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Original Article

Physiotherapy Section

Effect of Shoulder Rehabilitation on Acromiohumeral Distance in Rotator Cuff-related Shoulder Pain: A Quasi-experimental Study

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ABSTRACT

Introduction: Rotator Cuff-related Shoulder Pain (RCRSP) is a common musculoskeletal condition that causes pain and functional limitations. Reduced Acromion Humeral Distance (AHD) is associated with shoulder dysfunction in RCRSP. The Shoulder Symptom Modification Procedure (SSMP) may improve AHD and patient outcomes.

Aim: To investigate the effectiveness of a 12-week SSMP on AHD in individuals with Rotator cuff-related shoulder pain.

Materials and Methods: A single-blinded quasi-experimental study was conducted in the Department of Musculoskeletal Physiotherapy at RV College of Physiotherapy, Bengaluru, Karnataka, India, involving 60 participants aged 20 to 60 years with shoulder pain. Recruitment took place over six months, from February 2022 to July 2022. The researcher who performed the SSMP assessment and treatment was blinded to the pre- and post-test results of ultrasound imaging for AHD and Shoulder Pain and Disability index (SPaDi) scores. The response-guided treatment based on the SSMP assessment was administered twice a week for 12 weeks, with each session lasting 45 minutes. Pre-assessment of AHD and SPADI scores was conducted by an assessor, who also performed the follow-up evaluation after 12 weeks. Data were analysed using a paired t-test with R Software version 4.1.0, and a p-value <0.05 was considered statistically significant.

Results: The mean age was 42.67±11.46 years. At baseline, the mean AHD was 8.54±1.11 mm, significantly increasing to 9.14±1.11 mm after 12 weeks. The pre-test mean SPADI score was 64.77±30.22, significantly reducing to 10.33±6.5 post-intervention. A paired t-test revealed a significant reduction in SPADI scores (t=19.33, p-value <0.0001). The pre-test AHD was 8.54±1.11 mm, and the post-test AHD significantly increased to 9.14±1.11 mm (t=4.19, p-value <0.0001).

Conclusion: The 12-week SSMP significantly improved AHD and shoulder function in individuals with RCRSP. SSMP is an effective intervention for enhancing shoulder joint space, reducing pain, and minimising disability. Further studies are required to assess its long-term effects.

Keywords: Shoulder joint space, Subacromial impingement syndrome, Tendinopathy, Ultrasonography

INTRODUCTION

Shoulder pain is a prevalent musculoskeletal condition encountered in primary care. Globally, point prevalence estimates range from 6.9 to 26%, 1-month prevalence varies between 18.6 to 31%, 1-year prevalence ranges from 4.7 to 46.7%, and lifetime prevalence falls between 6.7% and 66.7% [1]. The recurrence rates over 12 months are approximately double the initial prevalence rates [2]. Among the various causes of shoulder pain, Rotator Cuff-related Shoulder Pain (RCRSP) is the most common, encompassing conditions such as subacromial pain syndrome (impingement syndrome), rotator cuff tendinopathy, and partial or full-thickness rotator cuff tears [3].

The management of RCRSP involves both conservative and surgical approaches, with the choice of treatment depending on various factors such as the severity of the tear, the patient's age, activity level, and the presence of symptoms [4].

Physiotherapy plays a crucial role in the conservative treatment of rotator cuff injuries, aiming to reduce pain and improve shoulder function. While physiotherapy is a critical aspect of management, the outcomes of various physiotherapeutic techniques may differ. Conventional conservative treatment typically includes a rehabilitation program focused on restoring Range of Motion (ROM), strengthening the muscles surrounding the joint, improving proprioceptive awareness, or a combination of these therapeutic approaches [5,6].

