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Progress of Research on Rehabilitation Treatments for Specific Symptoms of Knee Osteoarthritis

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Abstract. Knee osteoarthritis (KOA) is a common chronic degenerative bone and joint disease characterized by knee degeneration, pain, stiffness and knee dysfunction. The global prevalence of KOA has been gradually increasing with the aging of society and changes in lifestyle, rising by nearly 50% in the last 30 years, causing a heavy health and economic burden to patients, families and society. KOA cannot be completely cured at present, and all relevant guidelines recommend non-surgical and non-pharmacological treatments, mainly rehabilitation, as the preferred basic treatment for KOA. This paper adopts the literature search method to systematically analyse the relevant literature in the past 5 years, and review the rehabilitation methods for treating specific symptoms caused by KOA and the existing benefits and limitations of each therapy from various aspects, such as physiotherapy, occupational therapy, traditional Chinese medicine rehabilitation and emerging therapies, with a view to providing more valuable reference information for clinical rehabilitation and researchers, and to promote further development and application of rehabilitation methods for KOA.

Keywords: Knee osteoarthritis; rehabilitation; physical therapy; occupational therapy; traditional chinese medicine.

1. Introduction

Knee osteoarthritis (KOA) is a degenerative disease caused by a long-term combination of mechanical and biological factors. Studies have shown that the prevalence of KOA is rising by nearly 50% over the past 30 years; the prevalence of KOA in China has also reached 8.1% and has gradually become one of the major disabling diseases in China [1,2]. Therefore, it is socially and economically important to investigate rehabilitation methods for specific symptoms caused by KOA. Currently, there are no medications and therapies that can completely cure KOA, and there are mainly traditional rehabilitation therapies such as physical therapy (PT, including exercise therapy and physical factor therapy), occupational therapy (OT), and traditional Chinese medicine rehabilitation therapy, as well as regenerative therapy, rehabilitation robots, and other emerging rehabilitation therapies and technologies, which mainly play a role in relieving pain and improving knee function [1,2]. Although there are currently many summaries of rehabilitation methods for the treatment of KOA, the number of summaries of KOA-specific rehabilitation methods is still small and relatively one-sided, so it is particularly important to summarise KOA-specific rehabilitation methods in depth.

This paper adopts the literature search method, using Google scholar, Pubmed and other tools to systematically retrieve relevant domestic and international literature during 2020-2024 to review and summarise the rehabilitation methods for KOA-related symptoms, and to further analyse the current status of the development of emerging KOA-specific symptomatic rehabilitation techniques. By comprehensively analyzing the existing research results, this paper hopes to provide valuable reference information for clinical rehabilitation and researchers to promote the further development and application of KOA rehabilitation methods.

2. Physical Therapy (PT)

As defined by the World Confederation for Physical Therapy (WCPT), PT is a specialized healthcare service administered by licensed physical therapists to patients, encompassing a range of

interventions designed to promote, sustain, and rehabilitate optimal physical mobility and functional ability throughout all stages of life. Currently, physiotherapy methods for KOA-related conditions fall into two main categories: exercise therapy and physical factor therapy.

2.1. Exercise Therapy

Exercise therapy aims to restore or improve the function of various parts of the human body using the patient's own strength, the therapist's assistance or rehabilitation equipment, which can alleviate joint pain and improve the function of the knee joints and the quality of life of patients with KOA, and exercise therapy is a type of effective complementary therapy that plays a key role in the treatment of KOA [1,2].

2.1.1. Neuromuscular training.

The aim of neuromuscular training is to improve communication between the nervous system and muscles, which can improve body balance and increase knee stability.

