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Research Progress in Physical Therapy for Rotator Cuff-Related Shoulder Pain (RCRSP)

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Abstract. Rotator cuff-related shoulder pain (RCRSP) is a broad spectrum of injuries affecting patients all age groups. Individual in this condition typically experience shoulder joint pain, restricted joint mobility, and a decline in muscle strength. How to effectively intervene in the treatment of RCRSP has become a hot topic in clinical research. Current primary interventions consist of biological therapy and surgical treatment, which are commonly limited by high medical costs and prolonged rehabilitation cycles. Given the above drawbacks, physical therapy has gained increasing academic attention in the clinical management of RCRSP in recent years. Based on clinical research published in recent years, this review systematically analyzes the clinical efficacy and underlying mechanisms of exercise therapy, physical agent modalities and traditional rehabilitation interventions (acupuncture therapy, massage techniques, traditional Chinese medicine cupping therapy, topical applications of traditional Chinese medicine). The relevant evidence summarized in this article provides evidence-based references for the formulation of individualized rehabilitation protocols for patients with RCRSP.

Keywords: Rotator cuff-related shoulder pain(RCRSP), Exercise therapy, Electrophysical therapy, Traditional rehabilitation therapy

1. Introduction

As one of the most mobile joints in the human body, the shoulder plays a crucial role in enabling individuals to perform a wide range of daily activities. Shoulder movement and stability are largely maintained by the rotator cuff, which consists of the tendons of the supraspinatus, infraspinatus, teres minor, and subscapularis. Together, these structures form a cuff-like complex that provides dynamic movement and stability to the shoulder joint. Due to the high frequency of use in daily life and the high mechanical stress on the rotator cuff muscle group, the shoulder joint is prone to damage and degenerative changes, affecting patients' ability to perform daily activities. RCRSP is one of the most common causes of shoulder dysfunction, encompassing conditions such as rotator cuff tendinopathy, subacromial pain syndrome, subacromial impingement syndrome, as well as partial- and full-thickness rotator cuff tears. It often brings patients limited range of motion, pain, muscle weakness, and other burdens, causing functional impairment and seriously affecting daily activities. Epidemiological studies show that rotator cuff disease accounts for 85% of clinical cases

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of shoulder disease, and the prevalence increases with age [1]. The treatment strategies for RCRSP include surgical treatment, injection therapy, physical therapy, etc. Surgical therapy is widely used in some rotator cuff injuries, but it has limitations such as trauma, multiple postoperative complications, and long recovery periods. Injection therapies, including glucocorticoids, hyaluronic acid, and platelet-rich plasma, mainly focus on relieving pain and inflammation, with relatively limited optimization of overall shoulder joint movement patterns and muscle strength enhancement effects. In recent years, physical therapy has gradually received attention in RCRSP, mainly including exercise training, electrophysical therapy, and traditional rehabilitation therapy, aiming to restore full range of joint mobility and stability, improve muscle strength, alleviate pain, and help patients improve their quality of life [2].

However, there is no unified standard for the clinical application of physical therapy in RCRSP treatment, and there is still a lack of consensus on the development and implementation of the best treatment plan. And due to individual differences, there are still certain limitations in treatment [3]. Therefore, this review aims to provide a systematic summary of recent research advances in physical therapy for RCRSP. focusing on the clinical status and related mechanisms of exercise therapy, electrophysical therapy, and traditional therapy in physical therapy, providing more scientific reference for the development of personalized and refined rehabilitation plans in subsequent clinical practice.

2. Exercise therapy

As a core component of physical therapy, exercise therapy mainly includes traditional training modes and motion control exercise (MCE).

2.1. Conventional exercise therapy

The traditional training mode of RCRSP aims to alleviate pain, enhance muscle strength, and improve joint mobility. In recent years, the consensus-based three-phase shoulder joint treatment plan has become one of the mainstream exercise methods. The training gradually stages the treatment process: Early stage restore the ROM and reduce the pain and inflammation. In the middle stage, strengthen the scapular stabilizers and other stabilizing muscles, further increase the ROM and improve the function. In the later stage, enhance the neuromuscular control and the overall movement pattern of the shoulder joint. The treatment principle lies in pain management, scapular stabilizers and rotator cuff muscle strength training, and combined with activity improvement exercises. The treatment plan is dynamically adjusted according to the patient's condition progression and individualized factors.

