ÖZ

Amaç: Rotator cuff yırtıkları (RCY) omuzda ağrı, kuvvet kaybı ve fonksiyonel kısıtlılıklara neden olan yaygın yaralanmalar arasında yer almaktadır. Bu çalışmada RCY'de ağrıyı azaltmak ve fonksiyonel yetenekleri geliştirmek amacıyla solunum egzersizlerinin konvansiyonel fizyoterapiyle kombinasyonunun etkinliğinin incelenmesi amaçlandı.

Yöntem: Bu randomize ve tek kör çalışmada, 30-55 yaşları arasında RCY tanısı almış 30 birey yer aldı. Katılımcılar altı hafta boyunca rutin fizyoterapi uygulanan Konvansiyonel Grup (KG) ve aynı programa ek olarak solunum egzersizleri uygulanan Solunum Egzersizi Grubu'na (SEG) ayrıldı. Ağrı, Sayısal Ağrı Derecelendirme Ölçeği (NRS) ile ölçülürken; eklem hareket açıklığı (ROM) gonyometre ile, omuz fonksiyonelliği ise Kol, Omuz ve El Yetersizlik Anketi (DASH) ile değerlendirildi.

Bulgular: Tedavi öncesi gruplar arasında demografik özellikler ve temel ölçümler açısından anlamlı bir fark bulunmadı (p>0.05). Tedavi sonrasında her iki grupta da tüm parametrelerde iyileşme gözlendi (p<0.05). SEG, NRS-aktivite, DASH skoru ve Eklem Hareket Açıklığı (fleksiyon, abdüksiyon, internal ve eksternal rotasyon) açısından KG' ye kıyasla istatistiksel olarak daha etkiliydi (p<0.05). Bununla birlikte, omuz ekstansiyonu hareket açıklığı açısından gruplar arasında istatistiksel olarak anlamlı bir fark saptanmadı; her iki grubun tedavi sonrası değerleri benzer düzeyde kaldı (p>0.05).

Sonuç: Solunum egzersizlerinin konvansiyonel fizyoterapiye eklenmesinin RCY tedavisinde ek faydalar sağladığı gözlendi. Bulgular, RCY tedavi protokollerine solunum egzersizlerinin dahil edilmesinin ağrı yönetimi ve fonksiyonel iyileşmeyi artırabileceğini gösterdi.

Anahtar Kelimeler: Solunum egzersizleri, Fizyoterapi, Rehabilitasyon, Rotator cuff

INTRODUCTION

Shoulder pain is a prevalent musculoskeletal condition affecting a significant portion of the population. Studies have shown that the annual prevalence of shoulder pain is approximately 47%, while the lifetime prevalence can reach up to 70% [1]. Rotator cuff tear (RCT) is a prevalent condition frequently leading to shoulder pain and impairing functionality in various daily activities. This syndrome induces pain and disability among affected individuals [2]. Rotator cuff tears are prevalent in individuals aged 40-60 and show a significant increase with age. According to the study by Yamamoto et al., rotator cuff tears were identified in 6.7% of individuals in their 40s and 12.8% of individuals in their 50s. This study examined the prevalence of rotator cuff tears in general population and found a trend of increasing prevalence with age [3,4]. RCTs are distinguished by symptoms such as shoulder pain, restricted range of motion, weakened shoulder muscles, and impaired function [5,6]. Numerous studies have beenconducted on the efficacy of surgical and conservative treatment

