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Rehabilitation Options for the Knee Osteoarthritis (KOA)

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Abstract: This paper highlights the significant value of various rehabilitation therapies for treating knee osteoarthritis (KOA). Acupuncture, moxibustion, ultrasound, shortwave therapy, pulsed electromagnetic field (PEMF) therapy, low-intensity laser therapy, and electrotherapy are examples of widely recognized physical therapies with demonstrated efficacy. Based on a review of these techniques, moxibustion and electrotherapy rank as the most widely used therapies, with acupuncture coming in second. Electrotherapy is a simple, cost-effective method that can be administered at home, making it more convenient than acupuncture and other advanced techniques like ultrasound and PEMF. In contrast, acupuncture relies on the expertise of professionals. At the same time, more complex technologies such as shortwave, PEMF, and laser therapies are less accessible due to their technical nature and higher costs. However, while all of these therapies help treat KOA, their specific applications and ease of use vary, and the specifics of the choices need to be analysed on a case-by-case basis.

Keywords: KOA, rehabilitation, physical therapy.

1. Introduction

One of the most prevalent chronic illnesses in the world is knee osteoarthritis (KOA), which affects a growing number of people worldwide and has a major negative impact on both individuals and society as a whole. The most prevalent kind of arthritis, KOA, is more common in older people and obese people. It is estimated that among the global population aged 60 and above, approximately 13% of women and 10% of men exhibit KOA symptoms. The prevalence rate rises to around 40% in individuals over 70 years of age [1]. The incidence of KOA in China is 18%, with rates of 16.5% among those aged 40-49, 30.2% among those aged 50-59, 37.9% among individuals aged 60-69, and reaching 47.5% in those aged 70 and above [2].

Recent studies have demonstrated that KOA can be addressed with rehabilitative therapy. KOA is a persistent joint disorder marked by degenerative alterations in knee joint cartilage and subsequent osteophyte development. The symptoms of KOA often progress slowly, with knee pain, swelling, stiffness, and deformity gradually emerging over time. These symptoms lead to limited mobility, and in severe cases, complete immobility.

Although there are many types of rehabilitation therapies, different methods focus on varying treatment effects. This paper will search relevant literature published in PubMed, Web of Science, and Google Scholar in the last 12 years, reviews the various rehabilitation treatments for KOA and briefly summarizes the treatment effects, including pain relief, functional improvement, and recovery

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promotion, as well as the advantages of choosing different methods under specific circumstances. Since most treatment methods fall under physical therapy, this paper primarily focuses on physical therapy modalities.

2. Materials and methods

This paper includes studies published between 2012 and 2024 on any rehabilitation interventions for patients with KOA. A systematic search was conducted across three databases (PubMed, Web of Science, and Google Scholar) using three main concepts for keyword searches: knee osteoarthritis, rehabilitation, and physical therapy. A total of 87 articles were reviewed for this paper and inclusion criteria were determined based on the title. The following were the inclusion criteria:(1) Articles with case reports, series of case studies, randomized controlled trials, or pilot studies using adult human subjects (18 years of age or older); Improvements in pain, function, disability, and ultrasound are two distinct clinical outcomes. (3) English-language articles; during the inclusion process, the authors excluded (1) animal studies and in vitro studies; and (2) post-surgical rehabilitation of KOA. And 28 papers were screened for inclusion criteria and 59 papers were excluded.