A study involving 143 patients with RCRSP and developed a three-phase shoulder joint exercise plan based on each participant's symptoms and abilities. A 12 week supervised and home-based rehabilitation was implemented and followed up for 26 weeks to explore its effects on patients' pain, muscle strength levels, active ROM, and Health-Related Quality of Life (HRQL). The results showed that the patient's Visual Analog Scale (VAS) for pain significantly decreased in the early stages of treatment (week 6) ($p<0.001$), and the treatment effect continued until week 26, with an average decrease of about 3.2 points in VAS scores during activity at week 26 ($p<0.001$). The active ROM of the shoulder joint increased significantly at both the 6th and 12th week ($p<0.001$), while muscle strength further increased at the follow-up of 6-12 weeks ($p<0.001$) and continued until 26 weeks. This suggests that the three-phase shoulder joint exercise program has a positive effect on relieving pain and restoring shoulder joint function in patients [1]. However, this study also has

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certain limitations and lacks comparison with other exercise interventions. In the future, supplementary comparative studies are needed to further determine whether this approach has relative advantages.

2.2. MCE

Although the traditional three-stage treatment plan introduces motion control training as an advanced training mode, its core treatment principle does not include MCE as an intervention component. In the treatment of RCRSP, scapular stabilization training is often the main form of MCE, and in some clinical studies, biofeedback technology can be used as an auxiliary reinforcement training to improve overall shoulder movement patterns of the shoulder joint and improve its dynamic stability [4]. A 2025 randomized controlled trial enrolled 60 patients with RCRSP, who were assigned to three groups: a scapular-focused training group (P_G, n=20), a scapular-focused training plus electromyographic biofeedback group (P+EMGBF_G, n=20), and a control group (CT_G, n=20) receiving shoulder joint mobilization, massage, and upper limb strengthening exercises. The assessment included the Shoulder Pain and Disability Index (SPADI), Numeric Pain Rating Scale (NPRS), Disabilities of the Arm, Shoulder and Hand (DASH), scapular stabilizer neuromuscular Control (SSNC) scores, and dynamic scapular alignment. Within-group analysis showed that after 6 weeks of treatment, the SPADI score of the P_G group decreased by an average of 35.32 points compared to baseline, while the NPRS and DASH scores decreased by an average of 4.10 and 32.87 points, respectively. Additionally, 60% of patients' dynamic scapular alignment returned to normal ($p<0.001$). Between-group analysis found that compared with the CT-G group, the P_G group showed significant improvements in pain and functional indicators ($p<0.05$), while dynamic scapular alignment was significantly optimized. The P+EMGBF-G group achieved superior results in pain and functional outcomes, SSNC scores, and dynamic scapular alignment compared with the CT-G group ($p<0.05$). However, significant differences were observed only in SSNC scores when comparing the P_G group with the P+EMGBF_G group,with the P+EMGBF_G group showing superior outcomes ($p<0.05$) [5]. This indicates that scapular stabilization training contributes significantly to the improvement of overall shoulder movement patterns, pain relief,functional recovery, and the combination of biofeedback technology can further enhance the neuromuscular control ability of the scapular stabilizer muscle.

In summary, for RCRSP patients, three-phase shoulder joint exercise training can be implemented as a standard exercise plan, while MCE training can be carried out on the basis of enhancing muscle strength and range of motion through this plan, further optimizing shoulder joint exercise patterns and promoting shoulder function recovery

3. Electrophysical therapy

3.1. Electrostimulation

Pulsed electromagnetic field (PEMF) electrostimulation has emerged as a widely adopted therapeutic option for shoulder pain associated with rotator cuff pathology over the past decade. It is mainly divided into conventional transcutaneous electrical nerve stimulation (C-TENS) and neuromuscular electrical stimulation (NMES).