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methods for rotator cuff tears; however, conservative treatment is generally recommended as the first choice, particularly for non-traumatic tears [7,8]. In managing rotator cuff tears, conservative treatment options encompass a range of interventions such as exercises to improve range of motion (ROM), stretching, strengthening, and mobilization [9,10]. The primary objectives of conservative treatment are to alleviate pain, enhance muscle strength, and restore ROM [9]. In recent years, there has been growing interest in using breathing exercises as a therapeutic intervention for pain management and musculoskeletal disorders [11,12]. Studies on the positive effects of breathing exercises on pain management have shown that these exercises modify pain management have shown that these exercises modify pain perception and improve body alignment. Diaphragmatic breathing reduces pain perception by decreasing sympathetic nervous system activity and alleviating muscle tension, thereby improving posture [13,14]. The activation of the diaphragm has been found to alter the perception of pain and promote proper posture and body alignment, thereby contributing to overall well-being [15]. Evidence suggests that doing yoga with breathing exercises has the potential to reduce pro-inflammatory markers, indicating their effectiveness in mitigating inflammation [16,17]. Research has shown that breathing exercises reduce pain and improve quality of life and range of motion. It has been emphasized that diaphragm activation benefits body mechanics, particularly in musculoskeletal disorders [18]. In the study by Fernández-López et al., three different intervention methods, manual diaphragm therapy, myofascial trigger point treatment, and active diaphragm mobilization, were compared to evaluate the immediate effects on shoulder pain and mobility [19]. Our study focuses on the integration of breathing exercises into conventional physiotherapy, examining the long-term effects of reducing pain and improving functionality in rotator cuff tears. Unlike the study by Fernández-López et al., which assessed immediate effects, our study evaluates longer-term outcomes. Additionally, while their study compared three different intervention groups, our study investigates the effectiveness of combining breathing exercises with conventional physiotherapy. Although the study by Fernández-López et al. makes significant contributions to the literature, our study aims to address the gap by exploring the long-term therapeutic benefits of breathing exercises in rotator cuff tears, thereby providing a unique perspective and practical insights for clinical applications. The activation of the diaphragm has been shown to influence pain perception and enhance shoulder joint functionality. While previous studies have primarily focused on the isolated effects of breathing exercises on pain, posture, and the musculoskeletal system, limited research has explored their integration with conventional physiotherapy for individuals with rotator cuff tears (RCT). This study investigates the combined effects of breathing exercises and physiotherapy on pain reduction, improved range of motion (ROM), and enhanced shoulder functionality. It hypothesizes that incorporating breathing exercises into conservative therapy may yield superior outcomes compared to conventional interventions alone. By evaluating this integrated approach, the study aims to provide new insights into the role of breathing exercises in RCT rehabilitation, particularly their potential to improve pain management and functional recovery.

METHOD

Study Design

This randomized controlled trial utilized a single-blind design, with participants randomly allocated to one of two groups in a 1:1 ratio. A total of 30 individuals who fulfilled the eligibility criteria for the RCT were enrolled in the study. All participants received comprehensive information about the study and provided written informed consent. A total of 42 individuals were initially screened for participation. Seven individuals were excluded due to not meeting the inclusion criteria, and five declined to take part. Consequently, the final sample included 30 participants who were randomly assigned to one of two groups. In the Breathing Exercise Group (BEG), there were six males and nine females, and in the Conventional Group (CG), there were five males and 10 females.

Participants were sequentially numbered from 1 to 30 based on the order of their arrival at the clinic. These numbers were randomized using the randomization algorithm on the "randomizer.org" website to ensure homogeneous distribution among groups and minimize potential confounding factors. According to the randomized sequence, participants were assigned to either the CG (n=15) or BEG (n=15). The randomization process was conducted immediately after participants were enrolled in the study. To ensure blinding, all participants were provided with standardized information regarding the general benefits of the exercises, while group-specific details were not disclosed. This approach created the impression that both groups followed similar protocols, thus maintaining neutrality.

Participants

Thirty participants with a physician-confirmed partial tear of the supraspinatus at Istanbul Medipol University Hospital, who met the inclusion criteria, were recruited for this study. The participants were between the ages of 30 and 55, had no history of shoulder surgery, exhibited restricted shoulder joint range of motion, and had a diagnosed rotator cuff tear. The exclusion criteria were as follows: individuals with a history of significant shoulder trauma, anatomical deformities, skeletal fractures, diagnosed orthopedic or rheumatologic disorders, participation in a physiotherapy program within the last six months, presence of a cardiac pacemaker, current infections, recent myocardial infarction (within the last six months), or any other condition that could interfere with their ability to perform the prescribed exercises. The study's progress and participant flow are illustrated in the Consolidated Standards of Reporting Trials (CONSORT) flow diagram (Fig. 1).

