—Review—

Evaluation of the Role of Balneotherapy in Rehabilitation Medicine

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Balneotherapy is a treatment with healing waters, which includes bathing and physiotherapy in thermal water, therapeutic drinks, medical massage, and water jet massage. It is based on the buoyancy, physical properties, temperature, and chemical effects of mineral water. Throughout European and Japanese medical institutions, balneology and hot spring therapy is very much a part of routine medical treatment. The mechanism of balneotherapy is not yet completely understood. Balneotherapeutic procedures are mainly performed for the prevention, treatment, and rehabilitation of musculoskeletal diseases, but they have also proven useful for various other indications such as for the treatment or rehabilitation of dermatological diseases, immuno-inflammatory diseases, chronic pain syndromes, chronic cardiac diseases, and metabolic syndromes or neurological diseases as well as in the rehabilitation of patients with psychiatric conditions. Balneotherapy works well in the case of muscle tension, as it is relieving and relaxing, and it may be associated with improvement of various diseases. However, further investigations are necessary to determine the effectiveness, safety, standard procedures, and potential side effects of balneotherapy. (J Nippon Med Sch 2018; 85: 196–203)

Key words: balneotherapy, rehabilitation, chronic pain, cardiac diseases, metabolic syndrome

Introduction

Balneotherapy is defined as the therapeutic use of bathing agents such as mineral and thermal waters, muds, and gases[1,2]. For thousands of years, humans have been seeking solace in the waters of a hot bath. The new developments and events in balneotherapy may be summarized as follows.

1. Balneotherapy has gone global from Japan to Asia and to all over the world. In recent years, interest in medical balneology and hydro-climatology has increased worldwide. There is now a growing number of published articles on balneotherapy, originating from various countries and centers in different locations[3,4]. Japan is the country of the "onsen" (hot spring) and "ryokan" (Japanese-style hotel), i.e., the kingdom of balneotherapy. North American, Russian, Indian, and Chinese balneotherapy organizations are up and coming.

2. Balneotherapy protocols have become complex, as certain conditions require the most effective combinations of therapy[4,5]. In many countries, complex balneotherapeutic interventions are being used. Depending on local natural remedies, the experience of balneotherapy (thermal mineral water baths) is combined mostly with mud thermal therapy. Furthermore, drinking cures, inhalations, and other balneotherapeutic interventions are being combined for treating diverse conditions in different countries[1]. However, the most effective complex balneotherapeutic treatments for certain diseases remain to be tested.

3. Beyond the treatment of rheumatic diseases, the use of balneotherapy for dermatologic and other indications is being investigated[6]. Balneotherapy and spa therapy are being increasingly considered in evidence-based treatment guidelines for rheumatic diseases, including osteoarthritis, fibromyalgia, ankylosing spondylitis, early arthritis, rheumatoid arthritis, and lower back pain[7]. Among other indications for balneotherapy, dermatological diseases are first. The studies aiming to investigate the therapeutic effects of balneotherapeutic treatments on cardiovascular, metabolic, neurological, psychiatric, and respiratory conditions have been published recently.

4. The preventive effects of balneotherapeutic treatments are being studied, as this therapy is an old remedy for contemporary health risks[8]. Research interest in the

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beneficial and health effects of balneotherapeutic applications is growing as a need for measures to modify the major health risks of our time. Recently published scientific balneotherapeutic trials reported scientific evidence on the preventive effects of balneotherapy and spa therapy on metabolic syndrome and obesity as well as cognitive function and physiological status[9].

5. More insights into the effects of local natural spa waters and the specific chemical components of balneotherapeutic waters have been provided. Authors from various disciplines have published studies evaluating the specific effects of local natural spa water and mud used in balneological treatments and the effects of the specific chemical components of balneotherapeutic waters[10]. Besides the clinical trials with measurements of biological markers, some other publications have reported results obtained from cell cultures and experimental animal model studies, and they shed more light on the specific biological effects of a given balneotherapeutic remedy and specific elements of the mineral water, particularly sulfur and carbon dioxide[11].