3. Physical therapy

3.1. Acupuncture

Acupuncture is an ancient traditional Chinese therapy that aims to adjust the physiological and pathological states of the body by stimulating specific acupoints, thus achieving the goals of treating diseases and promoting health. Among patients with KOA, there is a growing expectation to relieve knee pain and improve functional impairments. As a non-pharmacological treatment, acupuncture has gained widespread international application. There have been studies in which participants were randomly assigned (1:1:1:1:1:1) to an acupuncture group, an electroacupuncture group, a warm acupuncture group, a mild acupuncture group, a sham acupuncture group, or Celebrex treatment. Each participant in each of the six groups received individual treatment for 4 weeks. The co-primary outcomes were changed from baseline to week 4 in Visual Analog Scale (VAS) scores and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) functional scores. At week 4, the change in VAS scores was lower in the electroacupuncture (-3.28) and warm acupuncture (-2.96) groups than in the sham acupuncture (-2.21) and Celebrex treatment (-2.14) groups. Changes in WOMAC function results were lower in the electroacupuncture group (-31.75), the warm acupuncture group (-27.02), and the mild moxibustion group (-27.15) than in the sham acupuncture group (-12.7) and the Celebrex treatment group (-16.94) [3]. The results showed that electroacupuncture had the best analgesic effect and was more effective in improving joint function, warm needling and mild moxibustion were the next most effective in improving knee dysfunction. Ordinary acupuncture had the least significant effect. This may be because electroacupuncture provides continuous electrical stimulation, exerts anti-inflammatory and analgesic effects, improves microcirculation, and destroys knee joint bone, among other effects.

3.2. Moxibustion

The principle of moxibustion primarily involves the use of mugwort, including moxa wool and moxa sticks, whose heat and stimulation upon contact with the skin surface act on acupoints or specific areas of the body. This stimulates meridians and promotes the flow of qi and blood to achieve therapeutic and preventive effects. Moxibustion therapy improves blood circulation in the knee joint by reducing cartilage damage and macrophage infiltration. Additionally, it promotes the repair of

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articular chondrocytes by suppressing the expression of inflammatory mediators like tumor necrosis factor, interleukin-6, and mast cell cyclooxygenase [4].

KOA patients primarily seek medical attention for pain since pain from arthritis and functional impairments significantly lower their quality of life. Moxibustion exhibits significant promise in reducing KOA pain and enhancing joint function, according to the data currently available. Although moxibustion may cause issues such as burns and itching, current evidence suggests that it remains a safe and effective treatment method [5]. However, although there is much evidence of the efficacy of moxibustion on patients and the safety of the therapeutic effects, there is not much data analyzing the therapeutic effects of moxibustion on patients, and the data on the therapeutic impact on patients still need to be further studied.

3.3. Ultrasound

The principle of ultrasound therapy for KOA is based on its mechanical vibration and thermal effects. Ultrasound generates a micro-massage effect through high-frequency sound waves in tissues, improving local blood circulation, promoting metabolism, and aiding tissue repair. Additionally, the thermal effect of ultrasound can heat deep tissues, relieve pain, and reduce inflammation and joint stiffness, thereby enhancing joint flexibility and alleviating symptoms of KOA. Ultrasound can be applied either continuously or in pulses. While continuous ultrasonography creates thermal effects, pulsed ultrasound produces non-thermal effects that can assist in reducing inflammation.

Therapeutic ultrasound is also thought to reduce edema, relieve pain, accelerate tissue repair, and decrease the Western Ontario and McMaster Universities (WOMAC) [6]. Also, therapeutic ultrasound can increase Range of motion (ROM) and decrease the Lequesne index (LI). In terms of functional improvement, there is no significant difference between phonophoresis and conventional ultrasound therapy. In general, therapeutic ultrasound is a safe method for alleviating pain, reducing knee stiffness, and improving function in patients with KOA. Some studies have shown that ultrasound therapy significantly relieved pain ($P < 0.00001$) and decreased WOMAC physical function scores ($P = 0.03$). In addition, ultrasound treatment increased the ROM ($P < 0.00001$) and decreased Lequesne index ($P < 0.00001$). Subgroup analyses of ultrasound sonication showed significant differences on the VAS ($P = 0.009$), but not on the WOMAC pain subscale ($P = 0.10$) or the WOMAC total score ($P = 0.30$) [7].

However, there may be some limitations. Specific therapeutic outcomes still require further study data for analysis.

