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The effects of telemedicine on Rotator cuff-related shoulder function and pain symptoms: a meta-analysis of randomized clinical trials

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Abstract

Background The effectiveness of telemedicine in aiding rehabilitation exercises among patients with rotator cuff (RC) disorders remains unknown. Therefore, this meta-analysis aimed to assess the effectiveness of telemedicine in patients with RC disorders.

Methods Randomized clinical trials (RCTs) on the effectiveness of telemedicine in patients with RC disorders were summarized through a meta-analysis. A systematic search for these RCTs was conducted in PubMed, Cochrane, Embase, and Web of Science databases up to July 2024. Statistical analysis was performed using Stata 16. Publication bias was estimated with the funnel plot and Egger's test.

Results Ten studies involving 497 participants (telemedicine group = 248 and conventional group = 249) were enrolled, with follow-up durations ranging from 8 weeks to 48 weeks. Functional outcomes measured by the Constant-Murley score were markedly improved after treatment in the telemedicine group compared to the conventional group. Moreover, compared to conventional treatment, telemedicine significantly improved shoulder function evaluated by Quick Disabilities of the Arm, Shoulder, and Hand Score, relieved pain assessed by visual analog scale pain score, and improved range of motion after treatment and in the final follow-up period.

Conclusion Telemedicine has demonstrated potential in alleviating pain and enhancing shoulder function and motion in patients with RC injuries. It may be a feasible intervention for rehabilitation exercises. Further research with a large sample size and standardized treatment is warranted to validate these findings.

Keywords Telemedicine, Rotator cuff disease, Rehabilitation

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Background

Within the realm of musculoskeletal disorders, there exists a diverse array of conditions, including rotator cuff (RC) disorders [1], subacromial impingement shoulder dislocation [2], and proximal humerus fracture [3]. The clinical manifestations of RC disorders are extensive, ranging from mild symptoms such as sleep disturbances and pain during overhead movements to severe symptoms like restricted active and passive range of motion (ROM), progressive weakness in the shoulder girdle, and functional impairment [4]. RC tears are the most frequent pathologies affecting the shoulder, accounting for 50–85% of shoulder conditions. Currently, conservative treatments for RC tears typically include physical therapy, non-steroidal anti-inflammatory medications, and injections (e.g., corticosteroid injections, hyaluronic acid (HA), platelet-rich plasma (PRP), stem cells) [5]. Recent studies [6, 7] have shown that PRP alone or in combination with other injectables (e.g., PRP+HA) can yield favorable short-term outcomes for individuals with RC tears. However, the efficacy diminishes over time, and up to 42% of patients with RC tears who receive conservative management experience tear progression and require surgical intervention [8]. Consequently, surgery for RC injuries has gained significant importance in the treatment of shoulder joint diseases. Among the various surgical options available, arthroscopic repair has become the preferred choice for most surgeons due to its minimally invasive nature and high levels of patient satisfaction [9]. However, shoulder surgery has been associated with multiple complications, such as deltoid injury, scarring, adhesions, pain, and stiffness [10]. Previous research and practice guidelines emphasize the importance of rehabilitation programs after shoulder surgery in achieving positive outcomes for patients [11, 12]. Effective rehabilitation programs can address key concerns related to ROM, pain, and muscle strength [9]. Besides, RC disorders are associated with substantial and persistent disability and pain, with approximately half of patients enduring pain or functional limitations for up to 2 years [13]. Most shoulder pain issues are addressed in primary care by physiotherapists and general practitioners. Therefore, it is essential to prioritize the effective management of patients after shoulder surgery to facilitate their functional recovery.

Telemedicine, which involves the use of communication technologies and electronic information, for remote diagnosis, treatment, and management, has become more prevalent in the field of orthopedic surgery, encompassing initial consultation, perioperative care, and rehabilitation [14]. Evidence has shown that telemedicine can alleviate shoulder pain and stiffness in the early period after shoulder surgery and improve shoulder rehabilitation [15]. Furthermore, telemedicine has the capacity to address geographic and social barriers that patients may encounter in accessing healthcare, ultimately improving their access to specialist care [16]. Despite its nascent development, telemedicine is gaining increasing recognition for its significance in the medical field and society. However, there is a lack of meta-analysis to determine the effectiveness of telemedicine technology in patients with RC disorders. This systematic evaluation and meta-analysis intended to determine the effectiveness of telemedicine during the follow-up period for patients with RC-related injury, aiming to provide clinical references for rehabilitation management and recovery outcomes for patients with RC disorders.