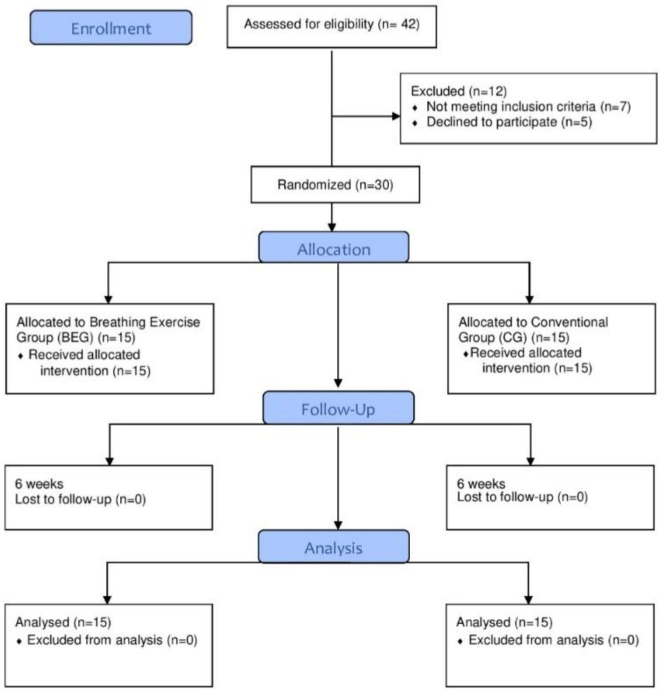

Figure 1. Design and flow of participants through the trial

Intervention

Conventional Group

In addition to standard physiotherapy techniques, a range of therapeutic modalities and exercises were used to treat the affected shoulder. These included cold pack application, ultrasound therapy, transcutaneous electrical nerve stimulation (TENS), finger ladder exercises, Codman exercises, shoulder wheel exercises, and wand exercises. The wand exercises were performed in both directions, with ten repetitions each, while the Codman exercises were completed with 30 repetitions in each direction. Ultrasound therapy was administered to the affected shoulder daily for six minutes per session, five days a week, over a total of 30 sessions. The ultrasound intensity was set at 1.5 W/cm^2, ensuring full contact with the shoulder area at a perpendicular angle. Manual stretching was conducted by the physiotherapist, targeting shoulder flexion, abduction, extension, external rotation, and internal rotation. These stretches were performed five times in each direction, with each stretch held for 20 seconds. TENS was applied for 20 minutes at a frequency of 100 Hz, and a cold pack was applied to the shoulder for 15 minutes [5,9]. All conservative interventions were conducted under the supervision of a physiotherapist five days a week for six weeks. An individualized exercise progression plan was designed for each participant based on their response to the treatment protocol. The progression framework involved gradually increasing the number of repetitions and the difficulty level of the exercises, ensuring an appropriate and stepwise increase in intensity tailored to each participant's individual capacity.

Breathing Exercises Group

In addition to conventional physiotherapy, diaphragmatic breathing, and thoracic expansion, breathing exercises were performed five days a week under the supervision of a physiotherapist.

Diaphragmatic Breathing Exercises Protocol

1. Participants assumed a supine position on a flat surface or bed with knees bent. A pillow was utilized, if desired, to provide support for the head and knees, enhancing comfort
2. One hand was placed on the upper chest area, while the other was positioned just below the rib cage on the abdomen.
3. Participants were instructed to inhale slowly through the nostrils, allowing the air to penetrate the lower abdomen deeply. While the hand on the chest remained stationary, the hand on the abdomen was raised.
4. Abdominal muscles were contracted, and participants were allowed to draw them inward during exhalation through pursed lips. The hand on the abdomen was returned to its initial position [20].

