MARMARA
MEDICAL JOURNAL

Original Article

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Evaluation of the effectiveness of telerehabilitation in cases with rotator cuff tendinopathy

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Submitted: 24.12.2024 **Accepted:** 31.03.2025

ABSTRACT

Objective: Our study was designed to investigate the effectiveness of adding telerehabilitation (TR) to a home exercise program (HEP) in patients with rotator cuff tendinopathy.

Patients and Methods: The study included 45 patients diagnosed with rotator cuff tendinopathy and randomly assigned into two groups. The control group was given a HEP, while the study group received the same program supplemented with TR and following the intervention, patients' shoulder joint range of motion (ROM) was assessed with a goniometer, and functionality was evaluated using the Western Ontario Rotator Cuff Index (WORC) and the Simple Shoulder Test (SST).

Results: In intra-group assessments, there was a significant decrease in the WORC physical symptoms subscale in the TR group at the follow-up assessment ($p<0.001$), whereas no significant difference was found in the HEP group ($p=0.189$). Regarding the total SST score, an increase was seen in the TR group post-treatment ($p<0.001$), while no difference was found in the HEP group ($p=0.373$). Upon comparing TR and HEP, including increased active abduction of the right shoulder, as well as active flexion, abduction, and external rotation of the left shoulder, that TR group patients had significantly better results than HEP group patients in WORC and SST ($p=0.007$ and $p=0.007$ respectively).

Conclusion: The results of our study indicate that following a HEP with TR enhances shoulder mobility and functionality more effectively than the HEP alone in patients with rotator cuff pathology.

Keywords: Shoulder, Rotator cuff, Tendinopathy, Telerehabilitation, Pain

1. INTRODUCTION

Rotator cuff (RC) syndrome is a common issue that affects both young and elderly populations, causing significant pain and impaired shoulder functions. This condition is a general term encompassing several different disorders, including shoulder impingement syndrome, RC tendinitis/tendinosis, and subacromial bursitis [1]. The RC consists of four muscles: the supraspinatus, infraspinatus, teres minor, and subscapularis. Due to its biomechanical properties, blood supply, and its position just below the coracoacromial ligament, the supraspinatus tendon is the most frequently injured tendon within the RC [2].

Rotator cuff tendinopathy (RCT) is one of the most common causes of shoulder pain [3]. Individuals frequently experience pain, weakness, and functional limitations [4]. Pain is the most commonly reported symptom and is exacerbated during both passive and active shoulder flexion [5]. The severity of pain and limitations in joint range of motion are key factors in assessing a patient's functional capacity and quality of life [6]. Decreased joint range of motion leads to limitations in functional activities. Increased restrictions in functional activities and pain significantly impact individuals' working lives, social activities, and basic daily living tasks [7].

Physiotherapy focuses on restoring flexibility, mobility, and strength in painful shoulders [8]. Conservative treatment methods are often preferred as they support tendon healing by

How to cite this article: Kaymaz R, Taspinar F, Engin O, Taspinar B. Evaluation of the effectiveness of telerehabilitation in cases with rotator cuff tendinopathy. Marmara Med J 2025;38 (2): 150-157. doi: 10.5472/1708854.

ISSN: 1309-9469

http://doi.org/10.5472/marumj.1708854
Marmara Med J 2025;38(2): 150-157

positively influencing metabolism, structural and mechanical properties [9]. These methods play a crucial role in improving patients' quality of life by restoring shoulder functions. Research on monitoring physiotherapy practices through telerehabilitation programs is becoming more frequent. Telerehabilitation is preferred due to its cost-effectiveness, easy accessibility, and time-saving benefits. In the literature, telerehabilitation applications are most commonly used for neurological and pulmonary diseases [10-13].