3.4. Shortwave therapy

The principle of shortwave therapy for treating KOA involves using the deep thermal effects generated by high-frequency electromagnetic waves to improve local blood circulation, enhance tissue metabolism and nutrient supply, and promote the absorption of inflammation and tissue repair. Through deep heating, shortwave therapy can effectively reduce knee joint pain, relieve muscle spasms, decrease joint stiffness, and increase joint mobility, thereby alleviating the symptoms of KOA. Shortwave therapy is an effective method for relieving pain in KOA patients, but it does not improve physical function. There have been studies analyzed by standardized mean difference (SMD) and risk ratio for continuous variable outcomes and dichotomous variables, respectively. Short-wave therapy was positive for pain (SMD, -0.53; 95% CI, -0.84 to -0.21). The pain subgroup showed an improvement in clinical symptoms in patients receiving pulse therapy (SMD, -0.83; 95% CI, -1.14 to -0.52) and a decrease in the pain scale in female patients (SMD, -0.53; 95% CI, -0.98 to -0.08). In terms of extensor strength, short-wave therapy was superior to the control group ($P<0.05$, $I^2=0\%$). There were no significant differences in physical function (SMD, -0.16; 95% CI, -0.36 to 0.05) [8].

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Whether there is a gender difference in the efficacy of short-wave therapy is another concern for clinicians because epidemiologically there are more women than men with osteoarthritis of the knee. From the analysis of pain data, the pulsed mode appears to be superior to the continuous mode (no heterogeneity) and there is efficacy in women (moderate heterogeneity). Regarding the treatment effect in male patients, the data did not show significant improvement. Specifically, the results of trials that included male patients did not support a significant effect of shortwave therapy in relieving osteoarthritis pain in the knee. Male patients showed weaker or no significant difference in pain relief compared to studies that included only female patients. Knee extensor strength can be increased by combining isometric workouts with short-wave treatment. Nevertheless, knee stiffness cannot be relieved with this therapy. Short-wave therapy appears to be a safe treatment for KOA based on its low rate of adverse effects.

3.5. Pulsed electromagnetic field therapy

The principle of PEMF therapy for treating KOA involves applying electromagnetic pulses at specific frequencies and intensities to stimulate the tissue cells surrounding the knee joint. These electromagnetic waves can penetrate the skin and act on cell membranes, improving the distribution of electrical charges in cells and enhancing their metabolism and repair capacity. Additionally, PEMF promotes blood circulation and nutrient transport, and reduces inflammatory responses, thereby alleviating pain, improving joint function, and promoting cartilage repair and regeneration. Therefore, PEMF is considered a non-invasive treatment method suitable for alleviating KOA symptoms.

3.6. Laser therapy

The principle of laser therapy for treating KOA involves using low-level laser therapy (LLLT) to irradiate the knee joint, stimulating the mitochondria within cells to promote the production of ATP (cellular energy) and enhance the cells' repair capacity. To relieve pain and swelling, the laser light increases local blood circulation, decreases the release of inflammatory mediators, and lowers the inflammatory response. Additionally, it can promote the regeneration of soft tissues and joint cartilage, improving joint function. Therefore, laser therapy is a non-invasive treatment method that helps alleviate the symptoms of KOA and promotes tissue repair.

Studies have compared the effectiveness of low-level laser therapy (LLLT) and high-intensity laser therapy (HILT) in treating KOA. LLLT combined with exercises (LLLT+E) (43% guided exercise, 43% home-based exercise, 14% both); HILT combined with exercises (HILT+E) (25% guided exercise, 25% home-based exercise, 50% both) [9]. Research has shown that both LLLT and HILT when combined with rehabilitation exercises, can improve knee pain and function. Based on indirect comparisons, HILT+E appears to be more effective than LLLT+E in relieving KOA symptoms. However, since this conclusion is derived from indirect comparisons, further direct comparative studies of these two laser therapies may be needed to confirm this finding.

