

A review of exercise training for the treatment of knee osteoarthritis

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Abstract. Knee osteoarthritis (KOA) is a chronic degenerative osteoarthritis that accompanies joint pain, joint deformities, and functional impairments. It is common in middle-aged, elderly, and female populations, and it has a serious impact on the daily activities and living standards of patients with the aging of our country's society, the number of patients with knee osteoarthritis continues to increase, and it will become a serious joint disease that poses a threat to the health of the middle-aged and elderly population. Due to its low economic cost, relatively simple treatment methods, and strong analgesic effects, exercise therapy has been recommended as the first-line treatment method for KOA in numerous domestic and foreign diagnostic and treatment guidelines. The methods of sports training for KOA mainly include strength training, aerobic exercise, water exercise, traditional health care exercise and other single treatment methods, as well as combination therapy of sports therapy and acupuncture and moxibustion. However, exercise therapy has not yet been widely used in China. Therefore, this article summarizes the research progress and existing literature evidence related to exercise training for KOA, with the aim of providing reference for the treatment of KOA through exercise training.

Keywords: Knee Osteoarthritis, Exercise Therapy, Review.

1. Introduction

Knee osteoarthritis (KOA) is a common degenerative joint disease, with joint pain and joint limitation being common clinical symptoms. Among them, joint pain is the most common clinical symptom of KOA. The prevalence mentioned in the 2021 China Osteoarthritis Diagnosis and Treatment Guidelines is 36.8%~60.7% [1]. The incidence of osteoarthritis is mainly over 40 years old, and the overall incidence rate of OA in China over 40 years old is as high as 46.3% [1]. It not only brings a heavy economic burden and pain to patients and their families, but also brings serious inconvenience to their daily lives, bringing a heavy burden and pain to society. Suffering from KOA not only leads to joint pain, deformity, and dysfunction, but also leads to joint deformity and dysfunction. In more severe cases, it can lead to hip fractures and a risk of all-cause mortality.

With the aging of the population becoming more and more serious in China, the incidence rate of KOA is also on the rise. According to the literature, the elderly are the people with high incidence of KOA [2]. Therefore, prevention and treatment of KOA is a crucial problem to be solved in modern society.

KOA may occur due to various factors, such as hormonal imbalance, obesity, genetics, etc. Generally speaking, the estrogen level of postmenopausal women will significantly decline, which is prone to a series of changes such as muscle strength decline and osteoporosis, increasing the wear of knee cartilage, leading to more prone to knee arthritis. Therefore, literature shows that, the prevalence and incidence rate of KOA in women will be higher [1]. Obesity can lead to excessive pressure on the knee joint, and long-term compression of the knee joint can easily trigger KOA. So, the pathogenic factors of KOA are very diverse.

At present, there is continuous research on the treatment of KOA through exercise training in clinical practice, but there is still relatively little review on the treatment of KOA through exercise training, and there is a lack of systematic cognitive treatment or research in this area.

This article starts from the perspective of the treatment of KOA through exercise training, summarizes the existing treatment progress and the mechanism of improving KOA through exercise training, in order to provide more theoretical basis for the treatment of KOA through exercise training.

2. The mechanism of action of exercise therapy in preventing and treating KOA

2.1. Improving motion control ability

The progression of KOA is related to abnormal physiological function of muscles, as this can lead to a certain degree of biomechanical changes [3]. Biomechanical changes are an important component of the pathogenesis of KOA, as there is a clear interaction between knee osteoarthritis and changes in surrounding muscles. During knee flexion movements from 0° ~ 45° , the quadriceps femoris provides a force for forward subluxation. Due to the 170° angle between the femoral anatomical axis and the tibial anatomical axis, and the patella being at the angle, there is a trend of outward dislocation, especially in the flexion position, tibial external rotation. The lateral displacement of the patella is maintained in a stable state due to the obstruction of the external femoral condyle and the traction of the medial femoral muscle, but it also increases the stress on the external femoral condyle. Under normal load conditions, the knee joint conducts uniformly downwards through the anatomical axis, and any pathological state that changes the axial relationship of the knee joint may lead to an increase in force on the knee joint. When the knee is varus, the force line shifts inward, increasing the force on the inner side of the tibiofemoral plateau. When the knee is valgus, the force on the outer tibiofemoral plateau increases; Mechanical load accelerates joint degeneration, and once abnormal force lines are formed, it can exacerbate local load and form a vicious cycle with abnormal force lines, leading to inflammation of the knee joint.