With the widespread adoption of telecommunications worldwide, the use of telerehabilitation has been increasing in various fields. Today, telerehabilitation is preferred in many areas such as treatment interventions, monitoring of progression, educating families, access to healthcare professionals, patient care, and coordination [14]. Despite the increased prevalence of telerehabilitation, especially after the pandemic, its use for orthopedic conditions has been insufficiently addressed in the literature. Numerous sources emphasize the importance of exercise for RCT [15-17]. Telerehabilitation could be an option for monitoring these exercises. A review of the literature reveals that telerehabilitation has not been extensively used for patients with shoulder pain. Therefore, this study was designed to examine the effectiveness of telerehabilitation in cases of RCT.

2. PATIENTS and METHODS

Study Design

Our study was designed as a randomized controlled trial consisting of two groups. The study was conducted at Izmir Democracy University Buca Seyfi Demirsoy Training and Research Hospital's Physical Medicine and Rehabilitation Clinic. Patients diagnosed with RCT were included in the study. The diagnostic algorithm outlined in the "British Elbow and Shoulder Society (BESS) guidelines' diagnostic criteria" was followed for diagnosis [15]. Firstly, it was determined whether the pain was originating from the shoulder itself or radiating from the neck. If the pain was confirmed to be shoulder-related, further evaluation was conducted to exclude other common causes of shoulder discomfort, such as instability, acromioclavicular degeneration, and frozen shoulder. Subsequently, Jobe's test, a critical assessment for identifying rotator cuff pathologies, was performed. According to the BESS guidelines, Jobe's test is described as 'abduction with the thumb down.' [15,18]. If other pathologies were ruled out and Jobe's test was positive, the patient was diagnosed with a rotator cuff tear (RCT). The study by Malliaras et al., was used as a reference for determining the sample size. It was determined that at least 15 participants were required in each group with 82% power [19]. Ethical approval for the study was obtained from the Izmir Democracy University Non-Interventional Clinical Research Ethics Committee with the decision dated March 1, 2023, and numbered 2023/03-01. The trial protocol has been registered under the number NCT06024551. All participants were informed before the study, and their voluntary consent was obtained. The randomization process was carried out using the randomized.org program.

Participants

Between March 2023 and November 2023, 57 cases diagnosed with RCT were screened for participation in our study. A total of 45 individuals agreed to participate. The inclusion criteria for the study were: being between 18-65 years old, having sufficient cooperation to perform the exercises, having access to internet-connected computer equipment, and having an active e-mail account. Individuals with a diagnosed neurological disorder, a history of fractures or surgery in the shoulder region, or a previous psychiatric diagnosis, those who have used steroid medications in the last six months, have a rheumatic disease, have a diagnosed oncological condition, or severe cardiovascular problem that affect involvement in exercises were excluded. Prior use of medication was inquired. Following inclusion in the study, patients' analgesic use was limited to paracetamol. Participants were randomized into two groups: the Telerehabilitation Group (TRG) and the Home Exercise Program Group (HEPG). After excluding participants who could not be reached, those who withdrew from the program due to medical issues, or those who did not complete the prescribed exercises, the study was finalized with 22 participants in the TRG and 23 participants in the HEPG (Figure 1).

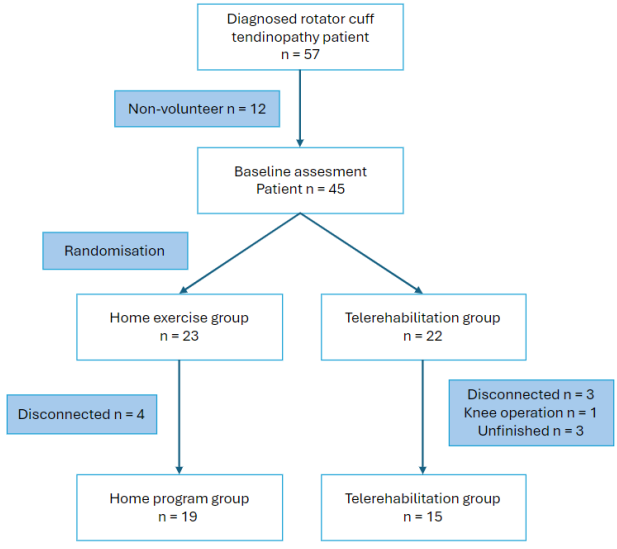

Figure 1. *Design and flow of participants throughout the study*

Exercise Intervention

In the HEPG, patients were provided with recommendations and exercises based on their shoulder pain conditions. These patients were given exercise diaries. Also, the recommendations were organized under the subheadings of planned posture/ergonomics, weight management/lifting techniques, and activity/movement, and were explained to the patients in detail. These recommendations are shown in detail in Figure 2.

