



# Beneficial effect of balneotherapy on osteoarthritis

## Korzystny wpływ balneoterapii na chorobę zwyrodnieniową stawów

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### Abstract

**Introduction.** Balneotherapy uses natural mineral waters, mud, and gases for health purposes. It is effective in treating various health conditions, including skin issues, and joint and muscle problems. It is gaining recognition as a non-drug treatment for rheumatic diseases and osteoarthritis. Osteoarthritis affects joint tissues. Hip and knee osteoarthritis are among the top causes of global disability. Treatments include medications, physical therapy, spa therapy, and sometimes surgery. The presents the results of a literature search regarding the effects of balneotherapy on osteoarthritis.

**Review Methods.** A comprehensive review was conducted to analyze the existing literature, primarily from the last 7 years. Original and review articles were systematically searched using the key words: 'balneotherapy', 'spa therapy', 'mud-therapy', 'osteoarthritis', 'hydrotherapy' in Google Scholar and PubMed databases.

**Brief description of the state of knowledge.** Hydrotherapy's therapeutic effects come from mechanical, thermal, and chemical factors. Thermal waters can reduce muscle tone and improve tissue flexibility and collagen elasticity. Sulphur compounds in sulphurous waters can reduce sensitivity and widen blood vessels. They promote tissue repair, remove harmful substances, and relieve pain. Mud therapy is a traditional treatment for knee osteoarthritis. This therapy has been found to reduce inflammation and improve immune response.

**Summary.** In recent years, studies have shown that balneotherapy can be an effective and well-tolerated adjunctive therapy for osteoarthritis. It can function as a substitute for patients who exhibit intolerance to conventional medications. Spa therapy has demonstrated efficacy in alleviating pain, reducing stiffness, and improving functional status in individuals with osteoarthritis.

### Key words

spa therapy, hydrotherapy, mud-therapy, balneotherapy (BT), osteoarthritis (OA)

### Streszczenie

**Wprowadzenie i cel pracy.** Balneoterapia wykorzystuje w celach zdrowotnych naturalne wody mineralne, błoto i gazy. Jest skuteczna w leczeniu różnych schorzeń, w tym problemów skórnych, stawowych oraz mięśniowych. Zyskuje uznanie jako niefarmakologiczna metoda leczenia chorób reumatycznych i choroby zwyrodnieniowej stawów (ChZS). Choroba zwyrodnieniowa stawów biodrowych i kolanowych jest jedną z głównych przyczyn niepełnosprawności na świecie. Jej leczenie obejmuje farmakoterapię, fizjoterapię, terapię uzdrowiskową, a czasem operację. Celem pracy jest dokonanie kompleksowego przeglądu literatury dotyczącej wpływu balneoterapii na ChZS.

**Metody przeglądu.** Dokonano kompleksowego przeglądu, analizując istniejącą literaturę naukową pochodzącą głównie z ostatnich 7 lat. Artykuły oryginalne i przeglądowe przeszukiwano za pomocą słów kluczowych: „balneoterapia”, „terapia uzdrowiskowa”, „terapia borowinowa”, „choroba zwyrodnieniowa stawów”, „hydroterapia” w bazach Google Scholar i PubMed.

**Opis stanu wiedzy.** Efekty terapeutyczne hydroterapii wynikają z czynników mechanicznych, termicznych i chemicznych. Wody termalne mogą zmniejszać napięcie mięśniowe i poprawiać elastyczność tkanek i kolagenu. Związki siarki obecne w wodach termalnych mogą zmniejszać wrażliwość i rozszerzać naczynia krwionośne. Wspomagają naprawę tkanek, usuwają szkodliwe substancje i łagodzą ból. Terapia błotna zmniejsza stan zapalny i poprawia odpowiedź immunologiczną.

**Podsumowanie.** Badania z ostatnich lat wykazały, że balneoterapia może być skuteczną i dobrze tolerowaną terapią wspomagającą w leczeniu ChZS. Może stanowić substytut dla pacjentów wykazujących nietolerancję leczenia konwencjonalnego. Balneoterapia wykazała skuteczność w łagodzeniu bólu, zmniejszaniu sztywności stawów i poprawie stanu funkcjonalnego u osób z chorobą zwyrodnieniową stawów.