Evidence-Based Medicine on Balneotherapy

Japan has many thermal and mineral springs and a history of the tradition of spa therapy and balneotherapy, which was used for the treatment of various diseases. The main aims of balneotherapy in the medical context are to relieve pain and increase muscular power and range of joint movement. Balneotherapy has been a mainstay of treatment for many years in the management of numerous medical conditions including arthritic and neurological conditions, and in rehabilitation following sporting injuries.

Bender et al.[3] reported a systematic review and meta-analysis of clinical trials conducted with thermal mineral waters, and the findings of which have been published in English by authors worldwide. The 122 studies identified from different databases include 18 clinical trials. Five of these trials evaluated the effect of hydrotherapy and balneotherapy on chronic lower back pain[7], four on osteoarthritis of the knee, two on osteoarthritis of the hand, and one on osteoarthritis of the shoulder. All reviewed trials reported that balneotherapy was superior in the long-term to tap water therapy in relieving pain and improving function, and spa therapy combining balneotherapy with mud pack therapy and/or exercise therapy, physiotherapy, and/or education was effective in the management of lower back pain and superior or equally effective to the control treatments in the short- and long-term. Bender et al.[3] concluded that the studied thermal mineral waters significantly reduced pain in degenerative joint and spinal disease, and osteoarthritis of the hand and knee, and they alleviated chronic lower back pain. However, better quality randomized controlled trials (well designed, conducted, and reported) are needed to evaluate the short-term and long-term effects of balneotherapy for relieving chronic back pain and providing broader beneficial effects[1].

Subsequently, Kamioka et al. proposed the spa therapy checklist (SPAC) that could assess the quality of studies reported on spa therapy, based on randomized controlled trials[12,13]. Assessing the quality of studies is particularly important for researchers' and clinicians' critical appraisal of health care literature and for systematic reviews[14]. Recently, a checklist to assess the quality of reports on SPAC was developed using the Delphi consensus method[13]. This checklist is simple and quick to complete, and it should help clinicians and researchers critically appraise medical and health care literature, reviewers assess the quality of reports included in systematic reviews, and researchers plan interventional trials of spa therapy. To assess the quality of studies on spa therapy based on randomized controlled trials by SPAC and to determine the relationship between the SPAC score and characteristics of publications, Kamioka et al.[12,13] searched the following databases: MEDLINE via PubMed, CINAHL, Web of Science, Ichushi Web, Global Health Library, the Western Pacific Region Index Medicus, Psyc INFO, and the Cochrane Database of Systematic Reviews for articles from 1990 to September 30, 2013. They concluded that to prevent a flawed description SPAC could provide indispensable information for researchers who are going to design a research protocol according to each disease[15].

Immuno-Inflammatory Regulation Effects of Hot Spring Water

Balneotherapy and spa therapy have long been used as safe, effective, and long-term alternative therapies for various dermatologic diseases in Japan. Among them are pruritic, xerotic, immuno-inflammatory, infectious, and ulcerative skin diseases. There are about 3,450 spas in Japan, and many of them are recognized as having specific therapeutic effects. However, the beneficial clinical effects of spa therapy and their underlying mechanisms are still poorly defined and understood. In Japan, the areas of distribution of hot springs coincide with the areas of granite distribution, and they are far from the geothermal