Methods

Search strategy

The current study followed the PRISMA guidelines (details are shown in Table S2) [17]. The study protocol was registered in the IPROSPERO (http://www.crd.york.ac.uk/prospero, registration number: CRD42023491547). The search strategy was designed by two researchers (Boyi Zhang and Zhihao Fang) using a combination of medical subject heading (MeSH) terms (telerehabilitation, telemedicine, shoulder joint, arthroplasty, arthroscopy, RC disorders) and their free words. PubMed, Cochrane Library, Embase, and Web of Science were searched from inception to July 2024. The flow diagram of study screening is displayed in Fig. 1. The detailed search strategy of PubMed is presented in Table S1.

Inclusion and exclusion criteria

To determine the effectiveness of telemedicine technology for patients with RC disorders, the eligibility criteria were set to screen high-quality RCTs under the Participants, Interventions, Comparisons, Outcomes, and Studies (PICOS) guidelines [18] as follows:

Participants: (1) age>18 years; (2) diagnosed with RC disorders and suffering from RC-related shoulder injuries and pain symptoms.

Interventions: Patients in the intervention group received any forms of telemedicine treatment such as gamification with supervised physical therapy, telemedicine programs, digital therapy, telephone-assistance programs, and videoconferencing.

Comparisons: Patients in the control group received standard treatment or usual rehabilitation. Detailed routine treatments were expressed in the retrieval results and study characteristics.

Outcomes: The primary outcomes were the Constant-Murley score (CMS), Quick Disabilities of the Arm, Shoulder, and Hand Score (Quick DASH), ROM, and visual analog scale (VAS) pain score. The above scores are primarily concerned with indicators of pain level, ROM, and stiffness of the shoulder joint.

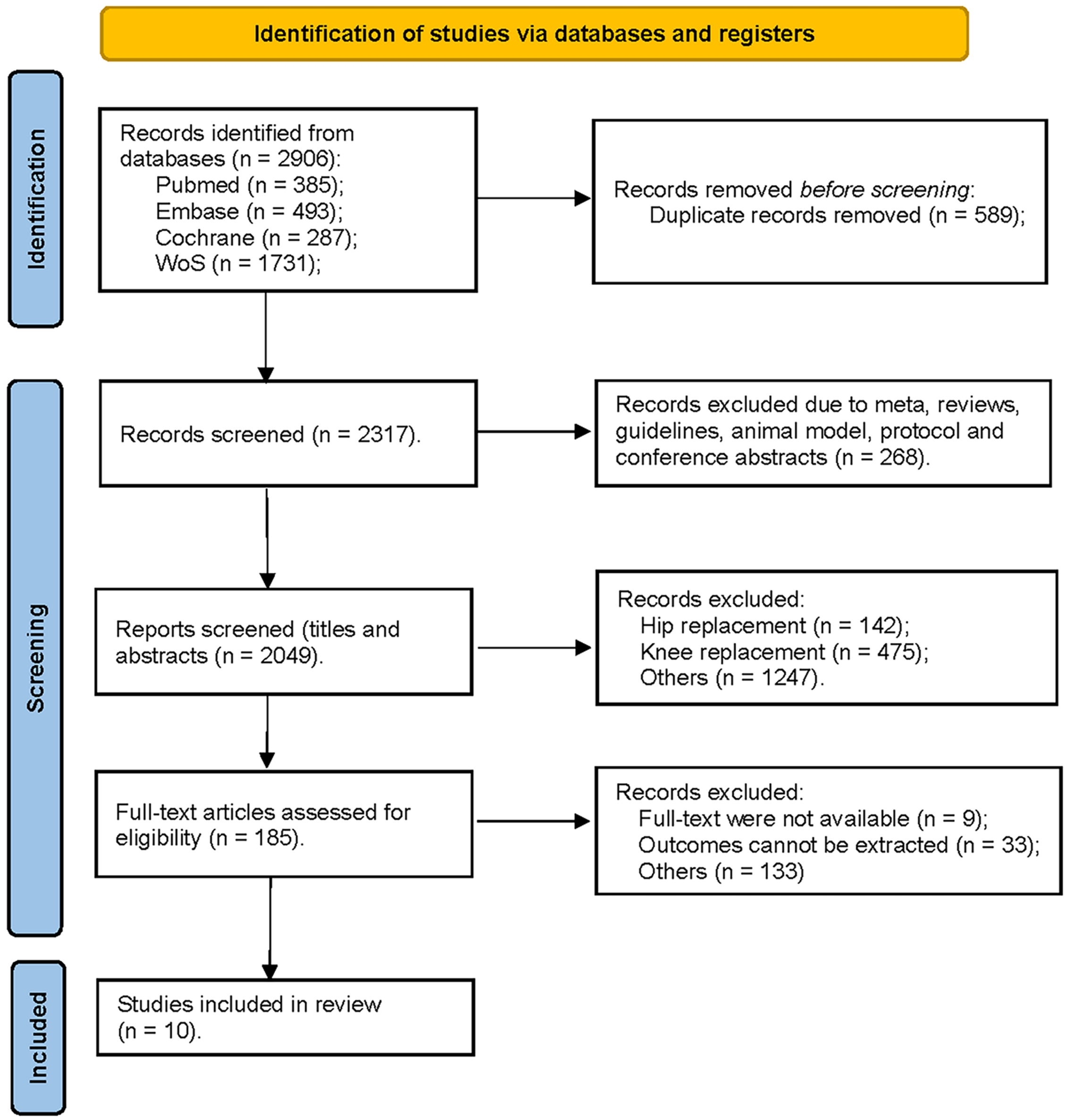

Fig. 1 Study screening process

Study type: RCTs or research investigated the effects of telemedicine on shoulder function or pain in patients with RC disorders (even though not an RCT, the baseline characteristics between the telemedicine group and the control group were similar).