http://doi.org/10.5472/marumj.1708854
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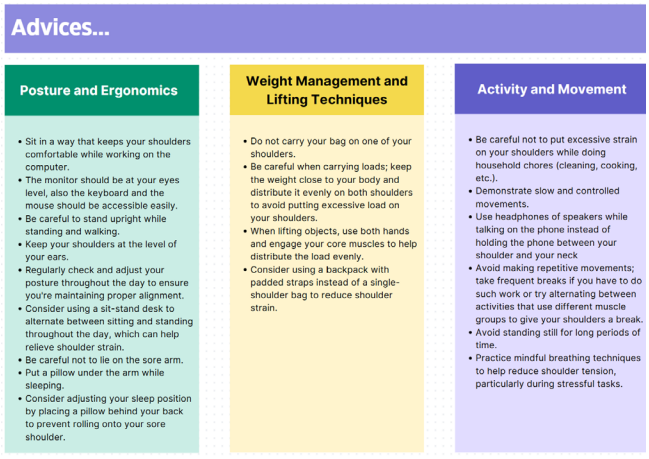

Figure 2. *Advices given to patients in the study*

Codman exercises were recommended for managing pain during the acute phase of recovery [20]. Isometric and wand exercises were implemented subsequent to acute phase. To ensure patient comfort and prevent exacerbation of symptoms, special attention was given to maintaining a pain level of not more than 5 on the Visual Analog Scale (VAS) throughout the exercise regimen [21]. Patients were instructed to repeat all exercises twice daily, with 10 repetitions per set, every day.

The same exercises and recommendations administered to the HEPG were explained and demonstrated to the TRG. In addition, participants in the TRG performed the exercises under the supervision of an online physiotherapist. Telerehabilitation was applied by the same physiotherapist for 20 minutes, 3 days a week for 4 weeks. Exercise was arranged according to the pain level. It was continued by taking short breaks when necessary. During these sessions, mistakes made during the exercises, precautions, and additional recommendations were addressed. Errors in the exercises were identified and corrected through video demonstrations and explanations via online platforms. For this follow-up, video communication tools such as Zoom, Microsoft Teams, or WhatsApp were used to provide remote access.

Assessments

The participant's age, height, weight, body mass index (BMI), disease duration, gender, education level, occupation, dominant side, disease duration, and medication use were evaluated and recorded in a pre-prepared form. Shoulder range of motion (ROM) was measured, and the Western Ontario Rotator Cuff Index (WORC) and Simple Shoulder Test (SST) were used to assess functional status [22,23].

ROM Measurement: For this measurement, the patient lay supine on a stretcher. A 180-degree universal goniometer was used for the assessment. The shoulder joint was measured in all directions, including active flexion, hyperextension, abduction, adduction, internal rotation, and external rotation, for both the right and left sides.

Western Ontario Rotator Cuff Index (WORC): The WORC was developed to measure the quality of life in patients with RCT. The scale consists of five subcategories: physical activities, sports/leisure activities, work, lifestyle, and emotions, with a total of 21 questions. Each question is in the form of a 100 mm visual analog scale. By summing the scores of the 21 items, a total score between 0 and 2,100 mm is obtained. A higher score indicates a poorer quality of life [19,22].

Simple Shoulder Test (SST): The SST is designed to evaluate function and symptoms in patients with shoulder disabilities. It contains 12 items related to shoulder function. The questionnaire is scored with "Yes" or "No" responses, with a total score ranging from 0 to 12. A lower score indicates greater disability [23,24].