The AHD, defined as the shortest distance between the acromion and the humeral head, is a critical anatomical parameter associated with the presence and severity of shoulder disorders like Subacromial Impingement Syndrome (SIS) and rotator cuff tendinopathy [7,8]. Ultrasound imaging, which measures parameters such as AHD and tendon thickness, is widely used in assessing shoulder pain [9,10]. Although the intra-rater reliability of AHD measurements is well-established in healthy populations, there is a significant gap in the literature regarding its reliability and clinical relevance in individuals with rotator cuff pathologies [11].

Typically, normal AHD ranges from 9 mm to 12 mm when measured by ultrasound in a neutral shoulder position, with reduced values between 6 mm and 10 mm observed in individuals with tendon pathology [11]. Prior studies, such as those conducted by Desmeules F et al., have demonstrated a significant correlation between increased AHD and improved shoulder function following rehabilitation in patients with acute to Subacute Subacromial Impingement Syndrome (SIS). However, these studies often involve small sample sizes or specific patient stages, limiting their generalisability [12]. More recent research by Savoie A et al., has suggested that rehabilitation centered on movement training could increase AHD in patients with chronic subacromial pain syndrome, alongside functional improvements, although the correlation between these changes was not reported [13].

Shoulder Symptom Modification Procedure (SSMP): The SSMP is an evidence-based approach used in shoulder rehabilitation that focuses on modifying symptoms through specific movement adjustments and exercises. SSMP is designed to identify and alleviate factors contributing to shoulder pain and dysfunction,

particularly in conditions like RCRSP. This approach emphasises real-time assessment and modification of shoulder mechanics to reduce pain and improve function, making it a potentially effective intervention for conditions involving altered AHD. The SSMP has shown varying levels of reliability and effectiveness in managing shoulder pain [14-16]. Some studies report favourable outcomes, highlighting its potential benefits. Despite existing evidence, there is a need for more robust research investigating the effectiveness of SSMP in patients with RCRSP.

This quasi-experimental study aims to evaluate the effectiveness of a targeted SSMP-based shoulder rehabilitation program on AHD in individuals with RCRSP. The novelty of present study lies in its unique focus on the targeted SSMP-based shoulder rehabilitation program specifically designed to improve AHD in individuals with RCRSP. While various rehabilitation strategies have been explored for shoulder pain, the application of SSMP in this context remains underexplored. By examining its direct effect on AHD, present study provides s new understanding of how targeted rehabilitation can bring about structural changes and improve functional outcomes for RCRSP, offering a new perspective for more focused and effective treatment options.

The present study is aimed to investigate the effectiveness of shoulder rehabilitation on AHD in individuals with RCRSP. The primary objective of the study is to assess the effect of shoulder rehabilitation on AHD in individuals with RCRSP. The secondary objective of the study is to assess the effect of shoulder rehabilitation on shoulder pain and disability using the Shoulder Pain and Disability Index (SPADI) in RCRSP.

Null hypothesis (H0): Shoulder rehabilitation has no significant effect on AHD in individuals with RCRSP.

Alternate hypothesis (Ha): Shoulder rehabilitation has a significant effect on AHD in individuals with RCRSP.

MATERIALS AND METHODS

A single-blinded, quasi-experimental study was conducted to evaluate the effectiveness of the SSMP on AHD in individuals with Rotator Cuff-related Shoulder Pain (RCRSP) in the Department of Musculoskeletal Physiotherapy, RV College of Physiotherapy, Bengaluru, Karnataka, India, after approval by the Institutional Ethics Committee (Ref: RVCP/RESEARCH/426A, dated 24-08-2021). The researcher took the permission to conduct the study in the OPD of the study Institute. The study was conducted over a period of six months, from February 2022 to July 2022. The population consisted of subjects with rotator cuff-related shoulder pain. The study utilised a convenience sampling design with a sample size of 60 participants. Shoulder rehabilitation was given twice a week for a total of 12 weeks, with each session lasting 45 minutes.