Studies were excluded for the following reasons: (1) telemedicine technology was not used to guide the recovery; (2) outcome metrics could not be quantified; (3) commentaries, letters, conference abstracts, or systematic reviews; (4) not in English; (5) the full text was not available.

Data extraction

Two researchers (Boyi Zhang and Zhihao Fang) independently undertook data extraction. During the data extraction process, any discrepancies were negotiated through discussion. After literature inclusion, the following information was extracted: first author, publication year, study type, surgical approach, specific measures of intervention, sample size, sex (male/female), age, baseline values, and values of outcome metrics after treatment and at final follow-up.

Quality assessment

The risk of bias (ROB) of the included RCTs was assessed independently by two reviewers (Boyi Zhang and Zhihao

Fang) with the Cochrane tool for risk of bias (ROB2) [19]. Each study was assessed in five specific domains: randomization, deviation from established interventions, missing outcome data, outcome measures, and selective reporting of results. Each domain was scored independently by two researchers, and the ROB for each domain was rated as "low (green)", "some concern (yellow)", or "high (red)". Disagreements during the scoring process were resolved through discussion or by seeking advice from the third researcher (Bin Ji). The assessment results were presented in the form of an ROB chart.

Statistical analysis

Data collected from the included studies were analyzed with Stata version 16. Continuous data were presented as mean and standard deviation [20]. The overall effect was visualized using the forest plot. Heterogeneity across studies was judged using I^2. $I^2 \geq 50\%$ implied significant heterogeneity, so a random-effects model was used (Differences in distribution can affect the overall true effect) [21]. The source of heterogeneity was determined using sensitivity analysis (leave-one-out method). Furthermore, subgroup analyses were performed based on gender, age, etiology, and study site. Conversely, $I^2 <$ 50% (Then a fixed-effects model was used and all studies in the analysis had a common effect size) implied low heterogeneity [21]. The funnel plot and Egger's test were utilized to appraise publication bias [22]. A P-value<0.05 obtained from two-tailed tests was indicative of statistical significance.

Results

Retrieval results and study characteristics

2687 records were initially retrieved. Of these, 2677 were excluded for not meeting the eligibility criteria. In the end, a total of 10 studies (248 in the telemedicine group and 249 in the control group) were included.

Table 1 summarizes the study characteristics and assessment results. Among the 10 included studies [23–32], most were conducted in the European regions, including United States (n=3) [25, 29, 31], Spain (n=2) [27, 28], Sweden (n=1) [24], Portugal (n=1) [23], Türkiye (n=1) [30], and UK (n=1) [26]. Another study was conducted in Australia (n=1) [32]. In terms of treatment and follow-up period, the intervention group received at least 2 weeks of telemedicine and at least 8 weeks of follow-up, such as through a telemedicine program, a telephone assistance program, and videoconferencing, whereas the control group all received traditional rehabilitation treatments. Various tools or modes were utilized in the telemedicine group, such as an inertial motion tracker (which provided real-time audio and video biofeedback during exercise) [23, 31], a webcam to communicate with an attending surgeon on a smartphone for supervised rehabilitation [24, 25, 29, 32], and interaction with a physical therapist who emailed images, videos, and parameters of each exercise program for treatment [28, 30]. The modalities used in the control group mainly included home-based movement exercises [23, 27, 28], usual face-to-face physical therapy [24–26, 29, 31], and conventional therapy [30, 32]. All patients had RC disorders due to diverse reasons, such as RC injury [23, 25, 29], shoulder dislocation [27], subacromial impingement syndrome [26, 28], calcific tendinopathy [26], and shoulder pain [30–32]. All included studies reported the corresponding preoperative and postoperative shoulder scores by the relevant outcome metrics, including CMS [23, 24, 28], Quick DASH [23, 27, 30, 31], ROM [23, 24, 26–28, 30], and VAS pain score [24, 25, 27, 29, 30, 32].

Quality assessment

Most studies used randomized sequences, did not selectively report the results, and defined follow-up durations and outcomes in both groups. Allocation concealment and blinding of participants and personnel were achieved in most studies. Two studies [23, 26] were rated as "some concern" due to the lack of blinding of participants and personnel. Furthermore, a study [24] was rated as "some concern" for not having randomized allocation and blinding. The quality assessment results are exhibited in Fig. 2.