heat energy related to volcanoes. Natural hot spring water in Japan can be classified into four main hydrochemical groups, i.e., Ca(Na)-HCO_3, Na(Ca)-HCO_3, Na(Ca)-Cl, and acidic Ca-HCO_3 types. They are mostly alkaline in nature and have low levels of chemical constituents. Some authors have performed series of clinical and laboratory studies on several hot springs in different locations and mineral concentrations to better understand their clinical effects and possible mechanisms of their beneficial effects[1,4,16]. These include the Haeundae (Na-Cl type), Seokmo-do (Na-Cl, Ca-Cl type), Suanbo (Na-HCO_3 type), Baekam (Na-HCO_3 type), and Dukku (Na-Cl type) areas. Utilizing humans, mice models[17], and keratinocyte cell lines, we evaluated the effects of each type of hot spring water on the changes of clinical symptoms of induced dermatitis, skin barrier functions, skin-infiltrating cells and related histologic findings, pro-inflammatory cytokine production, and helper T cell subset differentiation and proliferation. Generally, Lee et al.[17] found that the studied hot spring waters had the capacity to improve skin inflammation associated with atopic dermatitis and a tendency to downregulate the production of skin inflammatory cytokines and increase the $Foxp3^+$ T_{reg} cell population while decreasing the Th1, Th2, and Th17 populations[18]. They concluded that spa spring water treatment suppressed inflammatory cytokine production and modulated the differentiation of $CD4^+$ T cells into Th1, Th2, and Th17 cells, but not Regulatory T cells[19]. With these experimental protocols, researchers can compare the efficacy of spa spring waters immunologically.

The effects of balneotherapy on the immune system have been evaluated in some studies. Ernst et al.[20] prescribed a regular hydrotherapy regimen to 25 volunteers over a 6-month period and compared them with another 25 volunteers who received no hydrotherapy; they found a significant reduction in the frequency of head colds in those receiving hydrotherapy. Furthermore, those subjects who contracted a cold were less severely affected, and the duration of the infection was shorter, suggesting that regular hydrotherapy represents an effective prophylaxis against common colds. This finding was not confirmed in a further study of community hydrotherapy in school-aged children[21].

Chronic skin diseases such as psoriasis[17] have been assessed but mainly in the comparison of standard tap water with specific spa waters in Europe. Some of these studies have shown improvement with specific spas, suggesting that the minerals in the water have a direct effect on skin disease[22].

Chronic Pain Syndromes

Balneotherapy has been practiced for centuries in the management of chronic pain syndromes. It is based on the indigenous natural remedies of natural spas, such as thermal and mineral water and gases (carbon dioxide and radon). The beneficial effect of balneotherapy for chronic pain syndromes is probably a result of mechanical, thermal, and chemical effects.

Lower back pain (LBP) is the most common musculoskeletal complaint, and its lifetime incidence is estimated at 80%. It is a main cause of loss of work and has significant effects on the economy. Most patients with acute LBP improve spontaneously within 4 weeks; however, chronic LBP is extremely common and usually mechanical in nature.

Gore et al.[23] demonstrated economic benefits in using hydrotherapy to rehabilitate patients with LBP. Bello et al.[24] randomized 306 adults with chronic LBP to group hydrotherapy or land-based exercises, and they showed statistically significant improvements in those undergoing hydrotherapy and deterioration in those treated with standard physiotherapy, which is in accordance with Jókai's results[25]. Additionally, Balogh et al.[26] compared balneotherapy with mineral water versus tap water in individuals with LBP and showed some minor benefit from spa water therapy in the pain score, spinal movement, and local tenderness. Sjogren et al.[27] also showed improvement with hydrotherapy versus conventional land-based treatment in patients with chronic LBP. Further, Guillemin et al.[28] compared 50 patients with chronic LBP attending a spa resort in France with 52 similar patients receiving no spa treatment. This trial was of particular interest because the long-term effects were assessed after 9 months, and the authors showed continued reduction in pain, drug consumption, and spinal mobility in the spa-treated group.

Two out of three adults will experience chronic neck pain during their lifetime, but balneotherapy could help. The most common causes of neck pain—strains and sprains—heal within a few days or weeks after balneotherapy. A strain is when a muscle or tendon has been irritated by overuse or overextension. Similarly, a sprain is when a ligament has been irritated by overuse or overextension. Neck pain usually resolves within 2–3 months, but in some cases, it can be chronic. Forestier et al.[29] compared 44 patients with chronic neck pain treated with spa therapy to 42 patients treated with pulsed electromagnetic field therapy. Significant improvement was seen in both groups in terms of the pain score and range of

movement, which is in accordance with Koyuncu's results[30].