Mamta Joon et al (n=30) subjected 30 patients with KOA to 3 months of neuromuscular training via tele-rehabilitation, and the results showed that an average of 21 points improvement in patients' KOOS scores (95% CI 19.62 to 22.38) compared with the pre-treatment period, this suggesting that the patients' knee symptoms were significantly improved [3]. Decreased muscle strength is one of the most important risk factors for the development and progression of KOA, especially in the quadriceps muscle [1]. Manoj Abraham et al. subjected 27 patients with KOA to neuromuscular training for 1 month. The results showed that the patients' quadriceps strength increased slightly (SD: 10.8,12.2; $p = 0.03$) and NPRS pain scores decreased slightly (SD: 5.9,4.0; $p = 0.04$) compared to the pre-treatment period [4].

Adverse effects of neuromuscular training are mainly caused by inappropriate training, mainly a temporary increase in knee pain, and as this training requires improvement or even alteration of the patient's original basic movement patterns, it requires sufficient time and willpower on the part of the patient to perform this training.

2.1.2. Aquatic exercise.

The Chartered Society of Physiotherapists (CSP) defines aquatic exercise as a therapeutic programme that uses the properties of water (buoyancy, resistance) and is designed by qualified physiotherapists to improve patient function.

Aquatic exercise is a common rehabilitation exercise treatment for KOA that reduces the mechanical load on the knee joint and alleviates joint stress. Zhen Xu et al conducted a meta-analysis of 22 relevant studies (n=1394). The results revealed that, in comparison to the 746 individuals who did not receive treatment, the 648 patients who underwent aquatic exercise therapy exhibited noteworthy enhancements in terms of stiffness (SMD -0.57; 95% CI -1.03, -0.11) and physical function (-0.35; -0.52, -0.18) [5].

Although aquatic exercise does not have significant adverse effects, it is a venue-demanding that requires swimming pools with suitable water temperatures and depths, which adds to the cost of the exercise.

2.2. Physical Factor Therapy

There are many types of physical factor therapy (also known as physiotherapy), which mainly by promoting local blood circulation, relieve the inflammatory response to achieve the purpose of reducing knee joint pain; in the rehabilitation of KOA, it has become an important adjunctive intervention for KOA as a conservative treatment without the use of drugs and invasive manipulation, which is basically applicable to all stages [1,2].

2.2.1. Lasers.

Laser therapy involves the use of equipment to generate and deliver laser light to tissue to promote healing and reduce inflammation. The use of lasers with an output power of less than 0.5 watts is known as low-level laser therapy (LLLT) and the use of lasers with an output power of more than 0.5 watts is known as high-intensity laser therapy (HILT).

Mohd Azzuan Ahmad et al. randomized 34 KOA patients equally into LLLT and HILT groups, each treated for 12 weeks. The results indicated a decrease in TUG scores in each group compared to pre-treatment (HILT: MD: -0.88, 95% CI: -1.04,-0.72, $p < 0.001$; LLLT: MD: -0.53; 95% CI: -0.64,-0.41; $p < 0.001$); this suggests that LT treatment improves functional mobility in patients with KOA and that HILT is superior to LLLT [6].In a meta-analysis of laser therapy studies (n = 495), the results proved that VAS scores improved in both LLLT and HILT groups (LLLT: SMD -0. 67; 95% CI -1.05, -0.29; $P < 0.05$; HILT: SMD -2.06; 95% CI -3.14, -0.98; $P < 0.05$), suggesting that LT treatment improves joint pain in individuals afflicted with KOA and that HILT remains superior to LLLT [7].

LT may cause adverse effects such as bleeding, infection and, in rare cases, hirsutism. In addition, the high cost of purchasing the equipment required for LT, also need to train staff and the need for multiple treatments to achieve results make LT treatment more expensive.

2.2.2. Pulsed electromagnetic field.

Pulsed electromagnetic field (PEMF) therapy is performed by generating a time-varying magnetic field through an electric current delivered by a conductor, and the use of PEMF therapy is effective in reducing inflammatory responses and preventing cartilage degeneration in patients with KOA.

Byalovsky Y.Y. et al. randomized 66 patients with KOA to receive pulsed electromagnetic field therapy from the ALMAG+ device and a placebo group for 1 month each. The results showed that the treatment group had a significantly lower VAS score than the placebo group ($F=47.6$; $p=0.00006$), and more than a quarter of the patients no longer required NSAID/analgesic treatment, suggesting that the PEMF therapy can effective in relieving pain experienced by individuals with KOA [8].