C-TENS makes surface electrodes contact the skin directly, and electric current transmits between the areas corresponding to the two poles, which produces remarkable early analgesic effects on mild and moderate rotator cuff injuries in the non-acute phase. Sixty patients with mild and

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moderate rotator cuff injuries were grouped in a study to compare conventional rehabilitation therapy with or without combined C-TENS intervention. VAS assessment and CMS scoring were performed at the fifth treatment session. The results showed that the regimen combined with C-TENS had remarkable therapeutic effects (the VAS scores of the test group and control group were 3 and 3.5 points, respectively), and no adverse events were observed [6]. A separate animal study demonstrated that PEMF administration in a murine rotator cuff tear model promote early tendon healing, with the healing rates recovering to 80% and 60% in the first and second months after surgery, respectively. Furthermore, no joint injuries occurred, which facilitates the rapid recovery of partial functions in patients and improves the overall therapeutic effect [7].

NMES can activate the contraction of muscle fibers in the muscle groups surrounding the rotator cuff and optimize scapulohumeral rhythm and motor balance. A research grouped and evaluated 88 patients with rotator cuff tear undergoing RSA to compare therapeutic outcomes with and without NMES intervention. The NMES treatment lasted for one month. Follow-up data were collected and analyzed subsequently. The outcome measures confirmed that NMES treatment yielded substantial improvements in range of motion, with external rotation presenting the most pronounced enhancement--a mean rise of nearly 7° ($P<0.005$), demonstrating that NMES markedly facilitates the early rehabilitation of external rotation in RSA patients [8].

In studies published over the past five years, electrostimulation intervention therapy holds an unshakable auxiliary position. Although it is slightly inferior to rehabilitation modalities such as exercise therapy, it possesses irreplaceable advantages in the early stage of rotator cuff injury.

3.2. Extracorporeal shockwave therapy (ESWT)

As one of the important clinical interventions of RCRSP physical factor therapy, ESWT has been proved to have significant efficacy in alleviating shoulder pain and promoting rotator cuff-related tissue repair in recent years, and it has the advantages of safety and non-invasive [3]. Its main therapeutic mechanism may be to stimulate the release of biological mediators by mechanical shock wave acting on the lesion site, thereby promoting tissue remodeling and angiogenesis at the injury site, and accelerating the repair process of rotator cuff tendon. In addition, ESWT can also inhibit the conduction of pain through neuromodulatory mechanisms to achieve analgesic effect. A prospective randomized controlled trial enrolled 37 patients with rotator cuff injury associated with shoulder stiffness, randomly assigned to the ESWT Group (a single session of 3,000 shock waves at 24 kV in a single session, $N = 19$) versus the sham group ($N = 18$) , with follow-up extending to 12 months. The findings indicated that Visual Analog Scale (VAS), muscle strength and Constant and Murley scores (CMS) were significantly higher in the ESWT group than in the sham treatment group at the 6th month after intervention ($p = 0.012$, $p = 0.034$, $p = 0.026$) , and at the 12th month follow-up, VAS in the ESWT group was significantly lower than in the sham treatment group (0.0 vs. 0.5, $p = 0.025$) , muscle strength (20.0 VS 17.5, $P = 0.002$) and CMS (91.5 VS 85.0, $P = 0.005$) remained significantly superior. Studies have shown that a single high-energy ESWT has a positive effect on the long-term prognosis of functional recovery in patients with rotator cuff injury accompanied by shoulder stiffness [9]. More recent research has tended to use ESWT in combination with other treatments, and a 2024 study reported that, for patients with rotator cuff injury accompanied by incomplete rotator cuff tears, the combination of ESWT and hyaluronic acid (HA) injections achieved better outcomes in CMS, muscle strength, and shoulder range of motion ($p < 0.05$) compared with HA alone [10].

In summary, ESWT has shown important clinical value in the treatment of RCRSP, either alone or in combination with other therapies. However, because ESWT involves many treatment

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parameters (such as dose, frequency, etc.) , there is no consensus on the determination of its treatment parameters and the formulation of a unified treatment plan, in the future, more high-quality clinical studies are urgently needed to optimize its clinical efficacy.