The beneficial effect of balneotherapy was also observed in patients with fibromyalgia[31]. Fibromyalgia syndrome (FMS) is a chronic disorder characterized by widespread pain with localized tenderness. FMS leads to diffuse musculoskeletal pain with multiple tender points that are distributed widely and symmetrically throughout the body. FMS is extremely prevalent in the general population, affecting between 3% and 5% of women and about 1% of men. It is a condition associated with widespread chronic pain, fatigue, sleep disturbance, changes in personality and mood, and multiple other symptoms than cannot be easily explained. The condition is a significant cause of disability in the community, and unfortunately, no specific treatments have proven efficacy. Numerous studies have been performed in FMS to assess the effects of balneotherapy. Tomas-Carus et al.[32] compared hydrotherapy with land-based exercise in 34 patients with FMS and showed long-term improvements in pain, quality of life (QOL), muscle strength, and power in those receiving hydrotherapy. Several but not all patients with FMS showed prolonged benefit from water-based exercise[33,34].

Cardiac Disease

As a cardiovascular disease syndrome, chronic heart failure (CHF) continues to gain importance and is the common outcome of many cardiovascular diseases such as hypertension and coronary atherosclerosis; thus, it requires additional new strategies. A role for balneotherapy has been found in the treatment of chronic cardiac disease including heart failure. Hydrotherapy was thought to be potentially dangerous for patients with long-term heart disease; however, current studies have suggested that the heart can tolerate emersion in warm water, and heart function and general well-being can improve. Cider et al.[35] assessed the cardio-respiratory effects of warm water emersion in elderly patients with chronic heart failure and showed that hydrotherapy was well-tolerated and posed no danger to patients. Several reports have shown positive benefits in QOL, heart failure-related symptoms, heart rate responses, and stress hormone levels in patients with chronic heart failure treated with regular hydrotherapy regimens[36,37].

In 1989, Tei et al. developed a form of thermal therapy for heart failure, and it has been approved as one of the advanced medical care treatments by the Japanese government insurance system since 2013[38,39]. In 2007, they changed the name to Waon therapy, "Wa" means soothing and "on" means warmth; hence, Waon infers soothing warmth that comfortably refreshes the mind and body. Waon therapy is defined as "therapy in which the entire body is warmed in an evenly maintained far infrared dry sauna at a temperature of 60°C for 15 minutes and then rested supine on a bed outside the sauna where the body is covered with blankets for an additional 30 minutes, with fluids corresponding to perspiration being supplied at the end." Waon therapy has several characteristic features, that is, it is safe, nontoxic, gentle, and cost effective. This holistic medical care is globally available to patients with refractory diseases. There are various clinical applications of Waon therapy, and its effects are often dramatic. Particularly, a drastic recovery is often seen in severe CHF as well as peripheral artery disease (PAD) with intractable ulcers, chronic fatigue syndrome, fibromyalgia syndrome, and salivary secretion failure caused by conditions such as Sjögren's syndrome.

Tei et al. demonstrated that Waon therapy improved hemodynamics, cardiac function, ventricular arrhythmias, vascular endothelial function, neurohumoral factors, and sympathetic and para-sympathetic nervous system function[38,39]. They also found that 2–4 weeks of Waon therapy (once per day, 5 days per week) significantly improved clinical symptoms, and decreased brain natriuretic peptide level and cardiac size in patients with CHF[39,40]. Waon therapy improved the prognosis of patients with CHF as well as CHF in hamster and mouse models. The molecular mechanism by which Waon therapy improves vascular flow and the expression of endothelial nitric oxide synthase and capillary density has been demonstrated. Moreover, repeated Waon therapy is effective for patients with severe PAD, as evidenced by a substantial decrease in pain scores, increases in both the ankle-brachial pressure index and blood flow assessed by laser Doppler perfusion imaging, and formation of new collateral vessels on angiography[41]. Waon therapy often heals ischemic ulcers markedly. Waon therapy upregulates heat shock protein 90 and leads to angiogenesis through the Akt-endothelial nitric oxide synthase pathway in mouse hindlimb ischemia. Further, Tei et al.[39] conducted a multicenter, randomized study to establish the efficacy and safety of Waon therapy. They concluded that Waon therapy may accelerate the favorable actions of the renin-angiotensin-aldosterone (RAA) system modulators in CHF. Therefore, Waon therapy is an innovative and highly promising strategy for cardiovascular diseases, especially for treating refractory CHF and PAD.