Sample size calculation: The sample size for present study was calculated using the following formula:

$$n=(\{(Z\alpha/2)2.\ p.\ q\}\div d2)$$

Here,

Where:

- α=0.05: Significance level
- Z=1.96: Z-score at a 95% confidence interval
- p=37.2% (0.37): The study justified this sample size based on a similar prior study's estimated prevalence [1].
- q=1-p=0.6: Complement of prevalence
- d=15% (0.15): Margin of error

Therefore, $n=(\{(1.96)2\times0.37\times0.6\})\div(0.15)^2$

=39.80 (round off to nearest number n=40)

=40+15% non response error

=40+6

n=46

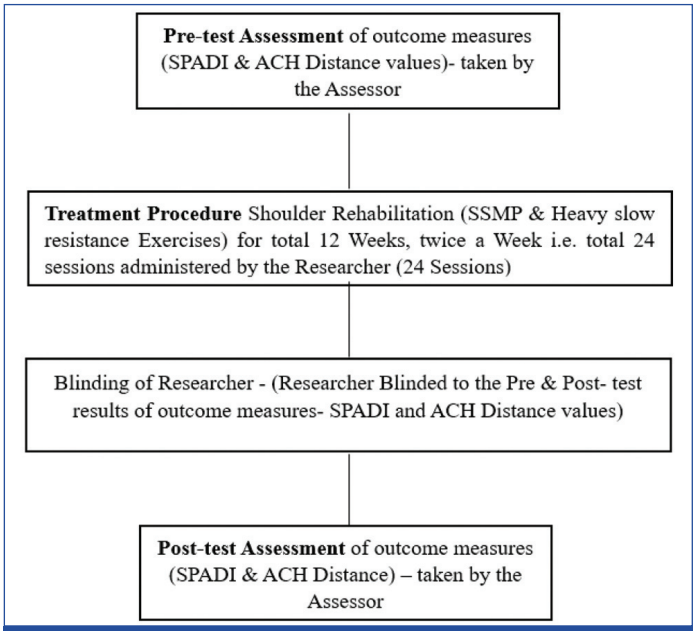
To ensure statistical power and account for possible dropouts, the sample size was rounded up to 60 participants.

Inclusion criteria: Subjects must be willing to participate as volunteers and sign the written informed consent form, aged 20-60 years; patients with unilateral pain; patients with shoulder pain for more than three months; presence of any of the three positive signs (Neer's impingement test, Hawkins test, painful arc, drop arm sign, or pain on resisted external rotation); and in the initial (painful) stage of frozen shoulder were included in the study.

Exclusion criteria: Individuals with a history of shoulder trauma, such as fractures; shoulder dislocation in the last two years; shoulder pain originating from the cervical spine; shoulder pain due to the following disorders: arthritis (e.g., rheumatoid arthritis), neurologic conditions (e.g., stroke), neoplastic conditions (e.g., breast cancer), and/or referred spinal pain (e.g., visceral referred pain); corticosteroid injections during the six months prior to the study; shoulder surgery within the past year; and history of direct contact injury to neck or upper extremity within past 30 days were excluded from the study.

Study Procedure

A total of 60 subjects were screened and recruited for the study based on inclusion and exclusion criteria. In present study, shoulder rehabilitation was administered over a 12-week period, incorporating both the Shoulder Symptom Modification Procedure (SSMP) and Heavy Slow Resistance (HSR) exercises [Table/Fig-1]. The SSMP, introduced by Lewis in 2009, is an evidence-based rehabilitation approach aimed at addressing shoulder pain and dysfunction [17]. This method focuses on modifying dysfunctional movement patterns to improve biomechanics, reduce pain, and restore function. The procedure involves techniques such as manual therapy, muscle facilitation, and movement modifications, and it was individually tailored for each participant. The SSMP was delivered twice a week for a total of 12 weeks, amounting to 24 sessions, with each session lasting for 45 minutes under the supervision of the researcher.



[Table/Fig-1]: Flowchart of the study procedure: pre-test assessment, 12-week rehabilitation (24 sessions) and post-test assessment.