4. Traditional rehabilitation therapies

Traditional rehabilitation therapies are rehabilitation techniques that integrate modern scientific concepts into traditional Chinese medicine approaches as these modalities gain international recognition, mainly including acupuncture therapy, tuina manipulation therapy, cupping therapy and external therapy of traditional Chinese medicine.

4.1. Acupuncture therapy

As a traditional Chinese therapeutic method, acupuncture uses fine needles to penetrate and stimulate specific acupoints to regulate human body functions, inhibit inflammation, and relieve pain and dysfunction. As one of the non-pharmacological therapies, acupuncture has attracted remarkable international attention in recent years. Studies have shown that acupuncture, whether used alone or combined with rehabilitation training and physical therapy, can effectively reduce inflammatory responses, improve the range of motion of joints and alleviate pain. In addition, various acupuncture techniques such as floating acupuncture, electroacupuncture, fire needle and warm acupuncture have all demonstrated their respective clinical values. Separate gene-knockout mouse strain exhibited 57.7%, 52.8% and 71% declines in pain sensation at the three successive testing timepoints(day 1, day 2, day 3). Collectively, these data substantiate that acupuncture produces prominent antinociceptive actions to alleviate inflammatory pain. In mice with different gene deletions, pain levels were reduced by on the first, second and third days respectively. This confirms the analgesic efficacy of acupuncture therapy against inflammatory pain [11]. A study enrolling 160 patients divided them into two groups, treated with scapular stabilization training (SST) alone and SST combined with acupuncture respectively. It found that the excellent rate of the combined acupuncture group was about 28% higher, and the total effective rate was approximately 16% higher compared with the group without acupuncture intervention [12]. For adhesive lesions in shoulders tissues, tiny needle-knife manipulation delievers obvious curative benefits. One systematic review combined with meta-analysis covering a cohort 6,536 subjects revealed superior overall recovery outcomes woth needle-knife therapy relative to physiotherapy and Western medicine, with a 39% elevated treatment efficancy. In addition, joint mobilization combined with warm acupuncture can improve patients' prognosis, with the curative effect nearly twice that of physical therapy or medication alone, which further reflects the prominent advantages of the acupuncture therapy system in improving shoulder joint function [13].

4.2. Tuina manipulation therapy

Tuina is a manipulative therapy that can improve patients' rehabilitation experience. It facilitates recovery by relieving shoulder muscle stiffness and activating deep fascia. Among them, trigger point massage therapy (TPMT) and percussion massage therapy (PMT) are two major application directions.

TPMT mainly targets the trigger points of shoulder pain. It adopts compression, kneading and other manipulations to release the hypertonic state of muscle fibers, improve blood circulation and metabolism, and relieve muscle adhesion. A controlled trial involving 45 young and middle-aged

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patients with rotator cuff injury adopted the Numeric Rating Scale (NRS) to evaluate range of motion (ROM). The results indicated that TPMT treatment yielded significant improvements in shoulder abduction and external rotation, with abduction and external rotation improved by 0.81 (95% CI: 0.07 to 1.55) and 1.35 (95% CI: 0.56 to 2.14), respectively [14].

PMT is a vibration-based treatment modality, yet its optimal therapeutic parameters remain unclear. A study screened 45 patients with supraspinatus tear and divided them into three groups for continuous intervention. Significant enhancements in shoulder joint mobility, pain relief, functional recovery and quality of daily living were observed in both groups receiving PMT at varying frequencies($P<0.05$): specially, shoulder flexion angle rose by 71.7°and 65.0° for the two subgroups. Moreover, shoulder abduction increased by 77.0° and 72.0° respectively. It verifies that PMT is a safe and effective rehabilitation intervention [15]. However, the optimal parameters of this therapy have not been fully clarified at present.