PEMF does not have significant or long-term adverse effects; patients may react with headache, fatigue, or nausea, and may experience mild tingling and redness at the treatment site. PEMF is not suitable for individuals who have undergone organ transplants, use implantable medical devices, and are fitted with magnetic implants.

3. Occupational Therapy (OT)

As defined by the American Occupational Therapy Association (AOTA), OT promotes health, wellbeing and quality of life by helping people to engage in meaningful activities, with treatments that vary from person to person and are highly individualized.

Currently, studies related to OT for the treatment of osteoarthritis mainly focus on the hand, Anne Therese Tveter et al. conducted a study of OT for carpal osteoarthritis (n=180),and the results showed that OT improved patients' grip strength (MD: 23.4; 95% CI 7.5, 39.3; $P = 0.004$) and reduced hand pain after grip (MD. -1.1; 95% CI -0.5, -1.7; $P = 0.001$) [9].There is insufficient evidence-based medical data to support its applicability to the treatment of KOA, but OT remains an important intervention strategy to address the effects of decreased mobility and social participation in patients with KOA [1].

4. Traditional Chinese Medicine Rehabilitation

It is defined as the use of Chinese medicine theory and method, combined with rehabilitation medicine technology, to help patients regulate, restore the physiological function of the body, improve the quality of life of a rehabilitation treatment, including acupuncture, tuina, etc.

4.1. Acupuncture

Acupuncture constitutes a crucial component of rehabilitation in the field of traditional Chinese medicine, through the use of small metal needles accurately pierced into specific acupuncture points in the body to produce stimulation, which can increase blood flow to the soft tissues, facilitate the absorption of local inflammatory mediators and alleviate knee joint pain.

Guang-Xia Shi et al. randomly and equally divided 60 KOA patients into EA group (electrified acupuncture using HANS-200A acupoint nerve stimulator) and MA group (acupuncture using the same instrument but without electrification), both of which were acupointed with 6-7 local acupoints, and both of which underwent three weekly sessions for a total of 8 weeks of treatment. The results showed that compared with the pre-treatment period, both the EA and MA groups significantly reduced the levels of the pro-inflammatory cytokine TNF-α (EA: 28.25 vs. 16.26 pg/mL, p=0.002; MA: 29.64 vs. 25.97 pg/mL, p=0.043) and the cartilage degradation biomarker MMP-3 (EA: 2,277.6 VS 1279.00 pg/mL p=0.002; MA: 2665.93 VS 1330.68 pg/mL, p=0.008) levels [10].

A meta-analysis of studies investigating the efficacy of acupuncture in the treatment of KOA(n=9422), demonstrated that the acupuncture treatment group exhibited a significant reduction in the WOMAC stiffness score compared to the usual care group (13 RCTs,1065 patients; MD = -1.13; 95% CI -1.51, -0.76) [11]. To some extent, this suggests that acupuncture may also alleviate joint stiffness and inflammatory response and slow down cartilage degeneration in patients with KOA [10,11].

Acupuncture has the characteristics of high safety, easy operation, etc. It will not cause permanent or fatal injury, and some patients may have reactions such as dizziness, tingling and haematoma at the point of needling, which will subside by themselves [10,11]. Acupuncture is not suitable for people with anxiety disorders, coagulation disorders, allergies to the materials used in acupuncture needles, or a phobia of acupuncture.

4.2. Tuina

Tuina is a low-cost and highly safe method, which works by stimulating specific acupuncture points in the meridians and blood channels of the human body through massage to repair the patient's cartilage tissues and promote the body's metabolism.