### Słowa kluczowe

balneoterapia, spa terapia, hydroterapia, terapia borowinowa, choroba zwyrodnieniowa stawów

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## INTRODUCTION

**Osteoarthritis (OA)** is the prevailing chronic joint disease, leading to progressive physical impairment, disability, and diminished quality of life in adults from middle to elderly age. The gradual deterioration of cartilage is linked with bone remodelling and the development of new bone tissue in the form of osteophytes and subchondral sclerosis. These observations may be variably associated with the concurrent presence of synovitis and inflammation of the entire structure of the joint involved in the OA processes. Severe OA can result in substantial functional impairment and the necessity for joint replacement surgery [1, 2]. Knee OA is one of the most common localizations, and diagnosis relies on specific criteria and the Kellgren and Lawrence grading scale, a radiological imaging classification ranging from grade 1 to grade 4, based on the presence and severity of joint space narrowing, osteophytosis, sclerosis of knees, and bone deformity [3] (Tab. 1).

The treatment options for OA include various pharmacologic therapies, such as topical, oral, and intra-articular medications, and non-pharmacologic approaches. Recommended treatments include symptomatic drugs (e.g. paracetamol, COX-2 inhibitors, acetaminophen, oral and topical NSAIDs, tramadol, duloxetine, and topical capsaicin), physical therapy, a range of motion aerobic exercises, balance training, self-efficacy and self-management programmes, cognitive behavioural therapy (CBT), stretching and strengthening exercises, yoga, intra-articular hyaluronic acid, intra-articular steroids, mesenchymal stem/stromal cells (MSCs) transplantation and kinesiotopeing [4–6]. Surgical procedures, such as arthroscopy, osteotomy, cartilage grafting, uni-compartment knee replacement or total knee replacement, should be considered for patients for whom medical therapy and other treatments have failed, and who have more severe disease [7, 8]. The non-pharmaceutical approaches include the use of spa therapy, as well as supervised water exercises in spa resorts [9].

**Balneotherapy (BT).** This is a form of therapy that dates back centuries, involving the use of natural mineral waters, peat, mud, as well as natural sources of carbon dioxide (CO<sub>2</sub>), hydrogen sulphide (H<sub>2</sub>S), and radon (Rn) for functional purposes, such as the prevention, treatment, and rehabilitation of various health conditions [10]. The beneficial effects of mineral waters are a result of their complex physical and chemical properties which include not only temperature, salt composition, and concentrations, but also osmotic pressure and electric conductivity. Each of these factors contributes to the unique therapeutic potential of mineral waters, making them a subject of great interest in various fields, from medicine to geology [11]. In addition, sulphurous mineral water has been scientifically demonstrated to possess bactericidal and antifungal properties [12]. This holistic approach harnesses the healing properties of these natural elements to promote overall well-being and alleviate a range of ailments. This treatment method is renowned for its ability

to address a wide range of health conditions, including skin issues, joint and muscle ailments, digestive disorders, respiratory problems, heart conditions, women's health concerns, metabolic imbalances, nervous system disorders, mental health challenges, and hormonal imbalances [13, 14]. Balneotherapy offers a comprehensive and natural approach to promoting wellness and addressing various health issues. In recent years, balneotherapy has gained widespread acceptance as a non-pharmacological intervention for the treatment of diverse rheumatic diseases. Its efficacy in alleviating pain, improving function, enhancing quality of life, and its favourable economic profile have contributed to its increasing utilization alongside other therapeutic modalities [15]. Furthermore, balneotherapy is cited for its beneficial effects on osteoarthritis (OA) in the EULAR recommendations [16].

## OBJECTIVE

The objective of this review is to comprehensively gather and analyze information pertaining to the beneficial impact of balneotherapy, especially mud-therapy and sulphur compounds therapy on the symptoms and progression of osteoarthritis.