Thoracic Expansion Protocol

In a seated or standing posture, the individual was directed to inhale deeply while raising both arms and retain their breath for 2-3 seconds. Participants were then instructed to exhale while lowering their arms. Following this, they were asked to fully adduct their shoulders, take a deep breath, hold it for 2-3 seconds, and then exhale. Next, they were directed to take a deep breath while raising one shoulder, holding it for 2-3 seconds, and exhaling as they lowered the elevated shoulder, repeating the process with the other shoulder. This sequence was performed five times during each exercise session [21].

Outcome Measures

All individuals' demographic information was recorded before the study. Before the application, the shoulder functionality of all individuals was evaluated with a Numerical Rating Scale (NRS), goniometric measurement, and The Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH). After the first evaluation, applications were made to the participants according to the groups they were interested in, and then the first evaluation methods were repeated.

Primary Outcome

The Numeric Rating Scale (NRS): NRS is commonly employed in both research and clinical environments to quantify the level of pain experienced by individuals [22]. In pain assessment, the absence of pain is commonly denoted as a numerical value of 0, while the most severe pain level is represented by a value of 10 [23].

Secondary Outcomes

Range of Motion: A universal goniometer was utilized to assess the range of motion in the affected shoulder for flexion, extension, abduction, as well as internal and external rotation. The reference values applied for these measurements were 45 degrees for extension, 0-180 degrees for flexion and abduction, and 0-90 degrees for both internal and external rotation [24].

The Disabilities of the Arm, Shoulder, and Hand (DASH): The DASH scale, created by the American Academy of Orthopedic Surgeons in collaboration with other professional organizations, is a standardized instrument used to evaluate physical limitations and functional impairments in individuals with upper extremity conditions. The DASH questionnaire includes three distinct subdomains. The first section consists of 30 questions, with 21 items focusing on the patient's difficulties in performing daily activities, five items assessing symptoms, and the remaining four items addressing social functioning, work productivity, sleep quality, and self-confidence. Higher scores on the DASH questionnaire indicate greater levels of disability and functional limitation, whereas lower scores reflect less disability and better functional status [25].

Ethical Approval

The trial adhered to the ethical principles outlined in the Declaration of Helsinki. The study protocol was approved by the Non-Interventional Ethics Committee of Istanbul Medipol University (date: 25.08.2022, approval number: 742). Additionally, the protocol was registered with ClinicalTrials.gov (NCT05584345).

Statistical Analysis

The required sample size for the study was calculated to be 30 participants, providing 80% statistical power ($\alpha=0.05$) with an effect size of 0.80, particularly for the pain assessment. This calculation was performed using G*Power software (version 3.1.9.2) [26]. The data were analyzed using IBM SPSS Statistics Standard Concurrent User Version 26 (IBM Corp., Armonk, New York, USA). Descriptive statistics were presented as frequency (n), percentage (%), mean ($\bar{X}$), standard deviation (SD), median (M), minimum (min), and maximum (max) values. The Shapiro-Wilk test was applied to check the normality of the numerical data distribution. To compare numerical characteristics between groups, the Independent Samples t-test was used, while categorical data were compared using chi-square tests (either Pearson chi-square or Fisher's exact test). Within-group changes in the dependent variables before and after the intervention were assessed using paired samples t-tests, and between-group differences were examined with independent samples t-tests. A mixed-design analysis of variance (ANOVA) was performed to compare variables across different time points within each group. Effect sizes were reported as partial eta-squared (η^2p), with thresholds of 0.01 for small, 0.06 for medium, and 0.14 for large effects, according to Cohen's d [27]. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

