Current Situation and Prospect of Exercise Therapy in Prevention and Treatment of Knee Osteoarthritis

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Abstract. Knee osteoarthritis (KOA) is a kind of chronic degenerative osteoarthrosis that mainly occurs in middle-aged and elderly people. The common clinical symptoms include knee joint pain, swelling and limited movement, which seriously affects the quality of life of patients, and has a certain degree of disability. As a safe and effective treatment method, aquatic exercise therapy has been accepted by more and more patients, and is gradually supported by international evidence-based medical evidence. In the rehabilitation of musculoskeletal injury, resistance training also plays a vital role. As a new type of treatment, blood flow restriction training can not only design personalized and precise rehabilitation programs, but also achieve the effect of traditional muscle strength training and high-intensity training while reducing the load, but also accelerate the rehabilitation of patients. Whether it is underwater exercise therapy or muscle strength training, there are differences in the efficacy of individuals. How to develop personalized exercise prescriptions to meet the needs of different patients with knee osteoarthritis has become a clinical problem that researchers need to consider in the next step.

Keywords: Sports rehabilitation, Osteoarthritis, Aquatic therapy, Muscle training, Blood flow restriction training.

1. Introduction

Knee osteoarthritis (KOA) is a condition in which the cartilage of the knee is damaged and there is a reactive proliferation of bone at the joint edge and under the joint. Osteoarthritis occurs in middle-aged and elderly people and is mainly characterised by knee pain, restricted movement and cartilage damage and narrowing of the bone gap [1]. Nearly 250 million people around the world are affected by it[2]. It seriously affects the quality of life of patients. The incidence of the disease is as high as 80% in people over 65 years of age in China. With the current ageing population in China, the number of people suffering from this disease is increasing year by year, so people should pay more attention to the prevention and treatment of osteoarthritis of the knee.

According to existing studies, the pathogenesis of knee osteoarthritis is still unclear, but it is mainly believed that its occurrence and severity are related to the increasing age of patients with knee osteoarthritis, the degree of obesity, hormone levels, sex difference and genetic factors [1,3]. There is no specific treatment available for osteoarthritis of the knee. The main existing interventions: such as oral and topical non-steroidal anti-inflammatory drug treatment, arthroscopic surgery, artificial joint replacement, etc., are mostly used to treat osteoarthritis of the knee in order to relieve the patient's pain and improve the function, etc., and cannot have a good therapeutic effect. There are many limitations, such as gastrointestinal irritation caused by prolonged use of NSAIDs, bleeding, perforation, and even cardiovascular disease [4].

Exercise therapy, on the other hand, has received a lot of attention from medical research and the general public as a conservative treatment in recent years. Scientific and regular exercise rehabilitation improves blood circulation in the lower limbs, strengthens lower limb muscles and protects damaged joints. Exercise rehabilitation for osteoarthritis of the knee is therefore "recommended" or "strongly recommended" in national and international treatment guidelines, especially for aquatic exercise therapy, which in the short term offers significant advantages in terms

of pain reduction, reduction in joint loading, improvement in mobility, increase in related abilities and improvement in quality of life [1].While there is still a lack of authoritative guidance and research input in this area. This paper summarises the current research on exercise rehabilitation therapy for osteoarthritis and proposes specific exercise rehabilitation treatment protocols in terms of exercise modalities and intensity, as well as for patients with different conditions, with a view to achieving practical, convenient and personalised results and enhancing the importance of exercise rehabilitation therapy for both doctors and patients.

2. Aquatic Exercise Therapy

Aquatic exercise therapy is a type of rehabilitation therapy that involves guided, planned and purposeful exercise training in water in a specific environment, leading to the prevention or intervention of disease. It mainly uses a series of physical properties of water, such as buoyancy, resistance, water temperature, water pressure and heat transfer, in order to achieve a new rehabilitation tool to help patients with osteoarthritis of the knee to reduce symptoms, relieve pain and improve function [5,6]. In recent years, aquatic exercise therapy has been widely used internationally with unanimous recognition by scholars.

2.1. Aquatic Exercise Therapy

Aquatic exercise training is safer than traditional exercise rehabilitation. During training, the water depth is 1.20-1.50m, the training frequency is 2-3 times/week and the water temperature is 30-33.5°C [7]. Although there is some variability in training methods, they can be grouped into four categories including the adoption of water warm-up adaptations (walking exercises, etc.), joint mobility training (squatting exercises for each joint extension, etc.), plyometric training (hip extensions and heel lifts in all directions, etc.) and aerobic endurance training [7].