Results of meta-analyses

Shoulder function measured by CMS

Available evidence suggests that CMS can assess shoulder pathology from four aspects [33], with two subjective aspects (pain and activities of daily living) and two objective aspects (joint mobility and strength). CMS is a more effective tool for evaluating impairment and recovery of shoulder function in patients with RC disorders [34]. 3 studies [24, 28, 35] reported the CMS, involving 72 participants (33 in the intervention group and 39 in the control group). After treatment, the meta-analysis revealed that telemedicine significantly improved shoulder motion (SMD=1.09, 95% CI (0.03, 2.15), P=0.044) compared to the control group (Fig. 3a).

Follow-up assessments were performed in these 3 studies (varied from 12 weeks [28] to 48 weeks [23], so we performed a meta-analysis of the long-term effects of telemedicine on shoulder function. The results showed that shoulder motion was greatly improved in patients in the telemedicine group compared to the control group, while the improvement did not reach significance (SMD=0.22, 95% CI (-0.71, 1.14), P=0.648) (Fig. 3b).

There was marked heterogeneity in post-treatment (I^2 = 74.6%) and final follow-up (I^2 = 60.2%), so sensitivity analyses were performed to ascertain the source of heterogeneity. The results were relatively stable in both time points. The Egger's test showed no significant publication

Table 1 Characteristics and quality assessment of the included studies

Study	Country	Sample size (*n*)		Age (mean (SD))		Sex (M/F)		Treatment details		Treatment duration	Follow-up duration	Surgical procedures	Outcome
		I	C	I	C	I	C	I	C				
Correia, F. D [23]	Portugal	27	23	61.30 (7.0)	60.04 (6.8)	7/20	4/19	an inertial motion tracker	home-based movement exercises	6 weeks	48 weeks	shoulder arthroscopy	CMS, Quick DASH, ROM
Eriksson, L [24]	Sweden	10	12	70.0 (8.0)	73.0 (9.0)	2/8	3/9	videoconferencing	usual face-to-face physical therapy	8 weeks	/	shoulder arthroplasty	CMS, ROM, VAS pain score
Kane, L. T [25]	USA	33	33	60.6 (8.5)	59.8 (5.0)	17/11	20/10	videoconferencing	usual face-to-face physical therapy	2 weeks	12 weeks	rotator cuff repair	VAS pain score
Marley, W. D [26]	England	33	31	52.9 (10.5)	54.4 (8.5)	13/20	13/18	exercise games supervised by a therapist	usual face-to-face physical therapy	12 weeks	/	shoulder arthroscopy	ROM
Martinez-Rico, S [27]	Spanish	36	35	26.5 (5.5)	29.0 (9.8)	26/10	28/6	a smartphone	home-based movement exercises	8 weeks	48 weeks	shoulder instability Surgery	Quick DASH, ROM, VAS pain score
Pastora-Bernal, J.M [28]	Spanish	8	10	49.6 (10.1)	54.8 (11.8)	4/4	6/4	interaction with a physical therapist who emailed images	home-based movement exercises	8 weeks	12 weeks	shoulder arthroscopy	CMS, ROM
Sabbagh, R. [29]	USA	28	32	64.43 (8.0)	64.1 (10.3)	14/14	17/15	a smartphone	usual face-to-face physical therapy	24 weeks	/	shoulder pain	VAS pain score
Çelik, E. B. [30]	Türkiye	20	20	38.3 (7.7)	39.8 (10.4)	8/12	12/8	self-mobilization exercises supervised by a therapist	usual face-to-face physical therapy	8 weeks	12 weeks	shoulder pain	Quick DASH, ROM, VAS pain score
Pak, S. S. [31]	USA	41	41	49.7 (12.6)	50.8 (12.9)	16/24	22/19	an inertial motion tracker	usual face-to-face physical therapy	8weeks	/	shoulder pain	Quick DASH
Malliaras, P. [32]	Australia	12	12	56.6 (11.0)	53.7 (11.5)	1/11	1/11	videoconferencing	/	6 weeks	12 weeks	shoulder pain	VAS pain score

Abbreviations I, Intervention. C, Control. M/F, Male/female; CMS, Constant-Murley score; Quick DASH, Quick Disabilities of the Arm, Shoulder, and Hand; VAS, Visual analog scale; ROM, Range of motion; SD, Standard Deviation