The demographic and clinical characteristics of the participants, including age, height, gender, and symptom duration, were similar between the Conventional Group (CG) and the Breathing Exercise Group (BEG), as summarized in Table 1. Table 2 presents the pre-and post-treatment comparisons for each group, as well as the differences between the groups. Both groups demonstrated significant improvements in NRS scores (at rest and during activity), DASH scores, and ROM parameters after treatment ($p<0.05$). However, the BEG group exhibited more pronounced improvements across all parameters compared to the CG group, with a significance level of $p<0.01$. For NRS-Resting, the BEG group achieved a larger reduction in scores (mean difference:-4.93±1.87, $\eta^2=0.844$) compared to the CG group (-3.20±1.15, $\eta^2=0.695$). Similarly, NRS-Activity scores decreased significantly in the BEG group (mean difference:-6.4 ±1.40, η²=0.943) compared to the CG group (-3.60±0.83, η²=0.839). DASH scores also showed greater improvement in the BEG group (mean difference:-62.28±11.75, η²=0.954) than in the CG group (-37.56±8.00, η²=0.882). Regarding ROM, the BEG group demonstrated substantial improvements in flexion, abduction, and internal and external rotation parameters. For example, ROM-Flexion increased significantly in the BEG group (mean difference: 69.27±17.82, η²=0.919) compared to the CG group (41.93±11.76, η²=0.805). ROM-Abduction improvements were also more notable in the BEG group (mean difference: 72.67±23.67, η²=0.871) than in the CG group (48.27±16.76, η²=0.748). For ROM-Internal Rotation, the BEG group achieved greater gains (mean difference: 46.33±11.72, η²=0.902) than the CG group (24.13±10.62, η²=0.714).

Table 1. Baseline characteristics of the participants

Baseline Characteristics	Group		Test (*p*)
	CG *n*=15	BEG *n*=15	
Age, (*years*)			
X±*SD*	44.60±6.99	45.73±8.31	*t*=-0.404
M (*min-max*)	47 (31-53)	49 (30-55)	(0.689)
Gender, *n* (*%*)			
Male	5 (%33)	6 (%40)	χ^2=0.144
Female	10 (%67)	9 (%60)	(0.705)
Height, (*cm*)			
X±*SD*	166.73±6.56	166.00±8.54	*t*=0.264
M (*min-max*)	165 (155-175)	165 (155-183)	(0.794)
Weight, (*kg*)			
X±*SD*	72.00±6.27	75.93±9.66	*t*=-1.323
M (*min-max*)	74 (60-85)	73 (60-90)	(0.197)
Body Mass Index, (kg/m^2)			
X±*SD*	25.97±2.68	27.75±4.44	*t*=-1.326
M (*min-max*)	25.6 (21.6-32.4)	27.7 (21.2-35.2)	(0.195)
Affected Side, *n* (*%*)			
Right	9 (%60)	9 (%60)	χ^2=0.001
Left	6 (%40)	6 (%40)	(0.999)
Time of onset of symptoms, (*weeks*)			
X±*SD*	2.73±1.22	3.07±1.75	*t*=-0.604
M (*min-max*)	2 (1-5)	3 (1-6)	(0.550)

CG:Conventional Group; BEG:Breathing Exercise Group; SD:Standard Deviation

DISCUSSION

In our study, significant pain, functionality, and ROM improvements were observed in both the conventional and breathing exercise groups. However, the breathing exercise group demonstrated superior outcomes across all measures. This suggests incorporating breathing exercises into conventional treatment may enhance therapeutic outcomes in individuals with rotator cuff tears.

Conservative physiotherapy approaches are considered the first treatment approach for shoulder pain in individuals with rotator cuff tears. Physiotherapy approaches aim to relieve pain by reducing muscle spasms and increasing soft tissue mobilization. Furthermore, physiotherapy interventions increase functionality by increasing ROM and strengthening muscles [28].

A meta-analysis study conducted in 2017 compared the effectiveness of surgical and conservative treatment in individuals with rotator cuff tears. It showed that surgical treatment was not more effective than conservative treatment alone [29]. In a study by Kukkonen et al., it was shown that surgical and conservative treatment is effective in reducing pain in individuals with rotator cuff tears [30]. In research, the effectiveness of surgical and conservative treatment on pain, muscle strength, and functionality in individuals with rotator cuff tear was examined, and as a result of the study, it was reported that although surgical treatment gave better results than conservative treatment, the differences were very small and not clinically significant [8]. In the case of a study investigating the effectiveness of surgical and conservative treatment on pain, functionality, and disability in individuals with a rotator cuff tear, no difference was observed between the effectiveness of both treatments on functionality. Although surgical treatment gave better results on pain and disability, the authors reported that the difference between the results was very small [31]. These literature findings demonstrate that conservative physiotherapy approaches are an effective treatment option for rotator cuff tears and can provide similar outcomes compared to surgical treatment. In our study, the conventional therapeutic interventions applied also yielded significant improvements in pain, range of motion, and functionality parameters in individuals.