2.1.1 Warming up in the water

This phase focuses on gradually acclimatising the patient to water exercise and completing the warm-up. Patients can be trained to stand in the water for the first time, and then walk in the water gradually after they get used to it, and the stride length should not be too large. Each walking training session should last 5-10 min [7].

2.1.2 Joint mobility training

This phase focuses on improving the mobility of the patient's joints and facilitating their functional recovery. Stand on one leg with the contralateral knee flexed and extended and the hip abducted and adducted 10 to 15 times. Pelvic, shoulder, trunk and neck flexibility and stretching exercises 10-15 times [3]. Also lunges and squats can be added as a way to improve knee mobility [7].

2.1.3 Plyometrics

In the water, the patient holds the edge of the pool and lifts the heel for 5-10s at a time, completing three sets of 10 reps. Four directional kicking exercises, 10 reps/set in each direction, performed for two sets [8].

2.1.4 Aerobic endurance training

Improves the patient's cardiorespiratory fitness and muscular endurance. Training methods include 20min dance training and riding a water bike in an upright position [9].

2.2. Principle of the Mechanism

The exact mechanism by which aquatic exercise therapy intervenes in osteoarthritis of the knee is unclear, but it is thought to influence intervention in osteoarthritis of the knee from the following points.

When training in water, the fluid resistance of water and the inertia of the current are used, and the patient needs to overcome the resistance created by the water and the inertia of the current during the

exercises performed in the water [5,7] in order to develop the strength of the lower limb muscle groups, improve the muscular endurance of the lower limb muscle groups and enhance joint stability [10].

Training in water, thanks to the buoyancy of the water, greatly reduces the pressure on the muscles, joints and surrounding connective tissue of the affected limb during exercise, thus relieving symptoms and reducing pain and discomfort [11]. In addition, constant water temperature and pressure relaxes the muscles around the knee, improves joint mobility, accelerates blood flow to the tissues around the joint, enhances the flow of body fluids, enhances metabolism and promotes the absorption of inflammatory factors at the site of injury [12]; Some studies have even pointed out that exercise in water can promote the secretion of relevant hormones, which can have an analgesic effect[11].

Aquatic training can also develop patients' aerobic capacity and reduce their body weight; improve their quality of life, increase their psychological acceptance of rehabilitation training and motivate them to adhere to it [13].

2.3. Therapeutic Effect of Aquatic Exercise Therapy on KOA

The most significant problem faced by people with osteoarthritis of the knee is mostly the limitation of daily activities due to the pain or the inability to carry out daily activities on their own. Rui Dong et al. conducted a meta-analysis of 579 subjects from eight randomised trials on the efficacy of water exercise in osteoarthritis of the knee and found that water exercise reduced patients' pain triggered by their own gravity, increased their walking speed and improved their activities of daily living [14].

After suffering from knee osteoarthritis, patients will not only suffer from physical pain, but also have anxiety. Luciano Acordi da Silva et al. conducted a randomised clinical trial with 92 elderly people to investigate changes in their psychological profile after aquatic exercise therapy, showing that the patients' depression index fell by 53% and their anxiety index dropped from 22.9 before treatment to 11.8, which improve their compliance to some extent [15].

Kim S et al. administered a pre-operative aquatic exercise therapy intervention for 4-8 weeks to 43 subjects with osteoarthritis of the knee who were about to undergo knee replacement within 4-8 weeks. The effectiveness of the subjects after the aquatic exercise therapy intervention was assessed using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC). The results of the study showed that mid-water exercise improved the patients' symptoms of osteoarthritis pain and stiffness in the knee and led to a reduction in each individual WOMAC subcategory. In addition, for a subset of subjects in the pre-hypertension range, the water exercise intervention resulted in a 3.1 decrease in systolic blood pressure after knee arthroplasty, compared to a 2.4 increase in systolic blood pressure in the regular control group. It can therefore be argued that aquatic exercise therapy is an excellent preoperative intervention for hypertensive patients who are about to undergo or are preparing for osteoarthroplasty of the knee [8].

2.4. Shortcomings of Aquatic Exercise Therapy

Aquatic exercise therapy faces a number of practical problems. For example, water sports require standardised venues and facilities, including swimming pools, hydrotherapy tanks, clean water and medical emergency equipment, and there are long lead times and high costs associated with training professional water sports therapists. Lack of awareness and acceptance of aquatic exercise therapy by medical practitioners is also one of the challenges in promoting aquatic exercise therapy.

3. Muscle Training

Muscle training is a common form of exercise training that can be performed in a variety of ways, including self weighted unassisted training, elastic band training, equipment training and blood flow restriction training. The enhancement of lower limb proprioception and improvement of body balance and stability can be achieved through scientific and systematic lower limb muscle training [16].