Statistical Analysis

The data were analyzed using IBM SPSS Statistics Standard Concurrent User V 26 (IBM Corp., Armonk, New York, USA). Descriptive statistics were presented as number of units (n), percentage (%), mean ± standard deviation ($\bar{x}$ ± SD), median (M), and minimum (min) and maximum (max) values. A Mixed Design ANOVA was used to compare the measurements between groups. Bonferroni correction was applied for the comparison of main effects in the Mixed Design ANOVA analyses. A p-value of <0.05 was considered statistically significant.

3. RESULTS

The average age of the participants in the study was 52.26 ± 9.32 years. The descriptive data obtained from the participants are shown in Table I. Baseline values between the groups were compared, and only the right shoulder flexion ROM was found to be significantly different. Other variables were similar across the groups (Table II). No significant differences were observed in the intra-group evaluations of active shoulder ROM between the pre – and post-exercise assessments in both the TRG and HEPG groups. In the functional assessment of the participants, a significant difference was observed only in the "Work" sub-parameter of WORC in the HEPG group, while all functional data (WORC and SST) showed statistically significant improvements in the TRG. Upon comparing the ROM between the groups, the TRG exhibited significantly greater ROM in flexion, abduction, and external rotation than the HEPG. Additionally, in the functional assessments using the WORC and SST, the TRG demonstrated statistically significant superiority over the HEPG across all parameters. (Table III) (Figure 3).

http://doi.org/10.5472/marumj.1708854
Marmara Med J 2025;38(2): 150-157

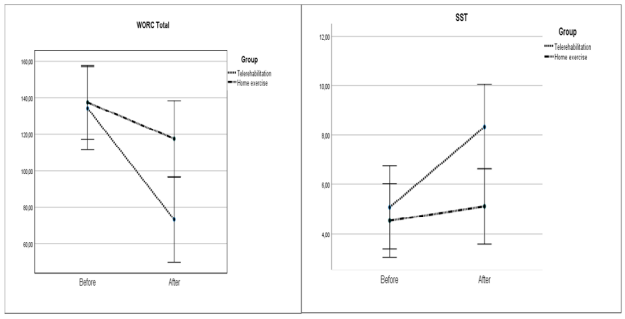

Figure 3. *Changes in functional status biomarkers in groups*

Table I.*Comparison of the demographic characteristics of the participants by groups*

	Groups		Test Statistics	
	Telerehabilitation	Home Exercises	Test Value	p-Value
Gender, *n (%)*				
Female	13 (86.7)	17 (89.5)	0.064	0.801‡
Male	2 (13.3)	2 (10.5)		
Age			0.678	0.515†
M (min-max)	54 (21-63)	55 (34-65)		
Height, *(cm)*			0.122	0.918†
M *(min-max)*	159 (150-178)	158 (150-188)		
Weight, *(kg)*			1.426	0.163¥
$\bar{x}$ ±*ss*	80.06±12.57	72.57±16.95		
BMI, (kg/m2)			2.076	0.046¥
$\bar{x}$ ±*ss*	31.18±4.34	27.81±4.96		
Education, n (%)				
Primary School	7 (46.7)	10 (52.6)	5.007	0.285‡
Middle School	4 (26.7)	1 (5.3)		
High School	2 (13.3)	6 (31.6)		
Undergraduate	1 (6.7)	2 (10.5)		
Postgraduate	1 (6.7)	0 (0.0)		
Occupation, n (%)				
Housewife	7 (46.7)	11 (57.9)	1.461	0.606‡
Civil Servant	1 (6.7)	0 (0.0)		
Other	7 (46.7)	8 (42.1)		
Dominant Side, n (%)			0.697	0.571‡
Right	13 (86.7)	18 (94.7)		
Left	2 (13.3)	1 (5.3)		
Duration of Illness			1.471	0.141†
M *(min-max)*	12 (2-120)	4 (1-72)		
Affected Side				
Right	4 (26.7)	5 (26.3)	0,002	0,999‡
Left	4 (26.7)	5 (26.3)		
Bilateral	7 (46.7)	9 (47.4)		
Prior use of Medication, n (%)			0.045	0.832‡
None	10 (66.7)	12 (632)		
Yes	5 (33.3)	7 (36.8)		