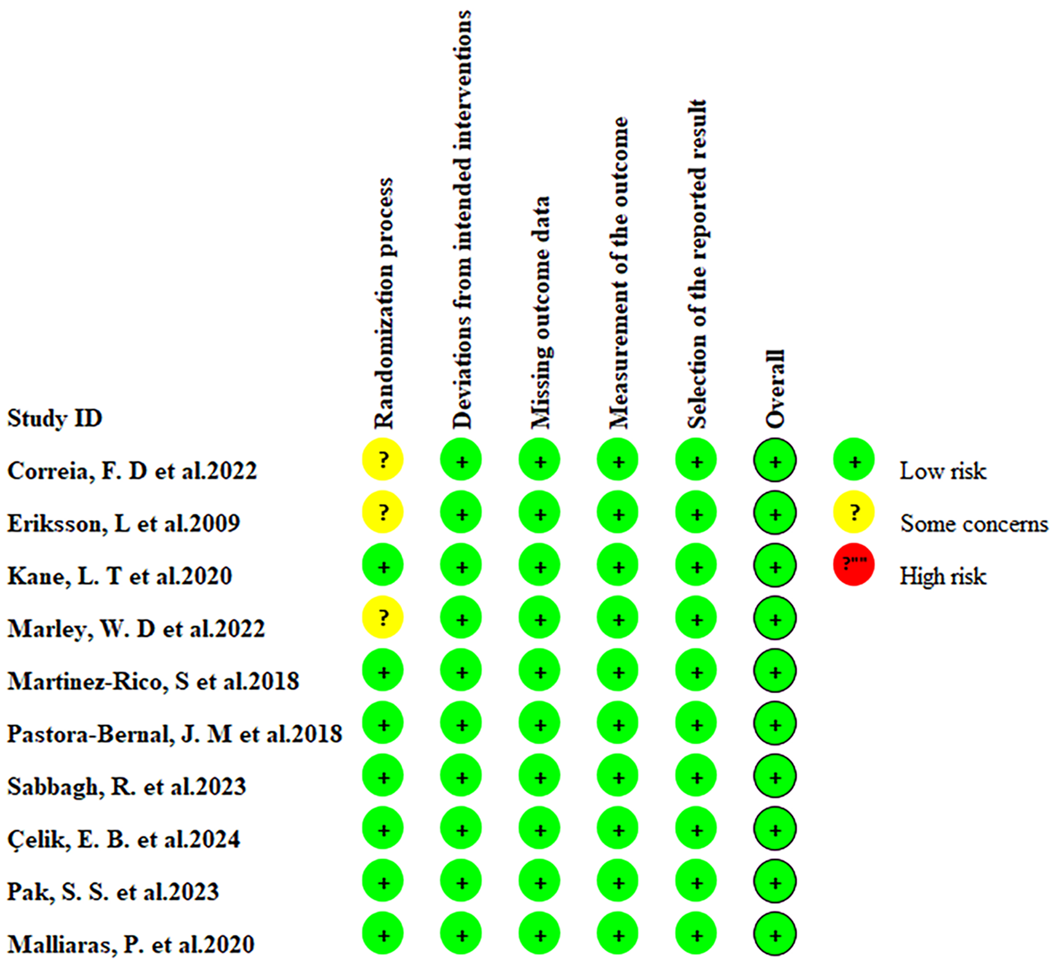

Fig. 2 Risk of bias assessment of included studies using the ROB2 tool

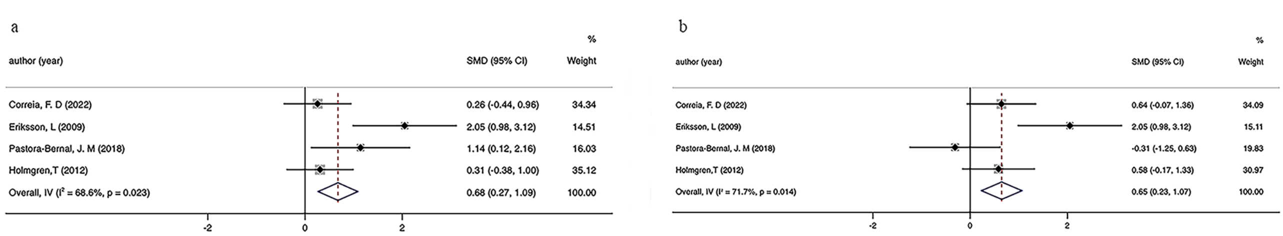

Fig. 3 Forest plots of the effect of telemedicine on CMS (**a**) the short-term effect (post-treatment) (**b**) the long-term effect (at the final follow-up)

bias (post-treatment, $P=0.217$, due to the limited numbers included for the final follow-up assessment, the Egger's test was not run).

Upper extremity function assessed by Quick DASH

The Quick DASH questionnaire is a widely used standardized tool for assessing a patient's upper extremity function and symptoms, including pain (at rest, during activity, and during sleep), muscle strength, and stiffness. Lower patient scores indicate better upper extremity function [36]. Four studies [23, 27, 30, 31] reported Quick DASH as an outcome indicator involving 224 participants (112 in the intervention group and 112 in the control group). The meta-analysis unraveled that telemedicine significantly improved upper extremity function and symptoms (SMD = -0.40, 95% CI (-0.66, -0.13), $P=0.003$) (Fig. 4a).

