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Impact of Bad Ragaz ring in hot spring water on knee osteoarthritis

A prospective observational study

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Abstract

To evaluate the impact of the Bad Ragaz ring method (BRRM) in hot spring water for knee osteoarthritis (KOA), this prospective study enrolled KOA patients treated at the hospital between March 2020 and December 2020. The primary outcome was the Western Ontario and McMaster Universities (WOMAC) osteoarthritis index score. A total of 60 patients were included, with 30 participants in the BRRM group and 30 patients in the non-BRRM group, respectively. The mean age was 56.4 ± 10.2 years (13 females), and the duration of disease was 5.0 ± 2.2 years in the BRRM group. The mean age was 56.0 ± 11.3 years (14 females), and the disease duration was 4.7 ± 2.1 years in the non-BRRM group. There were no differences between the 2 groups in the pain, stiffness, and function scores of the WOMAC (all $P > .05$) before treatment. The pre post difference in total WOMAC scores (56.57 ± 12.45 vs 36.81 ± 13.51, Cohen d = 1.52, $P < .01$) between the 2 groups was statistically significant. Compared with the non-BRRM group, the BRRM group showed lower scores for pain (6.5 ± 1.5 vs 8.1 ± 2.9, Cohen d = –0.69, $P = .01$), stiffness (2.7 ± 1.0 vs 5.0 ± 1.2, Cohen d = –1.93, $P < .01$), and function (14.8 ± 6.6 vs 26.7 ± 7.5, Cohen d = –1.68, $P < .01$) after treatment. In conclusion, the BRRM might improve the pain and function of patients with KOA.

Abbreviations: BRRM = Bad Ragaz ring method, KOA = knee osteoarthritis, WOMAC = Western Ontario and McMaster Universities.

Keywords: Bad Ragaz ring method, hot springs, knee joint, osteoarthritis, prospective study

1. Introduction

Knee osteoarthritis (KOA) is characterized by articular cartilage loss, bone remodeling, and periarticular muscle weakness resulting in knee joint pain, swelling, deformity, and instability.[1,2] The global prevalence of KOA was estimated at 3.8% in 2010.[3] The causes of KOA can be idiopathic or a consequence of chronic repetitive trauma or joint infection, congenital or developmental disease, crystalline deposition diseases, or autoimmune arthritis.[1,2,4] The risk factors for KOA include age > 50 years, female sex, increasing body mass index, prior knee injury, joint laxity, occupational or recreational overuse, and family history.[5,6] The clinical manifestations are severe and functional impairment, even disability.[1]

Drug therapy, physical therapy, surgical therapy, and alternative therapies can improve the clinical symptoms of patients with KOA.[2,7,8] In the treatment and prevention of KOA, exercise therapy is a cost-effective and well-accepted approach to reduce pain, improve physical function, and make patients effectively participate in social activities.[2,7,9] Previous studies have shown that exercise therapy can improve the pain, motor dysfunction, and quality of life of patients with KOA.[10–12]

The Bad Ragaz ring method (BRRM) is a technique based on the principles of proprioceptive neuromuscular facilitation techniques and is effective in pain control and muscle relaxation.[13,14] BRRM is an aquatic therapy treatment approach that uses a water-based strengthening and mobilizing resistive exercise model. Therapy is performed while floating horizontally in the water, with rings or floats supporting the neck, arms, pelvis, and knees. The extremities are used as levers to activate the trunk muscles.[15,16] However, to date, no studies have reported the effects of BRRM on KOA, though it showed improved pain,[15,16] physical function, strength, and quality of life[17–20] after aquatic exercise treatment.

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

The study was approved by the ethics committee of the Hainan Provincial Cadre Sanatorium. All participants signed the informed consent form.

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Remarkable curative effects were obtained in the treatment of KOA with BRRM in hot spring water in our team. Therefore, the aim of this study was to evaluate the impact of the BRRM on the management of KOA.