Research has shown that exercise therapy can enhance muscle strength by accelerating blood circulation, increasing muscle mass, and improving muscle function, thereby improving motion control and joint stability, improving muscle coordination around the knee joint, reducing wear and tear of knee cartilage, improving patient control of movement, improving lower limb stress imbalance, and thus playing a therapeutic role in KOA [4,5].

2.2. Delaying cartilage tissue degeneration

Inflammatory factors can inhibit chondrocyte proliferation and disrupt the extracellular matrix of chondrocytes, playing an important role in the pathogenesis of KOA, such as interleukin (IL-1), tumor necrosis factor (TNF), nitric oxide (NO), etc. If you want to delay cartilage degeneration, moderate exercise training can be conducted to reduce the levels of some inflammatory factors and improve joint function [6, 7]. Studies have shown that exercise therapy can inhibit the HDAC3/NF- κ B pathway in KOA model rats, reduce the expression of histone deacetylase 3 (HDAC3), nuclear factor- κ B (NF- κ B), and matrix metalloproteinase-13 (MMP-13), and increase the expression of type II collagen, this can improve the morphology of cartilage tissue and exert a protective effect on cartilage[8]. Meanwhile, the aging of chondrocytes is closely related to the SIRT6 gene, and specific exercise training can promote the expression of SIRT6, downregulate the expression of MMP-13, thereby inhibiting the

aging process of chondrocytes and delaying the degeneration of cartilage tissue, thus playing a therapeutic role in KOA [9,10].

2.3. Exert analgesic effects

An important component of chronic pain management is exercise, and the most significant factor affecting routine activities in KOA patients is joint pain. Joint pain in KOA patients can be alleviated through exercise therapy. The pain center of KOA patients is relatively sensitive, which can lead to changes in the corresponding brain regions of pain, and exercise therapy can reshape the patient's brain structure and function. Hansen S pointed out in their research that there is a correlation between the level of EIH response in patients before exercise therapy intervention and the degree of pain improvement, and EIH can be used to predict the analgesic effect of exercise therapy in KOA patients [11]. A study has found that allowing healthy and painless individuals to engage in a single aerobic or resistance exercise, and analyzing data from multiple experiments, it has been found that after exercise, it usually leads to exercise-induced pain loss (EIH) [12]. This exercise induced analgesic effect (exercise induced hypoalgesia, EIH) will appear immediately to 30 minutes after exercise, affecting the overall pain sensation, including the limbs being moved, and affecting the pain regulation ability of the central nervous system under long-term exercise, producing sustained analgesic effects or improving clinical symptoms of chronic pain. This can demonstrate that exercise training can have an analgesic effect on KOA and alleviate the impact of joint pain on patients' lives.

3. Single exercise therapy for knee osteoarthritis

An active or passive exercise based on biomechanics, exercise physiology, exercise anatomy, and neurodevelopment are called exercise therapy. The purpose of this therapy is to diagnose and improve skeletal muscle damage or dysfunction caused by various factors by enhancing muscle endurance and strength, as well as the stability of various joints. In exercise therapy, patients have a variety of options, including barehanded exercise and the use of some instruments to achieve the goal of exercise. KOA's exercise therapy generally includes strength training, aerobic exercise, water sports, Tai Chi and Ba Duan Jin.

3.1. Strength training

Strength training has the function of increasing muscle strength to maintain joint balance and enhance the biological function of surrounding tissues, commonly including static and resistance training. The most effective intervention for improving muscle strength is resistance training. Research has shown that during moderate to high intensity resistance exercise, the strength of the quadriceps femoris and hamstring muscles in patients with knee osteoarthritis increases by 6% ~ 46% [13]. The research results of Tariq M R and other scholars show that progressive resistance strength training is effective in reducing patient BMI, improve daily happiness and joint function [14]. Foreign scholars such as Warren B conducted knee extensor muscle strength training intervention on the contralateral limb of patients diagnosed with unilateral KOA for a period of 4 weeks. After the experiment, compared with the age-matched KOA control group (n=12), in late stage of KOA patients (n=26), after 4 weeks of intervention training, the KOA training group showed a 20% increase in strength and reduced co activation of bilateral hamstrings in the affected limbs, although untrained [15].