Metabolic Syndromes

Water temperature plays an important role in the metabolic effects of balneotherapy. In Japan, the most outstanding feature of balneotherapy is repeated whole-body immersion in warm water at 39–40°C. It has been suggested that balneotherapy is beneficial for patients whose platelet antioxidative defense system is damaged, such as those with diabetes mellitus and coronary heart disease.

The Ibusuki hot spring ("Sunamushi") sand bath (SB) has traditionally been used for the relief of musculoskeletal and neurological pain for 250 years, and 260,000 people visit it annually. The SB involves piling heavy (40–60 kg) and hot (50°C) sand on a person's body in the supine position; the sand is heated by the hot spring water that gushes at the seashore of Ibusuki. Tanaka et al.[42] studied the cardiovascular and metabolic effects of SB from the viewpoint of accelerated circulation. In this study, the general physical parameters (blood pressure, heart rate, and sublingual temperature) and plasma chemistry were examined in 20 healthy men (mean age 36 ± 10 years). The subjects wore a thin bathrobe, and a venous catheter was placed in their forearm for blood sampling. They rested in the supine position for 30 minutes and were subjected to an SB for 10 minutes at the municipal SB institute with hot spring piping under the sand. In another 28 healthy subjects (mean age 44.3 ± 2.4 years), cardiac outputs and plasma catecholamine and RAA activities were measured. An intra-cardiac study using Swan-Ganz catheterization was performed in 6 subjects. After 10 minutes of an SB, the diastolic blood pressure was significantly decreased by 6 mmHg, and the heart rate and sublingual temperature were significantly increased by +20 beats per minute and +1.1°C, respectively. The venous blood partial pressure of oxygen and pH levels were significantly increased by 20 mm Torr and 0.03, respectively, and the partial pressure of carbon dioxide was significantly reduced by 5 mm Torr. The lactate level, pyruvate level, and lactate-to-pyruvate ratio were significantly reduced, suggesting improved oxidative metabolism of the peripheral tissues[43]. Plasma catecholamine and plasma renin activity were elevated after the SB. All these results gradually returned to the resting level 30 minutes later. Cardiac output measured by the dye dilution or thermo-dilution method significantly increased from 5.6 L/min to 10.5 L/min after 10 minutes of the SB, and it decreased to 8.1 L/min after the pile of heavy sand was removed. The calculated total peripheral resistance significantly decreased, suggesting thermal vasodilation. Although the mean right atrial pressure and pulmonary arterial pressure increased during the SB, they immediately decreased after the pile of sand was removed. All these findings indicate that the basic effects of the SB are derived from strong hydrostatic pressure of the pile of heavy sand and thermal vasodilation. Increased cardiac output due to accelerated venous return and reduced afterload (total peripheral resistance) will induce sufficient oxygen supply and increase discharge of waste matter from the peripheral tissues. These data seem to be compatible with the clinical effects of the SB to relieve musculoskeletal pain and fatigue. Tanaka et al.[42] concluded that the significant clinical effects were induced by increased cardiac output due to the increased hydrostatic pressure of the pile of sand and thermal vasodilation.