In addition to SSMP, participants performed HSR exercises designed to strengthen shoulder muscles, improve joint stability, and enhance endurance. These exercises were progressively tailored to address specific weaknesses or imbalances identified during the baseline assessment [18,19].

The rehabilitation program was administered by the researcher, who was blinded to the pre- and post-test values of the Shoulder

Pain and Disability Index (SPADI) and AHD. This blinding ensured objectivity in evaluating the outcomes, preventing any bias in assessing the participants' progress.

The primary outcome measure was the change in AHD, reflecting improvements in shoulder health, while the secondary outcome was the change in SPADI scores, which assessed reductions in pain and improvements in shoulder function. At the end of the 12-week intervention, post-assessments were conducted by the assessor using the same methods to evaluate the effectiveness of the rehabilitation program in improving shoulder pain, mobility, and function.

Outcome measures:

1. Shoulder Pain and Disability Index (SPADI): The SPADI is a self-reported questionnaire used to measure pain and disability in individuals with shoulder disorders. It consists of 13 items divided into two subscales: Pain (5 items) and Disability (8 items), rated on a 0-10 scale. Higher scores indicate greater levels of pain and disability. SPADI has been shown to have excellent internal reliability and consistency [20].

2. The Acromiohumeral Distance (AHD): It is the shortest distance between the acromion and the humeral head, often measured using ultrasonography. This measurement is used to assess the spacing within the shoulder joint, which can be indicative of rotator cuff pathology or other shoulder impairments. In this study, AHD was measured by ultrasonography, with the patient seated and the upper limb in a neutral position. A linear transducer was placed over the anterior aspect of the acromion in the coronal plane. The distance was measured in millimetres, and the values were collected from the ultrasound reports by the assessor. The normal AHD, measured on ultrasound in the neutral shoulder position, ranges between 9 mm and 12 mm, while reduced values ranging from 6 mm to 10 mm in people with varying degrees of tendon pathology [11]. The reliability of AHD measurement by ultrasound has been assessed in many studies. For example, excellent intra-rater reliability (0.87-0.94) and moderate-to-excellent inter-rater reliability (0.64-0.92) of the AHD have been demonstrated using ultrasound in able-bodied individuals with healthy and impinged shoulders [12,21].

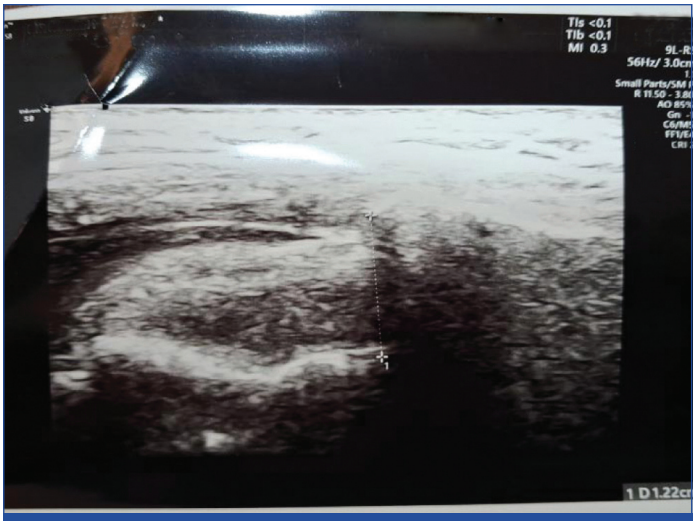
STATISTICAL ANALYSIS

Descriptive statistics were performed by analysing all categorical variables, which were presented in tabular form with results expressed as percentages. The quantitative variables were tested for normality; since most of them were non normally distributed, the results were presented in terms of Median {Interquartile Range, (IQR)}. However, the mean and Standard Deviation (SD) were also used to describe variables wherever needed. Additionally, the results were presented graphically whenever necessary. Inferential statistics were conducted using paired t-tests to compare pre-and post-intervention SPADI scores and AHD within the same group. A significance level of $p<0.05$ was considered statistically significant.