†Mann-Whitney U Test, ¥: Independent Samples t-Test, ‡: Pearson Chi-Square Test

Table II. *Comparison of baseline data of the participants*

Variables	TRG (15)	HEPG (19)	p
Shoulder Joint Active ROM			
Right Flexion	177.0±6.49	167.36±17.10	**0.048**
Right HE	41.0±8.49	36.57±12.58	0.253
Right ABD	171.0±16.27	158.94±27.86	0.148
Right ADD	45.0±0.0	43.15±6.91	0.311
Right IR	86.0±9.10	83.68±10.52	0.504
Right ER	87.33±7.98	76.84±18.57	0.050
Left Flexion	170.0±15.11	162.89±19.24	0.250
Left HE	40.33±8.12	41.84±8.20	0.596
Left ABD	155.33±34.40	142.36±33.59	0.277
Left ADD	42.66±6.77	43.15±8.20	0.853
Left IR	83.66±8.95	79.73±14.85	0.374
Left ER	78.0±17.40	63.68±26.23	0.078
Functional Assessment			
-WORC:			
Physical Symptoms	33.06±10.56	34.83±12.52	0.665
Sports/Leisure	26.95±8.17	27.02±9.69	0.892
Work	29.10±7.32	28.58±8.68	0.857
Lifestyle	24.94±11.83	25.66±11.37	0.858
Emotions	20.30±8.53	21.40±7.53	0.691
WORC Total	134.36±40.98	137.52±45.02	0.834
-SST (Simple Shoulder Test)	5.06±3.01	4.52±3.32	0.627

TRG: Telerehabilitation Group, HEPG: Home Exercise Program Group, ROM: Range of motion, HE: Hyperextension, ABD: Abduction, ADD: Adduction, IR: Internal rotation, ER: External rotation, WORC: Western Ontario Rotator Cuff Index, SST: Simple Shoulder Test

http://doi.org/10.5472/marumj.1708854
Marmara Med J 2025;38(2): 150-157

Table III. *Comparison of Intra-group and Inter-group Data of the Participants*

Variables	TRG (15)			HEPG (19)			p
	Pre-Treatment	Post-Treatment	p	Pre-Treatment	Post-Treatment	p	
Shoulder Joint Active ROM							
Right Flexion							
Right HE	177.0±6.49	179.33±2.58	0.474	167.36±17.10	167.63±16.19	0.927	**0.009**
Right ABD	41.0±8.49	39.33±12.93	0.541	36.57±12.58	38.15±10.69	0.514	0.774
Right ADD	171.0±16.27	176.66±12.90	0.390	158.94±27.86	151.84±37.82	0.228	**0.021**
Right IR	45.0±0.0	45.0±0.0	0.999	43.15±6.91	42.63±5.10	0.667	**0.083**
Right ER	86.0±9.10	88.0±5.60	0.548	83.68±10.52	81.31±15.26	0.424	0.118
Left Flexion	87.33±7.98	87.66±6.22	0.911	76.84±18.57	78.68±12.01	0.488	**0.013**
Left HE	170.0±15.11	176.66±7.94	0.156	162.89±19.24	162.63±20.77	0.949	**0.019**
Left ABD	40.33±8.12	44.33±7.52	0.123	41.84±8.20	41.84±11.20	0.999	0.466
Left ADD	155.33±34.40	169.33±24.04	0.117	142.36±33.59	142.10±38.52	0.973	**0.023**
Left IR	42.66±6.77	45.0±0.0	0.122	43.15±8.20	44.47±3.68	0.321	0.585
Left ER	83.66±8.95	87.33±4.95	0.220	79.73±14.85	79.73±18.89	0.999	0.140
	78.0±17.40	81.33±21.33	0.208	63.68±26.23	65.0±24.03	0.572	**0.047**
Functional Assessment							
-WORC:							
Physical Symptoms							
Sports/Leisure	33.06±10.56	19.19±13.10	**<0.001**	34.83±12.52	30.66±12.16	0.189	0.013
Work	26.95±8.17	14.67±8.49	**<0.001**	27.02±9.69	23.46±9.84	0.060	0.010
Lifestyle	29.10±7.32	14.24±8.51	**<0.001**	28.58±8.68	22.80±9.03	0.011	0.008
Emotions	24.94±11.83	12.79±11.40	**0.002**	25.66±11.37	21.82±10.31	0.077	0.021
WORC Total	20.30±8.53	12.33±9.53	**<0.001**	21.40±7.53	18.88±7.57	0.237	0.033
	134.36±40.98	73.24±44.82		137.52±45.02	117.63±43.98	0.373	0.007
-SST (Simple Shoulder Test)			**<0.001**				
	5.06±3.01	8.33±2.69		4.52±3.32	5.10±3.64	0.373	0.007