Regarding the long-term effects, 2 studies (64 in the intervention group and 67 in the control group) were followed up for 48 weeks [23, 27]. 40 participants (20 in the intervention group and 20 in the control group) [30] completed the final follow-up assessment for 12 weeks. At the final follow-up, the pooled results showed the functional recovery of patients was better in the intervention group

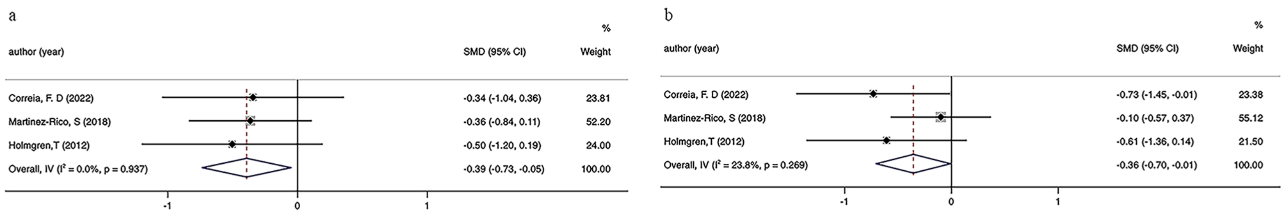

Fig. 4 Forest plots of the effect of telemedicine on Quick DASH (**a**) the short-term effect (post-treatment) (**b**) the long-term effect (at the final follow-up)

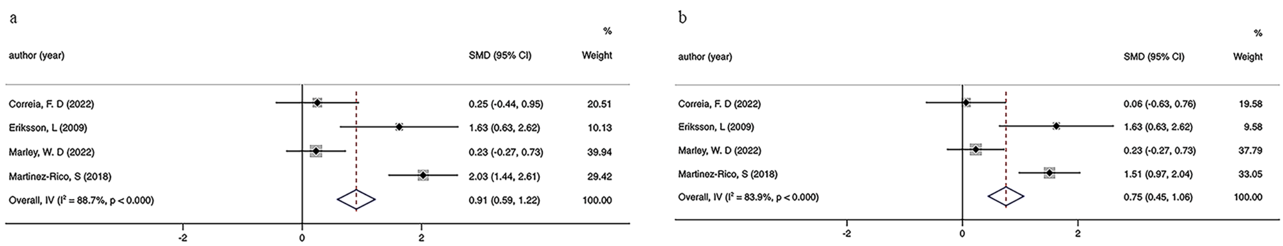

Fig. 5 (**a**) Forest plot of the short-term effect of telemedicine on post-treatment ROM (**b**) Forest plot of the long-term effect of telemedicine at final follow-up ROM

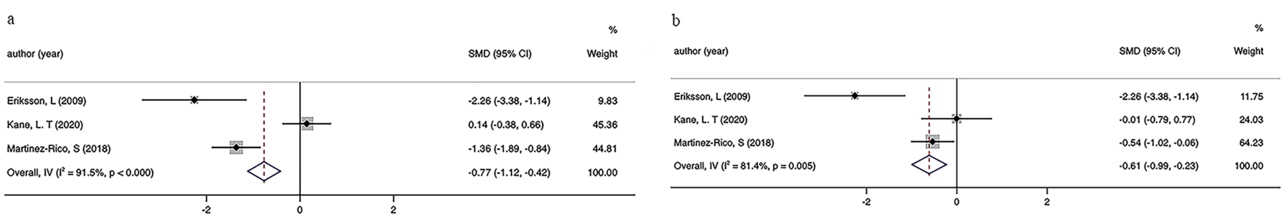

Fig. 6 Forest plots of the effect of telemedicine on ER (**a**) the short-term effect (post-treatment) (**b**) the long-term effect (at the final follow-up)

than in the control group (SMD = -0.57, 95% CI (-1.15, 0.01), P=0.055), while a significant difference was not observed between the two groups (Fig. 4b).

Marked heterogeneity was observed during the final follow-up (I^2 = 63.0%), so sensitivity analyses were performed to ascertain the source of heterogeneity. The results were relatively stable in both time points. The Egger's test showed no significant publication bias (post-treatment, P=0.295; final follow-up, P=0.267).

ROM

ROM is defined as the maximum arc angle through which a joint can move during movement, serving as an outcome measure for shoulder rehabilitation [37]. 3 studies [23, 27, 28] focused on ROM, and another 5 studies [23, 24, 26, 27, 30] focused on the degree of external rotation (ER).

In the 3 studies reporting ROM, 120 participants (59 in the intervention group and 61 in the control group) were enrolled. The meta-analysis showed notable differences in ROM between the two groups (SMD=0.95, 95% CI after telemedicine treatment (-0.54, 2.43), P=0.221) (Fig. 5a).