In a study in which patients with RC tendinopathy were treated with conventional exercise therapy, they were evaluated with the Constant Murley questionnaire, which included pain, daily living movements, range of motion, and strength parameters, in addition to the VAS for pain in daily life. As a result of the study, significant improvements were seen in both the Constant Murley score and VAS parameters [28]. A study conducted with 46 adults suffering from rotator cuff tears demonstrated that a structured rehabilitation program targeting the deltoid muscle, combined with electromyographic biofeedback, yielded positive outcomes in conservative treatment by improving shoulder flexion strength and enhancing patient satisfaction [32]. In a study comparing different exercise approaches after RC repair, both groups indicated significant improvements in all outcomes (DASH, pain, ROM, and strength) during the follow-up period [33]. It has been observed that shoulder functionality and pain are positively affected in patients with supraspinatus tendon rupture to whom electrotherapy modalities are applied [34]. Although significant improvements in ROM-Extension were observed within both groups after the intervention, the lack of a statistically significant difference between the groups may be attributed to the fact that extension movement is not as intensively utilized in daily activities as other planes of motion. This limitation could have resulted in a more restricted effect of the intervention on this specific motion plane, warranting further investigation in future studies. In our study, when we examined CG, in which electrotherapy modalities and therapeutic exercises were applied, we observed significant improvements in pain, functionality, and ROM parameters after treatment, similar to the results of studies in the literature.

Breathing exercises are known to be effective in sympathetic regulation and pain reduction [35]. Moreover, it has been suggested that vagal activity increases during breathing exercises, and thus, pain decreases [12]. It is recognized that respiratory exercises play a significant role in alleviating muscular tension in individuals experiencing pain [35]. In a study, breathing exercises were shown to be effective in increasing shoulder flexibility and decreasing shoulder pain in middle-aged female patients [12]. A different study suggested that breathing exercises may be effective in alleviating shoulder pain in patients undergoing laparoscopic cholecystectomy [36]. As a result of a case study in which the combination of PNF and deep breathing exercises was applied, a decrease in pain level and an increase in ROM values were observed [11]. In a separate study, indirect treatment of the shoulder using a protocol of manual therapy techniques targeting the diaphragm was found to be clinically effective in improving shoulder flexion and abduction movements [37]. A systematic review study revealed that manual diaphragm therapy showed a significant immediate effect on parameters related to rib, spine, and posterior muscle chain mobility [38]. Jafari et al. observed that hypoalgesia was more significant when breathing occurred at a slower frequency with a lower inspiration-to-expiration ratio [12]. Diaphragmatic breathing naturally stimulates the vagus nerve, leading to the suppression of peripheral inflammatory cytokine release, lowering sympathetic activity, activating the parasympathetic nervous system, and aiding in pain management [39]. Thoracic expansion exercises, as a specific type of breathing exercise, also play a critical role in improving musculoskeletal function. These exercises promote thoracic mobility, enhance lung capacity, and improve postural alignment, which may reduce compensatory movements during shoulder rehabilitation. By improving thoracic flexibility, they can facilitate more effective biomechanical movement patterns in the shoulder girdle, reducing pain and enhancing functionality [21].

Table 2. Intra-group differences of values pre-treatment and post-treatment and comparison of differences between groups