3.7. Electrotherapy

The principles of electrotherapy for KOA vary; low frequency (usually less than 1kHz), medium frequency (usually 1kHz-100kHz), and high frequency (usually above 100kHz) Electrotherapy for KOA is used to stimulate the nerves and muscle tissues by applying an electric current to the knee joint area. This electrical stimulation promotes local blood circulation, accelerates the elimination of metabolic wastes, and reduces the inflammatory response. At the same time, the electric current can activate the endogenous pain-relieving mechanisms in the body and reduce pain transmission, thus effectively relieving pain. The difference between the three is the different depths of treatment, which are high frequency, medium frequency, and low frequency in that order. Different frequencies of

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electrotherapy promote muscle contraction and relaxation, enhance muscle strength and coordination around the joints, and improve joint function. Therefore, electrotherapy is widely used as a non-invasive physical therapy to relieve symptoms of KOA.

60 KOA patients were included in a randomized single-blind trial and were split into three groups: one group received active interferential current (IFC) therapy at 40, 100, and 180 Hz, while the other group received a placebo. The treatment lasted for three weeks, five times per week. The following outcomes were assessed at the end of treatment and one month: VAS (pain at rest, pain during movement, and disability), physician and patient evaluations of treatment efficacy, 15-meter walking time, ROM, WOMAC, and weekly paracetamol consumption. The WOMAC subscales measuring function and pain both showed improvement from the baseline ($p<0.05$). Patients treated with sham IFC showed significantly reduced improvement in the WOMAC pain and function subscales ($P<0.05$), despite no difference in the degree of improvement between the IFC groups including 40, 100, and 180 Hz [10]. This study indicated that IFC therapy is an effective intervention for treating KOA, offering advantages in pain and disability outcomes compared to placebo IFC. However, no differences in treatment outcomes were found between different IFC frequency modulations, supporting the use of various IFC frequencies for pain relief.

4. Sports practice

The principle of sports rehabilitation in treating KOA is primarily focused on strengthening the muscles around the knee joint, particularly the quadriceps, and hamstrings. This helps stabilize the joint, reduce stress, and maintain joint flexibility, preventing stiffness. Low-impact exercises such as swimming and cycling can effectively reduce excessive pressure on the joints. Additionally, proper flexibility training helps maintain the ROM in the joint and slow down joint degeneration. Exercise rehabilitation not only alleviates pain but also improves joint function and promotes overall recovery.

Proper exercise training can prevent KOA or aid in its recovery. However, excessive training can exacerbate the condition. Experimental data shows that the risk of knee OA is related to the duration and intensity of high-level physical activity [11]. Athletes engaged in sports that involve rapid acceleration and deceleration, those whose training has a significant impact on the joints, or who participate in elite-level competitions for extended periods, are at greater risk of developing early OA. For athletes, the risk additionally rises in the event of aberrant joint architecture or alignment, joint instability, underlying muscle weakness or imbalance, or obesity combined with high levels of physical activity.

5. Patient education

The cognitive and psychological state of the patient is crucial for rehabilitation. Proper education, which helps patients understand the mechanisms of the disease, rehabilitation goals, and precautions, can reduce anxiety and improve their self-management abilities. Through a controlled trial of patient education interventions versus any non-pharmacological, it was concluded that although patient education achieved statistically better efficacy in terms of short-term pain and function compared to conventional treatment, although the difference was small, there was still a tendency for patients to have an improvement in inflammation. Currently, patient education should not be used as a standalone treatment but rather combined with exercise therapy to provide short-term functional improvements that are both statistically and clinically meaningful [12].

6. Discussion

Two accepted treatments for KOA include acupuncture and therapeutic ultrasonography. By stimulating particular acupoints and balancing the body's yin and yang, acupuncture is recognized to

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offer safe, effective, short- to medium-term pain treatment. More investigation is needed on its long-term analgesic effects, though. Although moxibustion is a gentler treatment for KOA, its efficacy is not as great as acupuncture's; however, when paired with medicine, it can yield far better outcomes.

Therapeutic ultrasound has applications in both imaging evaluation and pain relief for KOA, though its clinical efficacy is somewhat limited due to a lack of extensive research. Although acupuncture and therapeutic ultrasonography have both shown promise in treating KOA, further research, and complete experimental data are required to fully assess and compare their respective efficacies.