It has been thought that balneotherapy and hydrotherapy should be avoided in patients with chronic lung disease; however, recent studies have shown considerable benefits in these patients. Beamon et al.[44] reviewed the literature and reported an improvement in lung function in patients with chronic asthma on treatment with hydrotherapy. Moreover, Mitsunobu et al.[45] assessed patients with pulmonary emphysema over a 5-year period and showed long-term benefits from spa therapy in terms of lung function and oxygen capacity. Forgays[46] even suggested that hydrotherapy can be used to assist with smoking cessation. Wadell et al.[47] showed an improvement in lung function in patients with chronic obstructive pulmonary disease who received high-intensity hydrotherapy. In this study, 30 patients with moderate to severe chronic obstructive pulmonary disease were randomized to either the land-based exercise or hydrotherapy group. Those patients receiving hydrotherapy showed improvements in QOL, activity scores, and well-being compared with those performing land-based exercise and control patients who received no specific treatment.

Neurological Disease

Balneotherapy has been used in the rehabilitation of patients with numerous neurological diseases, including brain injury, multiple sclerosis, spasticity, and spinal cord injury with paraplegia or tetraplegia. In all studies, hydrotherapy has a proven role in rehabilitation, particularly when the water temperature is between 37°C and 41°C.

Spasticity or increased muscle tonus is a hallmark of upper motor neuron lesions, which is easy to identify but

difficult to quantify and treat. Increased muscle tonus of the lower limbs is a major obstacle to the rehabilitation of post-stroke patients with hemiplegia, and it can seriously impair gait stability and activities of daily living. Spasticity in affected limbs often inhibits the efficacy of physical therapy for the treatment of stroke or other central nervous disorders. Therefore, it is important to control muscle tonus, especially in physiotherapy, in order to improve voluntary lower limb movements.

Matsumoto et al. evaluated alterations in spasticity using F-wave parameters in post-stroke patients who experienced balneotherapy[48,49]. The anti-spastic effects of balneotherapeutic treatment were indicated by decreased F-wave parameters, in parallel with decreases in the modified Ashworth scale score. Body temperature significantly increased both immediately after and 30 minutes following balneotherapeutic treatment. These findings demonstrate that the use of balneotherapy (whole-body immersion at 41°C for 10 minutes and a footbath at 41°C for 15 minutes) is an effective non-pharmacological anti-spastic treatment that might facilitate stroke rehabilitation[49,50].

Aquatic exercise or underwater exercise has received increased attention as a technique capable of satisfying the social demands for more effective and safer therapeutic interventions in stroke rehabilitation[51]. In particular, it is one of the most effective interventions for improving balance, walking ability[52], range of motion, exercise tolerance, and for reducing fatigue in most post-stroke patients. The addition of repeated underwater exercise to conventional rehabilitation therapy for post-stroke patients could lead to faster and more efficient recovery of lower-extremity function improvement in QOL.

Psychological Disease

A few studies have addressed the psychological effects of balneotherapy. The clinical and psychological effects of hydrotherapy in rheumatic arthritis were investigated by Ahern et al., who demonstrated that hydrotherapy has beneficial effects in patients with rheumatic arthritis, specifically improvements in self-efficacy for function, pain, and stiffness[53]. Additionally, balneotherapy including spa therapy or aquatic exercise relieves mental stress and sleep disorders, improves general health, and reduces women's waist circumferences in sub-healthy people[54]. Especially, aquatic exercise had a small significant effect on pain reduction, improvement of function, QOL, and mental health. Compared to balneotherapy, exercise in water is more effective for treating musculoskeletal diseases than passive immersion. There are no long-term effects, so to maintain disease stability it is necessary to frequently participate in water exercises.

Conclusions

Balneotherapy has a wide role in the management of various medical conditions. Although the data in some research studies are of limited interpretive value, there is a developing body of evidence supporting the use of balneotherapy in wide-ranging conditions as varied as chronic arthritis, chronic pain syndromes, neurological disease, heart failure, and chronic lung conditions. As the understanding of human physiology has improved, it can be seen that balneotherapy has diverse benefits, with particular emphasis on QOL, well-being, and physical conditioning.

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