Kao Qiang Liu et al. randomly and equally divided 96 KOA patients into two groups, with the experimental group underwent 4 weeks of tuina therapy followed by 4 weeks of health education intervention, and the control group, 4 weeks of health education intervention followed by 4 weeks of tuina therapy were carried out. The results showed that compared with the pre-treatment period, the WOMAC pain score (45.96; 95% CI 35.82, 56.09; $P < 0.001$), stiffness score (31.42; 95% CI 26.37,36.46; $P < 0.001$), activity score (117.58; 95% CI 97.56, 137.61; $P < 0.001$), and VAS score (1.07; 95% CI 0.83, 1.32; $P < 0.001$)were significantly reduced, suggesting that tuina can effective in relieving knee pain and enhancing joint mobility in individuals with KOA [12]. In addition, tuina could also reduce monocyte and macrophage recruitment by decreasing the amount of RANTES and MCP-1 factors in order to alleviate from KOA inflammation [13].

Adverse effects of tuina are mainly caused by improper manipulation, including ecchymosis and soft tissue strains. Tui Na is not suitable for patients with bone and joint infections, local skin breakdown and diseases such as osteomyelitis, tumours, coagulation disorders and skin diseases.

5. Emerging Rehabilitation Methods and Technologies

5.1. Regenerative Therapy

Stem cell therapy is a regenerative therapy. Intra-articular mesenchymal stem cell therapy is an emerging and one of the most promising treatments for KOA. MSCs have the potential for self-renewal and multidirectional differentiation and are treated through targeted differentiation,

immunomodulation, anti-inflammation, pro-angiogenesis, microenvironmental improvement and regeneration promotion.

A systematic review and network meta-analysis of 16 studies (n=1005) to evaluate the therapeutic effects of different origins of MSCs in patients with KOA. The results showed a significant reduction in the subjective IKDC score in the adipose-derived mesenchymal stem cells (AD-MSCs) treatment group compared with the placebo group (IKDC: SMD -0.71; 95% CI -1.20, -0.21), whereas the umbilical cord derived MSCs (UC-MSCs) treatment group improved WOMAC scores more effectively (SMD 1.65; 95% CI 0.27, 3.03), suggesting that MSCs can be more effectively in alleviating pain and enhancing physical function [8]. Stem cell injection therapy for arthritis has some adverse effects compared to placebo, and there is no consistent stem cell source, mechanism of action, or preparation process, which needs to be further investigated in safety studies [1,14].

5.2. Rehabilitation Robots

Rehabilitation robots are categorized into upper limb robots and lower limb robots according to body parts, of which lower limb rehabilitation robots have a wide range of areas, mainly divided into therapeutic robots and assistive robots, including post-traumatic, post-operative and elderly health services, including a variety of different forms, with intelligence, automation and other features. It plays an important role in restoring and assisting patients affected by diseases and disabilities, and direct physical interaction with robotic systems can accelerate the rehabilitation process of patients or serve as a replacement for lost joint function. It has been shown that assisted therapy using rehabilitation robots may have advantages over traditional osteoarthritis treatments and is an ideal means of intervening in the management of KOA without drugs or surgery, with personalized and adaptive support tailored to the patient's condition [15, 16].

Currently, rehabilitation robots still need more research support in several aspects such as the human-robot physical interaction and cognition, and specific applications face economic, privacy and ethical issues [15,16].

6. Conclusion

This paper reviews and summarises the rehabilitation methods for KOA-related symptoms from various aspects, such as physical therapy (exercise therapy, physical factor therapy), occupational therapy, Chinese medicine rehabilitation therapy and emerging therapies, and analyses the benefits and limitations of each therapy. However, this paper summarises only those therapies that are strongly recommended by relevant guidelines, due to the wide variety of PT and the fact that the efficacy of some therapies is still unclear. To address these limitations, future studies could focus on the efficacy of applied OT on KOA to obtain sufficient evidence-based medical data.

However, it is undeniable that KOA-related rehabilitation techniques are gradually evolving towards diversification and personalization. In the future, together with the development of related technologies and continuous research, rehabilitation therapy will significantly improve its efficiency and effectiveness, thus greatly enhancing the rehabilitation experience and the overall quality of life for individuals with KOA.

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