Strengthening of maximal muscle strength and muscular endurance, enhancing the patient's ability to perform daily activities and movements, and reducing pain and stiffness and discomfort [17]. Improves body coordination and flexibility, improves body posture and reduces the risk of injury from muscle and joint damage [17]. In addition, muscle strength through plyometric training can improve cardiovascular health and immune system function, increase basal metabolic rate and benefit the body's overall health improvement [18].

Osteoarthritis of the knee as a common chronic degenerative joint disease in which muscle weakness and atrophy is a major feature in the progression of the disease. By maintaining scientific and regular lower limb muscle training, it can be used as a non-pharmacological treatment that can have a positive effect on the treatment and impact of patients with knee osteoarthritis and is a safe and effective means of rehabilitation [19].

3.1. Regular Muscle Training

Plyometric training has an important role to play in the treatment of KOA, but its mechanism of action is not yet fully understood. Current clinical studies have found that the mechanisms of action include the following. Joint movement promotes the movement of synovial fluid into and out of articular cartilage, improves cartilage metabolism and prevents or delays further degenerative changes in cartilage. Enhancing local blood circulation and promoting venous and lymphatic return, which facilitates the reduction of joint swelling and inflammation [4]. Exercise prevents synovial adhesions and the formation of vascular opacities, thereby increasing the range of motion of the joint and restoring its function. Pain reduction; stimulation of various receptors in the body's tissues to enhance "proprioception" through training [17].

3.1.1 Squatting against the wall

To perform the exercise, the patient needs to keep their back against the wall, keep their body upright with their feet shoulder-width apart and their hands naturally falling to their sides, with their heels about one foot away from the wall. The amplitude of the squat is determined by the patient's own situation and the angle of the knee should not exceed 60 degrees. After finding the right angle, hold still for a duration of about 30s~1min depending on the individual, to the extent that the muscles of the lower limbs appear sore and swollen, five times per set, two sets per day [20].

3.1.2 Elastic band lateral leg raise

Choose a looped elastic band. When performing the exercise, the patient should remain in a lateral position with the upper body close to the floor, keeping the pelvis perpendicular to the floor at all times during the movement. Place the elastic band over the knee 3cm above the knee and do side kicks with the knee straight, 8-12 reps per set, 3-4 sets each time with 3min rest between sets [21].

3.1.3 Bulgarian squat

To train, stand with your feet at a suitable distance from each other and place your back foot on a flat bench. Keep the upper part of your body straight and your head slightly tilted up. Keep the back straight, trunk perpendicular to the ground and squat at an even speed, the squat amplitude and weight should be determined by the patient's own condition. Each set should be performed 8-12 times, 3-4 sets each, with 3min rest in each set [22].

Regular plyometric training often requires high loads of resistance training in order to achieve muscle hypertrophy and muscle strength gains. However, the high load of resistance training often causes deterioration or pain in the patient's joints, so there is an urgent need for a new training method that does not cause secondary damage to the patient and has a good therapeutic effect. Blood flow restriction training, as a newer training method, can compensate to some extent for the deficiencies that occur with traditional plyometric training.

3.2. Blood Flow Restriction Training

Blood flow restriction training (BFR) for KOA is a relatively new tool that enhances the effect of exercise training by restricting blood flow by wearing a compression cuff approximately 1/3 of the way down the vessel during exercise. Compared to conventional plyometric training programmes, patients are subjected to multiple stimuli of 'pressure' and 'resistance' during BFR training, resulting in a more intense physical stimulus for the same load. As a result, BFR can significantly reduce the rate of sports injuries, increase training compliance and improve knee stability by sharing the joint load [23]. The mechanisms underlying blood flow restriction training are currently unclear. BFR may stimulate muscle hypertrophy through a variety of mechanisms, including increased secretion of metabolic hormones, enhanced muscle protein synthesis signalling pathways, ischaemia and hypoxia in muscle tissue, resulting in increased recruitment of fastidious muscle fibres, and increased cellular swelling in response to cell hydration [24].

Most studies chose a frequency of 2-3 sessions per week, with the most frequent study lasting 12 weeks [23]. The main training modalities for BRF are similar to conventional forms of plyometric training, again including isometric and isotonic plyometric training. The choice can be made according to the patient's condition.

3.2.1 Isotonic muscle strength training

Bilateral leg presses 30 reps for 1 set and 15 reps for 3 sets with 30s rest in between [25]. 3 sets of 10 reps each with hip abduction weight bearing (lateral lying) [26]. Leg extension, calf flexion and leg flexion. Repeat until the muscles are fatigued [27].