These 120 participants were followed up for 12 weeks [28] to 48 weeks [23, 27]. The meta-analysis of changed ROM values noted that at the final follow-up, patients in the intervention group had better shoulder function and rehabilitation outcomes than those in the control group (SMD=1.55, 95% CI (-0.70, 3.81), P=0.178) (Fig. 5b).

High heterogeneity was noted across studies (post-treatment, I^2 = 91.8%; final follow-up, I^2 = 95.7%). To determine the source of heterogeneity, we performed a sensitivity analysis, which showed relatively stable results in both time points. Egger's test manifested no publication bias (post-treatment, P=0.554; final follow-up, P=0.937).

The ER on post-treatment and at final follow-up was recorded in four studies, involving 226 participants (111 in the intervention group and 115 in the control group). The meta-analysis showcased that patients in the intervention group had a higher degree of ER improvement than those in the control group (SMD=1.12, 95% CI (0.31, 1.92), P=0.007) (Fig. 6a).

In addition, 142 patients were followed up for 12 weeks [26, 30] to 48 weeks [23, 27]. The degree of ER was calculated at the final follow-up. The results showed that at the final follow-up, patients in the telemedicine group displayed a greater degree of ER than those in the control group (SMD=0.78, 95% CI (-0.06, 1.62), P=0.067) (Fig. 6b).

Despite high heterogeneity at post-treatment (I^2 = 86.3%) and final follow-up (I^2 = 81.7%), sensitivity analyses showed relatively stable results in both time points. Egger's test reported no publication bias (post-treatment, P=0.557; final follow-up, P=0.075).

Pain Intensity evaluated by VAS Pain score

The VAS pain score, simple and suitable for various populations and settings, is extensively employed for evaluating pain intensity in a unidimensional manner, with higher scores indicating greater pain intensity [38]. Six studies [24, 25, 27, 29, 30, 32] reported VAS pain score, involving 273 participants (134 in the intervention group and 139 in the control group). The meta-analysis showed that telemedicine gradually relieved pain significantly (SMD = -1.67, 95% CI (-2.66, -0.69), P<0.001) (Fig. 7a).

124 participants (69 in the intervention group and 55 in the control group) were followed up for 12 weeks [25, 32] to 48 weeks [27]. The meta-analysis of VAS pain score demonstrated that compared to the conventional treatment, telemedicine-based rehabilitation exercises significantly relieved pain during follow-up (SMD = -1.15, 95% CI (-2.56, 0.25), P<0.001) (Fig. 7b).

Due to marked heterogeneity after treatment (I^2 = 91.2%) and at the final follow-up (I^2 = 89.4%), sensitivity analyses were implemented to ascertain the sources of heterogeneity. The results were relatively stable in both time points. Egger's test reported publication bias after treatment (post-treatment, P=0.026).

Discussion

To our knowledge, this is the first meta-analysis to evaluate the effectiveness of telemedicine for patients with RC disorders. The results showed that compared to the conventional treatment, telemedicine significantly improved shoulder function and relieved pain symptoms.

Shoulder pain is a prevalent factor contributing to sickness and disability, leading to a substantial drain on health resources and reduced productivity [39]. Our findings of VAS pain score suggested that telemedicine significantly relieved pain compared with conventional treatment, which echoed the results reported in two recent studies [24, 25]. This phenomenon can be attributed to the effectiveness of telemedicine in tracking changes in a patient's pain symptoms and providing timely feedback, which helps the early identification and rapid response to increased pain and allows for prompt adjustments to the treatment plan. Moreover, the incorporation of technology tools such as virtual reality, biofeedback, and electrical stimulation enables telemedicine to provide an immersive therapeutic experience that distracts the patients from pain and promotes neuroplasticity, ultimately alleviating pain. For instance, Özden F et al. [40] found that visual feedback services provided by telemedicine acted as a motivator for boosting involvement in rehabilitation, which may lead to greater improvements in clinical outcomes, particularly in pain relief [41]. The current findings further illustrated that follow-up care via telemedicine was as effective in pain control. This is a particularly important finding as recent literature suggests the potential of telemedicine in assisting pain management in RC disorders.