TRG: Telerehabilitation Group, HEPG: Home Exercise Program Group, ROM: Range of motion, HE: Hyperextension, ABD: Abduction, ADD: Adduction, IR: Internal rotation, ER: External rotation, WORC: Western Ontario Rotator Cuff Indeks, SST: Simple Shoulder Test

4. DISCUSSION

This study aimed to examine the effectiveness of telerehabilitation in cases of RCT. Our findings indicated that following a HEP with telerehabilitation support had a positive impact on shoulder ROM and functionality in patients with RCT.

Due to the pandemic and economic challenges, the use of digital devices has increased across various fields. As the use of digital devices has expanded, telerehabilitation has emerged as a promising option for medical interventions in recent years [25]. Telerehabilitation refers to the delivery of rehabilitation services remotely using communication tools [26]. In the field of rehabilitation, it is used for treatment interventions, monitoring disease progression, and educating family members/caregivers and healthcare professionals [14]. We aimed to investigate whether telerehabilitation, which has become widespread in recent years, would be effective in following the HEP of patients with shoulder pain.

A review of the literature shows that telerehabilitation is used for therapeutic purposes in many fields. For example, in a study by Eftekhari et al., the effects of telerehabilitation-based exercises were examined in elderly individuals with thoracic hyperkyphosis [27]. The study demonstrated that telerehabilitation improved quality of life and postural reactions. Similarly, Cramer et al., found that telerehabilitation facilitated social support and communication for patients [28]. In another study, the effects of telerehabilitation and home-based video exercises on muscle strength and functional capacity were investigated in patients

http://doi.org/10.5472/marumj.1708854
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with Duchenne Muscular Dystrophy. While patients in the telerehabilitation group participated in online exercises under the supervision of a physiotherapist, those in the video exercise group followed pre-recorded exercise videos. It was noted that the telerehabilitation group had higher participation rates and greater joint range of motion improvements. Participants and caregivers highlighted the advantages of telerehabilitation, such as ease of access and reduced infection risk [29]. In a study by Rodríguez et al., telerehabilitation was used to deliver HEPs, education, and self-care recommendations to patients with rheumatoid arthritis via the CareHand platform. They reported that the CareHand application yielded successful outcomes in terms of hand function, pain reduction, work performance, and overall satisfaction [30]. Similar to these studies, the results of our research showed that telerehabilitation provided successful results for shoulder joint range of motion and functional status in RCT patients.

Cox et al., conducted a systematic review in 2021 on telerehabilitation for individuals with chronic respiratory diseases. The study found significant improvements in dyspnea and exercise capacity in both the telerehabilitation and center-based pulmonary rehabilitation groups by the end of the rehabilitation period. Participation rates were 97% for the telerehabilitation program and 96% for the center-based rehabilitation program [28,31]. In 2023, Tore et al., examined the effectiveness of telerehabilitation in patients with knee osteoarthritis. Their study, which followed a HEP through telerehabilitation, demonstrated the effectiveness of telerehabilitation in managing the condition [32].