Variables	Group CG *n*=15	Group BEG *n*=15	Test Statistics	Group	Time	Group X Time	Power (%)
NRS-Resting							
Pre-test	5.87 ± 1.77	5.20 ± 1.86	F=1.013 p=0.323 η2=0.035	**F=12.869**	**F=206.313**	**F=9.370**	
Post-test	2.67 ± 1.05	0.27 ± 0.46	**F=66.219 p<0.001 η2=0.703**	**p=0.001**	**p<0.001**	**p=0.005**	**84.0%**
Mean difference	-3.20 ± 1.15	-4.93 ± 1.87		**η2=0.315**	**η2=0.881**	**η2=0.251**	
Test Statistics ϕ	**p<0.001 η2=0.695**	**p<0.001 η2=0.844**					
NRS-Activity							
Pre-test	8.27 ± 0.88	8.73 ± 0.88	F=2.091 p=0.159 η2=0.070	**F=12.223**	**F=564.516**	**F=44.258**	
Post-test	4.67 ± 0.82	2.33 ± 1.11	**F=42.875 p<0.001 η2=0.605**	**p=0.002**	**p<0.001**	**p<0.001**	**99.9%**
Mean difference	-3.60 ± 0.83	-6.40 ± 1.40		**η2=0.304**	**η2=0.953**	**η2=0.613**	
Test Statistics ϕ	**p<0.001 η2=0.839**	**p<0.001 η2=0.943**					
DASH							
Pre-test	74.44 ± 11.74	74.83 ± 12.26	F=0.008 p=0.930 η2=0.001	**F=14.658**	**F=740.324**	**F=45.393**	
Post-test	36.89 ± 8.81	12.55 ± 5.36	**F=83.526 p<0.001 η2=0.749**	**p<0.001**	**p<0.001**	**p<0.001**	**99.9%**
Mean difference	-37.56 ± 8.00	-62.28 ± 11.75		**η2=0.344**	**η2=0.964**	**η2=0.618**	
Test Statistics ϕ	**p<0.001 η2=0.882**	**p<0.001 η2=0.954**					
ROM-Flexion							
Pre-test	102.40 ± 14.86	105.07 ± 19.17	F=0.181 p=0.673 η2=0.006	**F=14.981**	**F=407.021**	**F=24.592**	
Post-test	144.33 ± 9.61	174.33 ± 9.04	**F=77.565 p<0.001 η2=0.735**	**p<0.001**	**p<0.001**	**p<0.001**	**99.8%**
Mean difference	41.93 ± 11.76	69.27 ± 17.82		**η2=0.349**	**η2=0.936**	**η2=0.468**	
Test Statistics ϕ	**p<0.001 η2=0.805**	**p<0.001 η2=0.919**					
ROM-Extension							
Pre-test	24.00 ± 11.83	31.00 ± 11.68	F=2.659 p=0.114 η2=0.087	**F=9.685**	**F=48.445**	F=0.736	
Post-test	34.67 ± 6.11	44.67 ± 1.29	**F=38.415 p<0.001 η2=0.578**	**p=0.004**	**p<0.001**	p=0.398	13.2%
Mean difference	10.67 ± 7.76	13.67 ± 11.09		**η2=0.257**	**η2=0.634**	η2=0.026	
Test Statistics ϕ	**p<0.001 η2=0.399**	**p<0.001 η2=0.522**					
ROM-Abduction							
Pre-test	82.07 ± 19.29	94.00 ± 21.06	F=2.619 p=0.117 η2=0.086	**F=19.793**	**F=260.842**	**F=10.619**	
Post-test	130.33 ± 17.21	166.67 ± 13.84	**F=40.597 p<0.001 η2=0.592**	**p<0.001**	**p<0.001**	**p=0.003**	**88.2%**
Mean difference	48.27 ± 16.76	72.67 ± 23.67		**η2=0.414**	**η2=0.903**	**η2=0.275**	
Test Statistics ϕ	**p<0.001 η2=0.748**	**p<0.001 η2=0.871**					
ROM-ER							
Pre-test	33.00 ± 18.69	42.33 ± 22.82	F=1.502 p=0.231 η2=0.051	**F=8.305**	**F=120.024**	**F=5.626**	
Post-test	58.33 ± 15.89	81.67 ± 10.12	**F=23.02 p<0.001 η2=0.451**	**p=0.008**	**p<0.001**	**p=0.025**	**62.9%**
Mean difference	25.33 ± 14.20	39.33 ± 17.92		**η2=0.229**	**η2=0.811**	**η2=0.167**	
Test Statistics ϕ	**p<0.001 η2=0.568**	**p<0.001 η2=0.760**					
ROM-IR							
Pre-test	34.33 ± 11.47	35.67 ± 9.23	F=0,123 p=0,728 η2=0,004	**F=12.883**	**F=297.842**	**F=29.561**	
Post-test	58.47 ± 14.05	82.00 ± 8.41	**F=30.983 p<0.001 η2=0.525**	**p=0.001**	**p<0.001**	**p<0.001**	**99.9%**
Mean difference	24.13 ± 10.62	46.33 ± 11.72		**η2=0.315**	**η2=0.914**	**η2=0.514**	
Test Statistics ϕ	**p<0.001 η2=0.714**	**p<0.001 η2=0.902**					