3.2. Aerobic exercise

Aerobic exercise, with a linear relationship between exercise load and oxygen consumption, refers to a type of exercise that primarily provides the energy needed for exercise through aerobic metabolism. Research has shown that moderate intensity aerobic exercise can slow down the progression of KOA. Baur A's research shows that rats with KOA can reduce the loss of proteoglycans in their cartilage and improve cartilage elasticity by performing treadmill exercise with a maximum oxygen uptake of 60% to 70% [16]. Yang Xijing's research results show that aerobic fitness exercise can reduce joint pain, increase joint range of motion, and improve joint function in KOA patients; And it is believed that

aerobic exercise may affect bone tissue metabolism by regulating the osteoprotegerin/nuclear factor κ B receptor activating factor ligand/nuclear factor κ B receptor activating factor system, thereby achieving a regulatory effect on bone and slowing down the process of KOA [17].

However, the pros and cons of using aerobic exercise to treat KOA are still controversial. Although aerobic exercise as a treatment method has a low age threshold and is suitable for KOA patients of all age groups, it requires specific conditions and environmental requirements (such as specific exercise schedules, exercise methods, oxygen uptake, etc.) to have a therapeutic effect on KOA. Conversely, it may cause irreversible damage to joints. The author believes that although aerobic exercise has advantages and disadvantages as a treatment method for KOA, it has a lower threshold for patient age and a weak dependence on various sports equipment. Therefore, it is recommended that KOA patients and healthy individuals engage in moderate aerobic exercise in their daily lives, which is beneficial for improving and preventing KOA.

3.3. *Water sports*

Water sports refers to the use of buoyancy, thermal conductivity, and fluid dynamics in water at a certain temperature to increase joint mobility and function, enhance muscle strength, improve systemic blood circulation, and thus have a therapeutic effect on KOA. According to literature, water exercise can enhance the strength of the quadriceps femoris muscle, alleviate pain and joint stiffness symptoms, thereby improving the joint function of patients and reducing the impact of KOA on their daily lives [18]. Further research has shown that water sports training has a significant effect on improving the muscle strength of knee joint extension and hip joint abduction, thereby having a good effect on improving the level of knee joint function. Foreign scholars Taglietti M used a randomized controlled trial to divide 60 KOA patients into two groups, the observation group received water exercise therapy, while the control group received health education, after 8 weeks, the results showed that the observation group was superior to the control group in reducing joint pain and improving joint function, furthermore, in the follow-up results after 3 months, it was further shown that persisting in water exercise can improve joint function [19]. However, after reading a large amount of literature, the author found that water sports as a treatment for knee osteoarthritis generally have mixed reviews. Some literature suggests that water sports have little therapeutic effect on knee osteoarthritis, so further research is needed to determine the effectiveness of water sports therapy and collect a large amount of clinical data for analysis.

3.4. *Traditional health movement*

Traditional Chinese medicine believes that with age, "kidney qi and spleen qi failure", coupled with long-term joint activity, leads to the degradation of muscles, tendons, ligaments, etc. Insufficient maintenance and affecting joint activity and function. Over time, Bi disease can lead to blockage of blood vessels throughout the body, leading to blood stasis. The body fluid stops accumulating into phlegm, causing phlegm and blood stasis to collide and block the circulation of qi and blood in the meridians. Failure to do so can cause pain, progression of the disease, and a vicious cycle. This can lead to joint swelling, deformities, joint skin ecchymosis, and even damage to the organs, forming visceral Bi, causing great pain to patients. Traditional health exercise therapy can unblock the blood vessels of the human body and improve the above problems.

3.4.1. *Tai Chi*. Tai Chi is a low-intensity aerobic exercise that not only enhances the body's control over various postures, but also moves the center of gravity through various movements to regulate the body's breathing rate, thereby relaxing muscles, increasing muscle strength and body balance. Tai Chi exercise can reduce nuclear transcription factors- κ B (nuclear factor κ -B, NF- κ B) To inhibit sympathetic nervous activity, thereby reducing the release of pro-inflammatory factors (such as TNF) to alleviate inflammatory reactions, alleviate the pain of KOA patients, and significantly improve knee joint function, pain, and stiffness [20].

3.4.2. *Ba Duan Jin*. As a traditional health and wellness technique in China, Ba Duan Jin has been discussed in both the "Neijing" and "Yijian Zhi" as a way to nourish one's health through fitness qigong. Ba Duan Jin is a rehabilitation exercise therapy with traditional Chinese medicine characteristics, established under the guidance of traditional Chinese medicine theory. It combines the Yin Yang Five Elements and Meridian Studies of traditional Chinese medicine, and is a traditional internal skill and mental method that guides health preservation and health care. It has the effects of exercising balance ability, preventing and treating diseases, correcting body types, and is a fusion of emotions and scenes, and an interactive exchange of mind and body. Related literature shows that the exercise of Ba Duan Jin can change the biomechanical angle of the spine and enhance its stability. At the same time, based on a large amount of literature, frequent practice of Ba Duan Jin can enhance the sensation of proprioception, enhance motor sensation, alleviate pain, adjust the biomechanical structure of the spine, thereby affecting the overall shape of the human body, and ultimately achieve the goal of improving gait. It is very suitable for rehabilitation exercise of KOA patients [21].