4.3. Cupping therapy

Cupping therapy in traditional Chinese medicine has long attracted widespread attention. Compared with tuina and acupuncture, cupping features a low operational threshold, low cost for home use, and a wide range of applications. It exerts remarkable effects on alleviating shoulder pain as well as promoting functional recovery and immune regulation. A randomized controlled trial including 30 young and middle-aged female patients with rotator cuff injury demonstrated that sliding cupping intervention produced obvious effects on pain relief, ROM recovery and functional rehabilitation in these patients. The effect sizes of shoulder extension and abduction were 1.65 and 1.57 respectively ($P<0.05$) [16].

4.4. External therapy of traditional Chinese medicine

There are abundant clinical studies on external Chinese medicine therapy, which also called Chinese Herbal External Skin Therapy (CHFST), for pain relief of various etiologies. In clinical practice, prescription formulations are usually modified in line with the therapeutic effects effects exerted on the human body, such as activating blood ti resolve stasis, eliminating wind-damp pathogen, and relaxing tendons to dredge meridians. For patients experiencing shoulder pain arising from rotator cuff lesions, clinical prescribing strategies are generally divided into two targeted modalities: acute symptom comtrol and chronic inflammatory regulation. In clinical herbal fumigation and washing practice, medicinal herbs are predominantly selected for their curative properties: activating blood to subside swelling and eliminating wind-damp pathogens, such as Cinnamomum cassia twig (Guizhi), Speranskia tuberculata (Tougucao)and Lycopodium japonicum (Shenjincao). Changchun University of Traditional Chinese Medicine explored the anti-inflammatory efficacy of quercetin in Traditional Chinese Medicine (TCM) and applied Mendelian randomization (MR) to evaluate Paeonia suffruticosa bark (Mudanpi) and Glycyrrhiza uralensis root (Gancao) , two herbal medicines rich in quercetin. The study concluded that Chinese herbal medicines possess prominent advantages in anti-inflammatory treatment [17]. Other studies have analyzed data from a 1:1 controlled trial involving 68 patients. The combined CHFST intervention group achieved significant pain relief within the first month of treatment, and presented higher FMA-UE scores reflecting better late-stage recovery compared with the control group without CHFEST combination therapy. The indicators of the CHFST group were 38.5 (34.5–43.5), while those of the non-CHFST control group were 34 (30–39). The WHOQOL-BREF scores were 96.6±14.5 versus 91.2±9.8 ($P<0.05$). It is concluded that combined CHFST therapy is valuable for acute pain relief and long-term functional recovery [18].

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5. Conclusion

RCRSP have been extensively carried out, with a growing body of relevant empirical evidence accumulating continuously. Adequate research on physical therapy for RCRSP has provided sufficient evidence and conclusions for evidence-based medicine. Exercise therapy, physical agent therapy and traditional rehabilitation therapy all exert therapeutic effects through their unique mechanisms and advantages.

They can promote tissue repair, mitigate pain symptoms, and further enhance the active and passive mobility of the shoulder joint in individuals with RCRSP, thereby restoring shoulder function and elevating quality of life. Although the above-mentioned therapies differ in efficacy and therapeutic focus, sorting out current clinical application status, levels of evidence and action mechanisms can still provide references for clinical practice targeting patients with special needs or those requiring multimodal combined therapy.

It should be noted that the clinical standalone application of MCE within exercise therapy remains somewhat controversial. Compared with the three-stage exercise regimen formulated based on clinical consensus, MCE is more suitable to be adopted as an auxiliary intervention. Electrical stimulation among physical agent therapies and cupping therapy in traditional rehabilitation are both auxiliary interventions. Although their mechanisms of action are basically clear, most research papers published in recent years focus on the combined application of these adjuvant therapies with other rehabilitation interventions. There is insufficient evidence to prove that these modalities exert significant therapeutic effects on patients with RCRSP when used as monotherapy. Meanwhile, there is no unified therapeutic parameter for extracorporeal shock wave therapy and electrical stimulation therapy across different literatures, and standardized protocols for treating rotator cuff injury in this field are lacking.

Future research on RCRSP can focus on comparative studies of therapeutic parameters of physical agent therapies, developing more precise individualized exercise therapy protocols, and conducting targeted data analysis for patients with RCRSP at different disease stages or with distinct clinical characteristics.

Author contribution

All the authors contributed equally and their names were listed in alphabetical order.

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