2. Methods

2.1. Study design and participants

This prospective study enrolled KOA patients treated at Hainan Provincial Cadre Sanatorium between March 2020 and December 2020. The inclusion criteria were; Age 50 to 70 years; Met the KOA diagnostic criteria according to the 2018 edition of the "Guidelines for the Diagnosis and Treatment of Osteoarthritis" by the Joint Surgery Group of Chinese Orthopaedic Association (meeting i and at least 2 of ii, iii, iv and v of the following criteria; Recurring knee pain within the past 1 month; X-ray results (standing or weight-bearing) showing a narrowing of the joint space, subchondral bone sclerosis and/or cystic degeneration, and osteophyte formation at the joint edge; age ≥ 50; morning stiffness ≤ 30 minutes; bone rubbing or bone rubbing sensation when moving); Without medication or rehabilitation within the past 3 months, and; Normal cognitive function. The exclusion criteria were; Rheumatoid arthritis or other arthritis of the knee; Obvious functional impairment of the knee joint due to knee surgery or major trauma, or; Definite spinal cord injury or motor neuron disease. The study was approved by the ethics committee of the Hainan Provincial Cadre Sanatorium. All participants signed the informed consent form.

2.2. Procedures

This study was an observational study in which the patients voluntarily chose their treatments. Only the patients with contraindications to hydrotherapy did not receive BRRM treatment. The patients in the non-BRRM group received basic treatment and drug treatment according to the therapy plan for KOA in the 2018 edition of "Guidelines for the Diagnosis and Treatment of Osteoarthritis." Basic treatment mainly included health education and physical therapy, not including aquatic exercise. Drug treatment mainly involved nonsteroidal anti-inflammatory drugs. The routine treatment course was basically carried out according to the guidelines and the individual patient's condition.[21,22]

In addition to conventional treatment, the participants in the BRRM group received BRRM treatment. BRRM was performed at the rehabilitation hydrotherapy sports training pool in the water treatment center and adopted a "1-to-1" training mode. The auxiliary tools were swimming rings of different specifications. The specific training method was that the therapist stood in the water, provided a fixed position to the patient, and performed 1-on-1 training with the patient. The main training techniques included rhythmic initiation, antagonistic muscle reversal, repetitive contraction or stretch, isotonic combination, timing adjustment, hold-relaxation, and contraction-relaxation. The BRRM intervention was performed 3 times a week with a 1-day interval between each time, and 8 weeks of continuous training was a treatment course.

2.3. Outcomes

The primary outcome of this study was the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which consists of 3 dimensions with a total of 24 items, namely 5 pain items, 2 stiffness items, and 17 functional items related to the degree of difficulty in completing daily activities.[23,24] According to the 5-point scoring method, the symptoms are divided into none, mild, moderate, severe, and very severe, with 0, 1, 2, 3, and 4 points, respectively, and the total score of the scale is 96 points. The lower the score, the better the functional state of the knee joint of the patient. Before and after treatment, professional rehabilitation therapists used the WOMAC to evaluate patients' knee function and treatment efficacy. Before and after treatment, professional rehabilitation therapists used the WOMAC osteoarthritis index to evaluate the knee joint dysfunction of patients with knee osteoarthritis from pain, stiffness, and function. The minimum clinically important difference/change of the WOMAC score in patients with knee articular bone osteoarthritis was 5.1.[25] The Kellgren-Lawrence grading method was used to grade the patients.[26] Grade 0: normal; grade I: suspected osteophyte hyperplasia and suspected narrowing of the knee joint space; grade II: significant osteophyte hyperplasia and suspected narrowing of the knee joint space; grade III: moderate to moderate osteophytes, with clear narrowing of the knee joint space and sclerotic changes; grade IV: massive osteophyte formation, significant narrowing of the knee joint space, severe sclerotic lesions, and obvious deformities.

2.4. Statistical analysis

The statistical analysis was performed using SPSS 18.0 (SPSS Inc, Chicago, IL). Continuous data that conformed to the normal distribution (according to the Shapiro–Wilk test) were presented as means ± standard deviation and analyzed using Student *t* test (between 2 groups) and the paired *t* test (within a group). Continuous data with a skew distribution were presented as median (range) and analyzed using the Mann-Whitney *U* test. The Wilcoxon signed ranks test was used for the within-group analyses. The categorical data were presented as n (%) and analyzed using the chi-square test. Two-sided *P* values < .05 were considered statistically significant.

3. Results

Sixty participants were enrolled. There were 30 participants (13 females and 17 males) in the BRRM group, with 10 cases of left KOA, 15 cases of right KOA, and 5 cases of bilateral KOA. The mean age was 56.4 ± 10.2 years, and the duration of the disease was 5.0 ± 2.2 years. There were 30 patients (14 females and 16 males) in the non-BRRM group, with 11 cases of left KOA, 13 cases of right KOA, and 6 cases of bilateral KOA. The mean age was 56.0 ± 11.3 years, and the disease duration was 4.7 ± 2.1 years (Table 1).