CG:Conventional Group; BEG:Breathing Exercise Grou;, NRS:Numerical Rating Scale; DASH:The Disabilities of the Arm Shoulder and Hand Questionnaire; ROM:Range of Motion; ER:External Rotation; IR:Internal rotation; F:Assesses the significance of differences between group; p<0.05 indicates statistical significance; η^2:Represents effect size (0.01 small, 0.06 medium, 0.14 large), ANOVA test was used to evaluate differences between groups.

In a study by Fernández-López et al., the immediate effects of diaphragm manual therapy, myofascial trigger point treatment, and active diaphragm mobilization on shoulder pain and mobility were compared, showing improvements in pain levels and range of motion (ROM) [19]. However, these effects were evaluated in the short term without focusing on sustained outcomes.

In contrast, our study assessed the integration of breathing exercises with conventional physiotherapy over a longer duration of six weeks, examining their impact on pain, functionality, and ROM in individuals with rotator cuff tears. While Fernández-López et al. emphasized immediate post-intervention changes, our findings highlight the extended therapeutic benefits of breathing exercises, suggesting their role in not only reducing pain but also enhancing functionality and long-term rehabilitation outcomes. This comparative approach underscores the novelty of our study in addressing sustained effects and practical applications of breathing exercises within a broader treatment framework for rotator cuff injuries. We propose that breathing retraining exercises lower the respiratory rate, correct dysfunctional breathing patterns, and normalize respiratory chemistry (by increasing end-tidal CO_2, restoring pH balance, and enhancing tissue oxygenation). This, in turn, reduces the excitability of the nervous and muscular systems, leading to analgesic effects [40]. Breathing exercises regulate the autonomic nervous system and exert direct biomechanical effects on core stability. Improved core stability and diaphragmatic control can reduce compensatory movements during shoulder rehabilitation, leading to more efficient movement patterns and decreased pain. In our study, we suggest that the superior outcomes observed in participants who received breathing exercises could be due to the analgesic effect induced by these exercises, which in turn led to an increased range of motion and improved functionality. It is well-established that breathing exercises alleviate pain perception through relaxation mechanisms. Furthermore, considering the anatomical and physiological connections between the diaphragm and shoulder via innervation and myofascial tissue, these exercises may directly influence shoulder function [19]. One of the key strengths of our study is the innovative application of breathing exercises in the context of rotator cuff tears. This area has been under-researched in literature. We suggest that incorporating breathing exercises into the rehabilitation program for rotator cuff tears, alongside traditional musculoskeletal approaches, could be effective, and we recommend that further research be conducted in this area.

Limitations

The limitations of our study include the inclusion of individuals with partial tears of the supraspinatus muscle; however, no grouping or classification was performed based on the tear size, which may have influenced the results. Additionally, the absence of a control group that did not receive any exercise intervention makes it challenging to isolate the specific effects of the treatments. Future studies are recommended to investigate long-term outcomes (e.g., beyond 12 weeks) for a more comprehensive understanding.

CONCLUSION

In conclusion, conventional treatment and breathing exercises are effective options for individuals with rotator cuff tears. Breathing exercises have more advantages in improving pain, ROM, and shoulder functionality than conventional treatment. Given the potential of breathing exercises to improve pain and functionality, clinicians may consider incorporating these exercises into standard rehabilitation protocols for rotator cuff tears.

Ethical Approval: *2022/742 Non-Interventional Ethics Committee of İstanbul Medipol University*

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