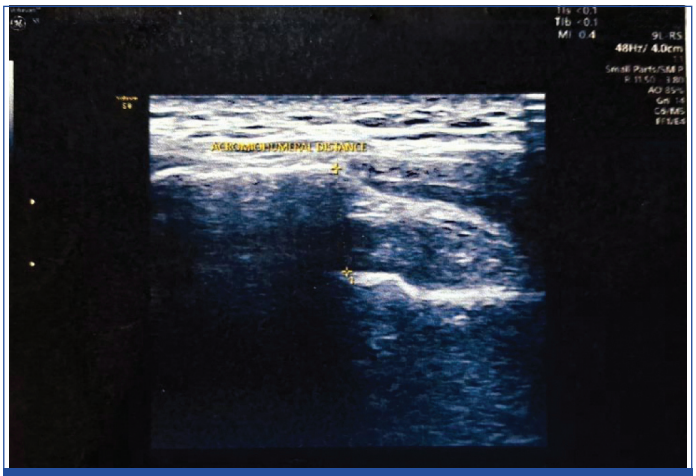
RESULTS

The image shows the pre-intervention ultrasound scan used to measure the AH distance. The AH distance was recorded as 11 mm, indicating a mild narrowing of the subacromial space [Table/Fig-2]. The post-intervention ultrasound scan used to measure the AH distance has been depicted in [Table/Fig-3]. The AH distance was recorded as 12 mm, showing an improvement in the subacromial space compared to the pre-intervention scan.

The demographic characteristics of the 60 subjects who participated in the study are presented in [Table/Fig-4]. The mean age was 42.67±11.46 years, with the majority (36.67%) belonging to the 50-60 age group. The gender distribution showed that 58.33% were males and 41.67% were females. [Table/Fig-5] displays the diagnosis



[Table/Fig-2]: The AHD was recorded as 11 mm, indicating a mild narrowing of the subacromial space.



[Table/Fig-3]: The AHD was recorded as 12 mm, showing an improvement in the subacromial space compared to the pre-intervention scan.

distribution. A higher proportion of participants (63.33%) were diagnosed with right-side RCRSP, while 36.66% had left-side RCRSP.

Parameters	Category	n (%)	Mean±SD
Age (years)	20-30	12 (20.00%)	42.67±11.46
	30-40	12 (20.00%)	
	40-50	14 (23.33%)	
	50-60	22 (36.67%)	
Gender	Male	35 (58.33%)	
	Female	25 (41.67%)	

[Table/Fig-4]: Demographic characteristics of subjects who participated in the study. SD: Standard deviation

Parameters	Category	n (%)
Diagnosis	L RCRSP	22 (36.66%)
	R RCRSP	38 (63.33%)
Total		60 (100.00%)

[Table/Fig-5]: Tabular representation of descriptive statistics-diagnosis. Data are presented as frequency (n) and percentage (%) L RCRSP: Left rotator cuff-related shoulder pain; R RCRSP: Right rotator cuff-related shoulder pain

The intervention outcomes are summarised in [Table/Fig-6,7]. SPADI scores showed a statistically significant improvement (p-value <0.0001) post-intervention, with the mean score decreasing from 64.77±30.22 to 10.33±6.5. Similarly, AHD distance increased significantly (p-value <0.0001) from 8.54±1.11 to 9.14±1.11 post-intervention. These findings indicate that the intervention had a positive and significant impact on both pain/disability scores (SPADI) and ACH distance over the 12 weeks.