There were no differences between the 2 groups in the pain, stiffness, and function scores of the WOMAC (all $P > .05$) (Table 2) before treatment. Compared with the non-BRRM group, the BRRM group showed lower scores for pain (6.5 ± 1.5 vs 8.1 ± 2.9, Cohen d = –0.69, $P = .01$), stiffness (2.7 ± 1.0 vs 5.0 ± 1.2, Cohen d = –1.93, $P < .01$), and function (14.8 ± 6.6 vs 26.7 ± 7.5, Cohen d = –1.68, $P < .01$) (Table 2) after treatment. The pre post difference in total WOMAC scores (56.6 ± 12.4 vs 36.8 ± 13.5, Cohen d = 1.52, $P < .01$) between the 2 groups was statistically significant. As shown in Table 2, improvements in the total WOMAC scores and pain, stiffness, and function scores of the WOMAC were also observed in both groups (all $P < .01$). Eighty-seven points fifty-four percentage of patients exceeding the minimum clinically important difference/change.

4. Discussion

The present study showed that it resulted in lower scores in pain, stiffness, and function following BRRM in hot spring water compared with non-BRRM treatment. Therefore, the results suggested that the BRRM might improve the pain and function of patients with KOA.

KOA is a chronic degenerative disease involving the knee joint and surrounding soft tissues. KOA displays a growing impact

Table 1

Comparison of baseline characteristics between two groups (n = 60).

Characteristic	BRRM (n = 30)	Non-BRRM (n = 30)	*P* value
Age (yr), mean ± SD	56.4 ± 10.2	56.0 ± 11.3	.88
Sex, n (%)			
Male	17 (56.7)	16 (53.3)	.80
Female	13 (43.3)	14 (46.7)	
Affected side, n (%)			
Left	10 (33.3)	11 (36.7)	.89
Right	15 (50.0)	13 (43.3)	
Bilateral	5 (16.7)	6 (20.0)	
Course of disease (yr), mean ± SD	5.0 ± 2.2	4.7 ± 2.1	.55
Outpatient, n (%)	12 (40.0)	14 (46.7)	.60
Inpatient, n (%)	18 (60.0)	16 (53.3)	
Kellgren-Lawrence			.72
0	2 (6.7)	1 (3.3)	
I	5 (16.7)	8 (26.7)	
II	10 (33.3)	9 (30.0)	
III	13 (43.3)	12 (40.0)	

BRRM = Bad Ragaz ring method, SD = standard deviation.

Table 2

Comparison of WOMAC scores between two groups (n = 60).

Characteristic	BRRM (n = 30)	Non-BRRM (n = 30)	Cohen d	*P* value
Total WOMAC scores				
Before treatment	84.2 ± 12.8	85.3 ± 11.1	−0.09	.72
After treatment	23.5 ± 5.5	42.2 ± 8.9	−1.29	<.01
Pre post mean difference	56.6 ± 12.4	36.8 ± 13.5	1.52	<.01
P value	<.01	<.01		
Pain				
Before treatment	14.8 ± 2.2	14.7 ± 2.7	0.04	.83
After treatment	6.5 ± 1.5	8.1 ± 2.9	−0.69	.01
P value	<.01	<.01		
Stiffness				
Before treatment	9.8 ± 1.3	9.7 ± 1.2	0.07	.61
After treatment	2.7 ± 1.0	5.0 ± 1.2	−1.93	<.01
P value	<.01	<.01		
Function				
Before treatment	58.9 ± 11.3	57.7 ± 10.8	0.11	.67
After treatment	14.8 ± 6.6	26.7 ± 7.5	−1.68	<.01
P value	<.01	<.01		

BRRM = Bad Ragaz ring method, WOMAC = Western Ontario and McMaster Universities.

on individual and public health.[27] The early manifestations of KOA are during weight-bearing activities, such as pain when climbing steps and squatting. The later manifestations are pain and stiffness after prolonged sitting. Interlocking flexion of the joint also occurs when the stabilizing meniscus and ligaments are damaged, increasing the risk of falls.[28] The knee is susceptible to OA due to its central role in weight-bearing. Medial joint space narrowing often leads to pseudo-laxity of the medial collateral ligament and hyperextension of the lateral collateral ligament, resulting in genu varus deformity. Knee pain can rapidly cause severe flexion deformity, resulting in functional lower extremity uneven length, shortened stride length, and quadriceps fatigue or tightness.[29]