3.2.2 Isometric muscle training

Curran et al. use isometric leg presses with concentric or eccentric movements. The intensity of the training was 70% of the patient's 70 times maximum, but the results of the study showed no significant difference in muscle strength between the BFR group and the control group with high intensity exercise [28].

3.3. Applications Therapeutic Effect of BFR on KOA

Segal, N., Davis et al. investigated the use of BFR in men at high risk of knee osteoarthritis by dividing male subjects into blood flow restriction low and high load groups for 8 weeks of training. The results of the study showed that BFR achieved similar results in terms of quadriceps muscle strengthening at low loads compared to traditional high resistance training, while the pain levels in the BFR group were relatively low. BFR may therefore be more suitable for rehabilitation of patients with osteoarthritis of the knee than conventional high resistance training [26].

Pitsillides, A, included a total of 8 randomised controlled trials including a total of 221 patients. The aim is to evaluate the effectiveness of BFR in the treatment of patients with osteoarthritis of the knee. Findings suggest that BRF can produce similar results in terms of improved muscle strength, function and quality of life, and is more effective in reducing pain, as well as showing advantages in reducing muscle atrophy, compared to traditional strength training [25].

3.4. Shortcomings of the BFR

Currently, the main effect of conventional plyometric training for KOA is achieved by improving muscle atrophy, increasing the strength of the muscles around the knee and increasing muscular endurance. Therefore the intensity of the load during training should not be less than 60-80% 1RM, otherwise their training will not achieve muscle hypertrophy [28]. However, the higher loads are very risky for older, less fit patients, and the intensity of the training can even cause secondary damage to the knee joint.

Meanwhile several existing studies have demonstrated the effectiveness of BRF, but the extent to which it is effective is unclear. . Some of the studies showed that the improvement in BRF was not significant. Also, there are no clear standards for cuff pressure, width, etc. Due to the variability of

intervention protocols and the impact of different postures, it was not possible to conduct a MATE analysis [23]. In conclusion, BRF as an emerging training method needs more research and experimentation to be systematically refined.

4. Summary

The pathogenesis of KOA is unclear and may be related to a number of risk factors. The pathology is characterised by damage to the cartilage of the knee joint and reactive hyperplasia of the articular margins and subarticular bone. As an emerging therapy, aquatic exercise therapy has more obvious advantages in the treatment of KOA in sports rehabilitation.Existing studies have shown that aquatic exercise therapy is effective in relieving knee pain, enhancing lower limb muscle strength and maintaining cardiovascular fitness, while reducing knee joint loading during exercise.The training methods are diversified, combining plyometrics, aerobic endurance training and joint mobility training into aquatic exercise therapy, which makes it a multi-faceted way to improve the rehabilitation effect of patients.

As a non-surgical, non-pharmaceutical treatment, conventional muscle training has been an important and fundamental exercise therapy intervention for many years and has an irreplaceable role in the treatment of KOA. By adhering to scientifically correct plyometric training, the strength and muscular endurance of the muscles around the knee joint can be enhanced, improving joint, stability and clinical manifestations such as pain, stiffness and discomfort. It has many advantages such as low financial requirements, high patient acceptance, ease of implementation and adherence, and is recommended in many national and international guidelines.Blood restriction, as a form of plyometric training, has been gaining interest in recent years. By restricting the blood supply to the muscle tissue during training, it achieves the same loading stress as conventional plyometric training, which in turn stimulates the body to produce an adaptive response. It can also significantly reduce the rate of sports injuries, share the load on the joints, and reap better exercise results with lower loads and higher safety.

5. Future Prospects

Due to the specific nature of water sports and the existence of resistance to underwater sports, it is not currently possible to accurately assess and manage the intensity of water sports. Therefore, future research into aquatic exercise therapy for KOA should be conducted with precise intervention protocols that strictly control environmental factors such as water depth and temperature. Also develop a better system for assessing the intensity of exercise. It is also important to focus on the patient's immediate and long-term outcomes and to record any adverse effects that occur to provide a more precise and effective protocol for the book's exercise therapy for KOA.

The higher loads used in the treatment of KOA are very risky for elderly, less fit patients, and the intensity of their training can even cause secondary damage to the knee joint. Therefore, in the future, there is still a need to conduct a lot of clinical research on the optimal frequency, intensity and duration of training, in order to find the best balance between frequency, intensity and duration of training and the rehabilitation effect.

Although an emerging form of training, it is gradually being accepted as an alternative to conventional plyometrics. However, its clinical research is insufficient and its acceptance needs to be widespread. Therefore, numerous clinical trials are needed to prove its efficacy and effectiveness. A professional exercise prescriber is needed to tailor the training programme to each individual and to ensure that the training is carried out under supervision to avoid secondary injuries caused by incorrect training methods.

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