Parameters	Pre-test Mean±SD	Post-test Mean±SD	t-value	p-value
SPADI	64.77±30.22	10.33±6.5	19.33	<0.0001

[Table/Fig-6]: Comparison of SPADI scores pre- and post-intervention after 12 weeks. For SPADI: Paired t-test

Parameters	Pre-test Mean±SD	Post-test Mean±SD	t-value	p-value
ACH distance	8.54±1.11	9.14±1.11	4.19	<0.0001

[Table/Fig-7]: Comparison of ACH distance pre- and post-intervention after 12 weeks. For ACH distance- Paired t-test

DISCUSSION

The present study investigated the effects of shoulder rehabilitation (SSMP with HSR exercises) on AHD in individuals with RCRSP. The results demonstrated significant improvements in SPADI scores and AHD post-intervention, aligning with findings from previous research while also highlighting novel insights.

The mean age of participants in present study was 42.67±11.50 years, which aligns with similar studies focusing on RCRSP. For instance, a study by Lin YS et al., reported comparable age demographics, emphasising that middle-aged adults are commonly affected by shoulder disorders [21]. However, studies such as the Standard verus Accelerated of Renal-Repacement Therapy (STAART) trial observed a higher mean age of 59 years, reflecting variations in age distribution across different research contexts [22]. These differences underscore the importance of tailoring interventions based on age-specific factors, as younger individuals may have sport-related aetiologies, while older populations often face degenerative causes [23].

In terms of gender distribution, our study included 35 males and 25 females, with males showing a higher representation. Previous literature provides mixed findings regarding gender differences in shoulder pain prevalence. While some studies suggest that males are more prone to disabling shoulder pain, others highlight higher prevalence of pain in females [24,25]. These inconsistencies may be attributed to cultural, occupational, and socioeconomic factors, which were not explored in our study.

The significant improvement observed in SPADI scores (mean reduction from 64.77 to 10.33) aligns with findings from quasi-experimental studies utilising SSMP, where similar reductions in pain and disability scores were noted [26]. However, unlike previous studies that primarily focused on short-term outcomes (4 weeks), our study extended follow-up to 12 weeks, providing insights into the sustained benefits of this intervention.

Regarding AHD, our findings support earlier research indicating that interventions targeting scapular stabilisation can improve AHD by optimising shoulder kinematics. Studies by Kim SY et al., demonstrated that Scapula Setting Exercises (SSE) increased AHD and enhanced scapular stabiliser muscle activation, particularly of the serratus anterior and trapezius muscles, during passive shoulder elevation [27,28]. However, a cross-sectional study with 97 patients found no significant correlation between AHD and pain or functional outcomes [29]. This suggests that while improvements in AHD are valuable, they may not directly translate to clinical outcomes in all cases.

The findings of present study highlight the effectiveness of SSMP combined with Heavy Slow Resistance (HSR) exercises as a promising intervention for managing chronic RCRSP. Clinicians can adopt this approach to address both functional limitations and biomechanical deficiencies. Additionally, the integration of long-term follow-ups in rehabilitation protocols may ensure sustained outcomes. Future research should focus on exploring the age- and gender-specific responses to SSMP interventions. Multicentre randomised controlled trials with larger sample sizes are needed to generalise findings. Additionally, investigating the underlying mechanisms linking AHD changes to clinical improvements could provide a deeper understanding of treatment efficacy.

The current study adds to the growing body of evidence supporting SSMP as an effective approach for managing RCRSP. While the results are promising, continued research is essential to optimise intervention protocols and enhance clinical outcomes across diverse populations.

Limitation(s)

The sample size and demographic characteristics may limit the generalisability of the results. Variability in demographic characteristics, such as age and gender, may have influenced outcomes. Pre-existing conditions, including musculoskeletal or systemic issues, and co-morbidities such as obesity and diabetes, could have impacted participant responses. Future research should explore larger, more diverse populations and longer follow-up periods to assess the long-term benefits of shoulder rehabilitation. Finally, without comparing SSMP to other interventions, the relative effectiveness of this novel approach remains unclear.

CONCLUSION(S)

The study demonstrates that shoulder rehabilitation significantly improves AHD and reduces pain and disability in patients with RCRSP. The results support the effectiveness of the rehabilitation program and highlight the need for targeted interventions based on demographic and clinical characteristics.

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