At present, the rehabilitation treatment of KOA mainly includes drug treatment and non-drug treatment.[2,7,8] Non-pharmacological treatments include patient education and self-management, weight loss, joint protection, and rehabilitation training.[2,7,8] When necessary, the main purpose of medication is to relieve pain and control inflammation. Oral analgesics, non-steroidal anti-inflammatory drugs, and corticosteroid injections are the mainstays of treatment for KOA.[2,7–9,30,31] Drug therapy has obvious advantages in relieving pain, but its long-term use has side effects on the liver and kidney function and the gastrointestinal tract.

Clinical guidelines recommend physical therapy as an effective method for the treatment of KOA. Physical therapy has advantages such as being noninvasive, not involving drugs, and adaptable to each patient's capacity and willingness. Aquatic physical therapy also has additional advantages. Indeed, water immersion decreases joint overload, relieves pain, and improves exercise capacity, and the water offers a natural resistance for exercising, and the resistance stops when a movement stops.[18–20] The physical effect produced by hydrostatic pressure enables the amplification of external sensory stimuli, the increase of tactile and proprioceptive system stimulation[32–35] and can effectively increase local blood flow.[32–35] Warm water has an analgesic effect on patients with myeloid arthritis, stimulates spindle cells and skin thermoreceptors, indirectly reduces muscle tension and contracture, promotes swelling elimination, reduces joint and soft tissue stiffness, and enables patients to move their joints in a wider range. Because the water environment provides an effective protective environment for the patients, the psychological factors of the patient's fear of falling are reduced, and the patients' mentality of avoiding physical activities decreases. On the other hand, aquatic physical therapy requires assistance and a specific facility, preventing practicing alone at home. Nevertheless, only a small weekly time investment can improve a patient's condition.[18–20]

The BRRM is based on the principle of proprioceptive neuromuscular facilitation and was designed to treat various movement disorders of the musculoskeletal system. It has outstanding effects on pain control and muscle relaxation.[14,36] The main principle of BRRM is the characteristics of water buoyancy, resistance, hydrostatic pressure, and heat conduction to provide a suitable exercise environment for patients with osteoarthritis and can make patients perform some sports that they could not be able to perform on land. Knowing how to swim is not even a prerequisite for BRRM because of the floatation devices and the shallow waters.

In the present study, even though the 2 groups showed decreased WOMAC scores after 8 weeks of treatment, the decrease was larger in the BRRM group. There are numerous studies on the effectiveness of aquatic physical therapy and balneotherapy in patients with KOA in the literature,[17,37–46] but it has to be noted that these previous studies did not necessarily use BRRM and were not performed in hot spring water or heated pools, and some studies included patients with KOA and hip osteoarthritis. Nevertheless, these previous studies support the present 1. Our hospital has a natural sodium bicarbonate spring due to its unique geographical environment. In 1 liter of spring water, the total solid composition is more than 1 g, of which the anion is mainly heavy carbonate ion (HCO^{3-}), and the cation is mainly calcium ion (Ca^{2+}). When combined, it mainly forms calcium bicarbonate. It has a unique relieving effect on arthritis, dermatosis, neurasthenia, colds, beauty, and skin whitening and cleaning.[47–49]

4.1. Limitations

Few studies in China analyzed the changes in pain and motor function of patients with KOA after BRRM. This study expands on previous studies that suggest that aquatic physical therapy has positive effects in improving pain and function in patients with KOA. Nevertheless, there are limitations to this study. The sample size was small, and no sample size calculation was performed. All participants were from a single center. No randomization was performed. The treatment period was short, and no follow-up was performed. The range of motion, muscle strength, and other data were not evaluated. Finally, the mechanisms were not explored.

The effect of cessation of BRRM on symptoms and exercise capacity in patients with KOA and the possible differences in efficacy caused by sex and body mass index need to be further explored.

5. Conclusion

In conclusion, aquatic physical therapy using BRRM in hot spring water for 8 weeks might improve the pain and function of patients with KOA. BRRM might be an available treatment for the management of KOA.

Author contributions

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