In addition, our meta-analysis noted that telemedicine significantly improved both physical and shoulder function indices (i.e., CMS, Quick DASH, and ROM) in the post-treatment and follow-up period. Diverse rehabilitation programs are available for RC-related symptoms. Ferlito R et al. demonstrated that physical exercise program of the scapulothoracic complex in scapular motor function is an effective alternative for patients with subacromial impingement syndrome [42]. Karamanlioglu DS et al. reported that for patients with subacromial impingement syndrome, acupuncture treatments relieved pain and improved shoulder function [43]. However, previous rehabilitation programs often placed patients in a passive role. Enhancing the availability of guideline-recommended care through telemedicine for the Internet-based delivery of patient-directed care has the potential to improve healthcare quality and outcomes. One explanation for the improvements in the telemedicine group is that they receive more extensive, frequent, and continuous physiotherapy [24]. When patients in the telemedicine group were discharged from the hospital, the rehabilitation chain did not break and shoulder motion training was not stopped. Another explanation could be that the patients could stay at home, allowing for better preparation and concentration on the training [27]. Generally speaking, patients are more likely to be cared for with their preferred physiotherapists in their selected care setting, which is important for their quality of rehabilitation. This approach promotes care continuity and ensures

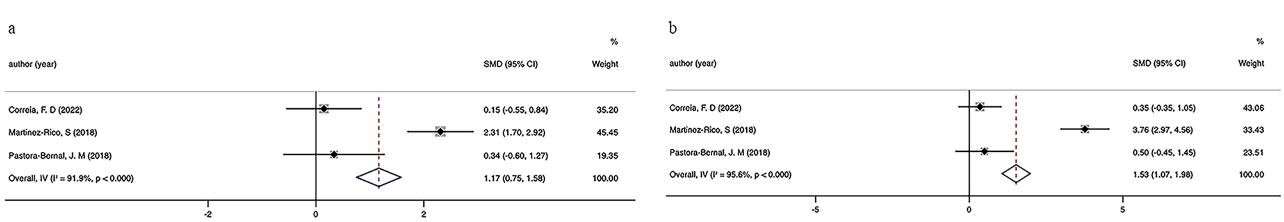

Fig. 7 Forest plots of the effect of telemedicine on VAS Pain Score (**a**) the short-term effect (post-treatment) (**b**) the long-term effect (at the final follow-up)

that patients receive the necessary help and support when required [44, 45]. Failure to perform effective rehabilitation exercises can lead to joint adhesions, pain, and even the risk of secondary surgery [46]. The telemedicine group was under the guidance of a physiotherapist from the hospital who possessed knowledge in managing such patients. These attributes afford individuals a more convenient and professional way to better improve physical and shoulder functions.

There are also some limitations. First, the synthesized effectiveness of telemedicine in our meta-analysis may be influenced by the number of included studies and samples due to insufficient data in some studies and unpublished records. Second, one study noted that patients receiving postoperative care can also benefit from telemedicine, as it enables safe and effective early follow-up and greatly shortens the duration of each visit, suggesting the socio-economic benefits of telemedicine [25]. However, due to the limited research on telemedicine, cost-effectiveness, socio-economic benefits, hospital visit burden, and patient satisfaction of telemedicine cannot be used as outcome indicators, and most of them are qualitative indicators. Third, the diversity of telemedicine modalities was not estimated in the current meta-analysis due to the limited number of studies. Fourth, the rehabilitation frequency of telemedicine and conventional treatment was not described throughout the rehabilitation exercise program. Given these limitations, more research on telemedicine is needed in the future to provide more precise recommendations for clinical practice. Further investigation is necessary to illustrate the significance of telemedicine for rehabilitation and exercise for its clinical application. Therefore, there is a pressing need for further clinical trials to substantiate the effectiveness and safety of telemedicine, along with an exploration of its suitability for different patient populations. In addition, close monitoring and reporting of participants is essential for intervention adherence, as it significantly impacts the effectiveness of telemedicine [47].

Conclusions

In conclusion, our meta-analysis supports that telemedicine is superior to conventional therapy in terms of pain relief and shoulder motion improvement. The application of telemedicine to patients after RC-related injury is an emerging area of interest. However, further research is needed to fully understand the overall effectiveness of telemedicine in the rehabilitation of RC disorders, especially for considering various surgical procedures and the demographic characteristics of patients.

Abbreviations

CMS	Constant-Murley score
ER	External rotation
MeSH	Medical subject heading
HA	Hyaluronic acid
PICOS	Participants, Interventions, Comparisons, Outcomes, and Studies
PRP	Platelet-rich plasma
Quick DASH	Quick Disabilities of the Arm, Shoulder and Hand Score
ROM	Range of motion
ROB	Risk of bias
RC	Rotator cuff
RCTs	Randomized clinical traits
VAS	Visual analog scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-024-04986-4.

Supplementary Material 1

Supplementary Material 2

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Not applicable.

Author contributions
All authors contributed to the study conception and design. Writing - original draft preparation: Boyi Zhang; Writing - review and editing: Boyi Zhang, Zhihao Fang, Kundang Nian, Bing Sun, and Bin Ji; Conceptualization: Bing Sun, Kundang Nian; Methodology: Zhihao Fang and Bin Ji; Formal analysis and investigation: Boyi Zhang and Zhihao Fang; Resources: Kundang Nian and Bing Sun; Supervision: Bin Ji, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability
All data generated or analysed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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