Compared to acupuncture, short-wave therapy shows notable effectiveness in treating KOA, but the technology and equipment for this treatment still require further advancement, making it less suitable as a first-line option. Treatment choices should always be tailored to the individual's condition and based on a physician's recommendation. A combination of acupuncture and short-wave therapy can also yield favorable outcomes for KOA. Integrating different physical therapies, which target various mechanisms, can enhance overall therapeutic results. Two popular physical treatments for KOA symptoms include short-wave therapy and PEMF therapy. They are different in important ways even though they have certain similarities. While both can be used as complementary therapies for KOA, PEMF therapy promotes bone cell metabolism and repair by controlling electrophysiological processes both within and outside of cells. Short-wave therapy, on the other hand, improves blood circulation and stimulates tissue repair through its thermal or non-thermal effects. However, both therapies have relatively high thresholds in terms of technical requirements, and the appropriate treatment should be determined based on the individual's condition and medical advice.

Electrotherapy is an effective intervention for the treatment of KOA and can significantly improve pain and joint function. Its non-invasive nature and versatility across different frequencies make it an attractive treatment option, which can be seen as a comprehensive treatment approach. By promoting muscle coordination and strength around the knee, electrotherapy helps to enhance joint stability and mobility, addressing some of the core limitations faced by patients with KOA. Although electrotherapy has demonstrated significant benefits in reducing pain and improving function, some limitations must be considered. The lack of frequency-specific differences suggests that more research may be needed to determine whether certain frequencies produce better outcomes in specific subgroups of KOA patients. Further research is needed to optimize its application and understand the long-term benefits for patients with KOA. In addition, the long-term effects of electrotherapy and its optimal combination with other physical therapies, such as exercise, remain to be further studied.

7. Conclusion

The purpose of this paper is to organize the important value of rehabilitation therapies for the treatment of KOA. In a word, various rehabilitation therapies offer significant benefits for KOA, including pain relief, improved joint function, and enhanced recovery. Acupuncture, electrotherapy, and ultrasound therapy are widely recognized for their pain-relieving properties, while techniques such as moxibustion and shortwave therapy contribute to improved blood circulation and tissue repair. Among these, electroacupuncture has shown superior efficacy in pain relief and functional improvement, while therapeutic ultrasound provides valuable benefits in alleviating pain and increasing joint mobility. However, the choice of therapy should be tailored to the individual's condition, as different therapies address specific aspects of KOA. For example, PEMF therapy focuses on enhancing cell metabolism and tissue regeneration, whereas shortwave therapy uses deep tissue heating to reduce inflammation and pain. Combining different rehabilitation modalities, such as acupuncture with shortwave therapy, may further improve therapeutic outcomes.

Physical rehabilitation, particularly exercise, remains critical in managing KOA, as it strengthens muscles around the joint, reduces stiffness, and stabilizes the knee. Patient education also plays an

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essential role, providing individuals with the knowledge to manage their condition and optimize rehabilitation efforts. While some therapies are more effective in certain contexts, further research is needed to fully understand their long-term benefits and to optimize the treatment strategies for KOA.

In addition, the combination of different rehabilitation techniques needs to be further investigated. Single or combined application of different rehabilitation techniques can achieve good therapeutic effects, but whether the combined application of different rehabilitation techniques applies to other related treatments needs to be further researched and discussed. For the same disease, if the rehabilitation techniques are applied in combination, whether the effects are consistent or different, or whether the combined use is synergistic, equivalent, or even less effective, there are fewer related studies. In the future, it is necessary to observe the differences in the clinical effects and mechanisms of the combined application of different rehabilitation therapies on KOA, evaluate the necessity and scientificity, avoid the waste of resources and aggravation of medical burdens, and provide a scientific basis for the optimization of the combination therapy, promote the practice and innovation, which will promote the practice and innovation of combination therapy.

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