Although, there are numerous studies in literature involving telerehabilitation, it has been observed that telerehabilitation is not commonly preferred for shoulder-related pathologies. Therefore, our study was designed to focus on RCT, the most frequently occurring shoulder pathology. The treatment of patients with RCT is typically managed through medical interventions and HEPs. If pain persists, physical therapy is initiated. However, it is often unclear how consistently patients follow the HEP or how correctly they perform the exercises. It is possible that if the exercises are monitored more closely, the recovery rate could be more successful. Based on this hypothesis, our research was planned to monitor home exercise programs through telerehabilitation.

In a study similar to ours, Pastora-Bernal compared telerehabilitation with in-clinic rehabilitation for patients who had undergone arthroscopic subacromial decompression. It was observed that both groups had similar recovery rates. The comparable results of the two approaches suggested that telerehabilitation was well accepted by both physiotherapists and patients, with the added advantages of flexibility in terms of time and location [33]. Malliaras et al., also noted that patients with shoulder conditions showed ease in adapting to telerehabilitation programs [19]. Although these studies were planned on the shoulder, Pastora-Bernal et al., did not use shoulder-specific questionnaires in their study. In addition, both Malliaras et al., and Pastora-Bernal et al., did not evaluate the shoulder joint range of motion in their studies [19,33]. In this respect, we think that our study is important in terms of evaluating shoulder joint range of motion and functional status.

The strengths of our study include, to the best of our knowledge, being the first in the literature to evaluate the impact of a telerehabilitation on shoulder range of motion. Our study is the first to evaluate the effect of supervising a HEP through telerehabilitation. We believe that this approach will also serve as a pioneer in the follow-up of home-based exercise programs administered to patients via telerehabilitation. Our study also revealed that telerehabilitation enhanced patient motivation and contributed to more consistent adherence to their exercise routines. Therefore, we think HEPs are a promising option for patients when the advantages of remote follow-up are considered.

Despite the important findings of our study, it has certain limitations. One notable limitation is the short duration of the follow-up period. A longer follow-up could provide further insights into the long-term benefits of telerehabilitation in patients with rotator cuff syndrome. The second limitation pertains to the lack of blinding of participants. Patients may have pre-existing expectations about the effectiveness of telerehabilitation, influencing their outcomes. Finally, the majority of participants in the study were female, which may affect the generalizability of the findings.

In future studies, it may be important to investigate the effectiveness of telerehabilitation in different age groups and populations with different pathologies, especially those who have difficulty leaving home and have problems reaching a health institution, such as children or elderly people. In addition, the long-term effects of regular and controlled home exercise programs combined with telerehabilitation can be investigated. It is thought that it is important to spread such studies to integrate technological devices into therapies that are becoming more prevalent in the health field and to increase remote interventions.

Conclusion

As a result of our study, it was observed that monitoring HEPs for shoulder patients through telerehabilitation by a specialist improved joint range of motion and functionality. Telerehabilitation can be considered a preferable method due to its cost-effectiveness and its flexibility in terms of time and location.

Compliance with Ethical Standards

Ethical approval: This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by Izmir Democracy University Non-Interventional Clinical Research Ethics Committee with the decision dated March 1, 2023, and numbered 2023/03-01. The trial protocol has been registered under the number NCT06024551. All participants were informed before the study, and their voluntary consent was obtained.

Conflict of interest: The authors declare that there is no conflict of interest.

Financial support: This study received no specific grant from any funding.

Author contributions: RK: Literature research, writing, data collection and processing, FT: Conception and design of the study, writing, analysis, reviewing and editing, drafting the manuscript OE: Conception and design of the study, data collection and processing, revising the manuscript critically for important intellectual content, BT: Literature research, revising the manuscript critically for important intellectual content, drafting the manuscript. All authors read and approved the final version of the manuscript.

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