4. Combination therapy for knee osteoarthritis

Scholars such as Zhang Lihua have studied the influence of acupuncture and moxibustion (Dongyuan acupuncture) combined with exercise training on the disease development of KOA patients. The clinical efficacy shows that the recovery rate of the combined group is significantly better than that of the exercise group and acupuncture group, indicating that the combination of acupuncture and exercise therapy can achieve a synergistic effect. And the advantages of combining acupuncture and exercise therapy under the guidance of Dongyuan acupuncture method include the following aspects: firstly, the optimization of acupuncture point selection and formula. Inheriting the academic ideas of Dongyuan's acupuncture method, on the basis of traditional acupuncture for local acupoint selection, it has added the connotations of tonifying the spleen and stomach, benefiting the vital energy, and regulating the organs, reflecting the overall idea of combining symptomatic and fundamental treatment. The second is the combination of initiative and passivity. Acupuncture belongs to passive treatment, while exercise therapy involves active participation, with one movement and one stillness, and learning from each other to complement each other's strengths. The third is the combination of different mechanisms of action. The analgesic effect of acupuncture treatment is a key factor reflecting the effectiveness of KOA treatment [22].

At present, many clinical guidelines recommend exercise therapy as the main intervention measure for preventing and treating KOA, so exercise therapy should be the first line treatment method for KOA. Exercise therapy can significantly alleviate joint pain and improve joint function in KOA patients, thereby improving their quality of life. By combining with acupuncture therapy, the effect is significantly better than that of a single exercise therapy. However, in terms of clinical efficacy, the difference between the two has not reached statistical significance, it may be related to the small sample size, so its specific mechanism of action still needs further research.

5. Discussion

The author found through literature review at home and abroad that although significant progress has been made in research on the treatment of osteoarthritis through exercise training, there are still several shortcomings: (1) For KOA patients who have received long-term exercise therapy, there is a lack of long-term observation of their physical indicators, which makes it difficult to evaluate the efficacy of long-term use of exercise therapy. (2) Older KOA patients have poor motor and self-management abilities, and may not be able to complete training goals as required, on time, and in quantity during exercise therapy, thus failing to achieve the goal of treating KOA through exercise therapy, and even causing irreversible damage to the knee joint. (3) Different KOA patients have different conditions and constitutions, and the same exercise training program has different therapeutic effects for different patients. (4) Most of the research on the treatment of KOA through exercise training in China remains at the clinical efficacy level, and there is a lack of in-depth research on its underlying treatment

mechanisms, resulting in a lack of strong evidence-based evidence. Domestic scholars should strengthen their research in this field.

6. Conclusion

Exercise therapy is an important component of non-pharmacological treatment for KOA, as it is widely used in the treatment of KOA due to its safety, effectiveness, affordable price, and relatively convenient treatment methods. It is also recommended as a first-line treatment method for KOA in numerous guidelines. For KOA patients who do not require surgical treatment, exercise therapy can effectively alleviate joint pain and significantly improve their quality of life to a certain extent. Long term adherence to scientific and reasonable exercise can enhance knee joint muscle strength, delay the degradation of articular cartilage tissue, promote the growth of knee joint ligaments and bones, improve joint stress at the knee joint, and thus play a preventive and delayed role in disease progression.

There are still some shortcomings in exercise therapy, and the author believes that the following measures can be taken to improve the current problem: (1) For KOA patients who have received long-term exercise therapy, regular follow-up should be conducted to collect detailed data on their various functional indicators, in order to provide data support for the effectiveness of long-term exercise training treatment for KOA. (2) Relevant medical enterprises are actively developing auxiliary devices for sports rehabilitation training, urging older KOA patients to train on time, and assisting patients in regulating their movements during the training process to avoid unnecessary joint and muscle damage. (3) When doctors recommend KOA patients to receive exercise training for treatment, they should help them specify personalized training content to avoid blind training, which may result in ineffective exercise training. At present, the acceptance of sports training treatment for KOA in China is not high. Therefore, while strengthening the promotion of sports rehabilitation treatment for KOA, we should continue to conduct in-depth research on sports therapy, develop personalized therapies for each KOA patient, and provide professional rehabilitation guidance during the treatment process to improve the treatment effect of sports training treatment for KOA.

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