## MATERIALS AND METHOD

A comprehensive review was been conducted to analyze the existing literature primarily from the last 7 years. Review articles and randomized clinical trials on large and small patient cohorts were considered. The search terms used to achieve this goal were: 'balneotherapy', 'spa therapy', 'mud-therapy', 'osteoarthritis', 'hydrotherapy' in Google Scholar and PubMed database.

## STATE OF KNOWLEDGE

**Therapeutic effects of hydrotherapy.** A therapy using a combination of mechanical, thermal, chemical, and microbiological factors, the effects of which can be categorized into non-specific and specific mechanisms. Non-specific, or hydrotherapeutic, mechanisms are associated with the physical properties of water. On the other hand, specific, or hydromineral effects are contingent upon the organic and inorganic compounds, as well as the community of microorganisms present in mineral water, mud, or other peloids with therapeutic properties [17]. The primary mineral phases commonly found in therapeutic peloids include phyllosilicates, which are mineral compounds with a sheet-like structure, quartz, feldspars, calcite, and dolomite. Additionally, peloids from volcanic environments may also contain mineral phases, such as pyrite, a metallic yellow mineral, alunite, sulphur, Fe-oxides, and opal, which is a precious stone exhibiting a spectrum of colours [18].

**Table 1.** Kellgren and Lawrence grading system for evaluating the extent of knee OA.

Grade	0	1	2	3	4
Description	No features of OA	Minute osteophytes	Definite osteophytes	Large osteophytes, moderate joint space reduction	Joint space greatly reduced, subchondral sclerosis

**Thermal waters.** A therapy providing heat and buoyancy, which can help reduce muscle tone, thereby potentially increasing the pain threshold in nerve endings. Thermal waters increase the flexibility of soft tissues, increase collagen elasticity, and improve functional status. Balneotherapy, or the use of baths in mineral-rich thermal waters, is also thought to provide pain relief through the gate control theory of pain, wherein stimulation of the body surface by the heat and pressure of the water contributes to pain relief. Additionally, immersion in thermal or mineral waters can lead to peripheral vasodilation due to the effects of water temperature and chemical components present in these waters [11]. Furthermore, heightened heat stimulation results in hyperaemia of periarticular sites, which assists in the elimination of inflammatory cytokines and chemokines, subsequently mitigating pain. The augmented blood flow to inflamed tissues facilitates the removal of noxious substances, promotes tissue repair through enhanced oxygen supply, eliminates free radicals, and exerts counter-irritant effects that alleviate pain. Furthermore, thermal waters enhance the pliability of soft tissues and potentially reduce pain and spasms, enhance collagen elasticity, and improve functional status [9]. The elevation of beta-endorphin levels, which is increased by stimuli by hot temperature during various forms of spa therapy, has been observed [19].

**Sulphur compounds.** The main active agents in sulphurous waters with desensitizing and vasodilator actions, and are present in the cartilage structure, e.g. chondroitin sulphuric acid. Increased blood flow to inflamed tissues removes noxious substances, promotes tissue repair due to an increased oxygen supply, removes free radicals, and has counter-irritant effects that relieve pain [20]. Some authors have proposed that sulphur, an element found in cartilage tissues, passes through the skin during the thermal bath and, after diffusing through soft tissues and extracellular spaces, is carried by the blood, penetrates the connective tissue, and is incorporated into mucopolysaccharides which have a protective action on the cartilage [21].

Hydrogen sulphide (H<sub>2</sub>S), a compound commonly employed in sulphur baths, manifests antioxidant properties by mitigating the impact of reactive oxygen species (ROS) and reactive nitrogen species (RNS), while concurrently augmenting the expression of antioxidant enzymes through the activation of the transcription factor nuclear factor erythroid-derived 2-like 2 (Nrf-2) [22, 23]. ROS are acknowledged for their role in provoking vascular cell damage, inflammatory cell recruitment, and lipid peroxidation, collectively contributing to vascular remodeling. The antioxidant attributes of sulphur baths may serve to counteract these deleterious effects. Moreover, hydrogen sulphide engenders fat-soluble polysulfides in the skin, facilitating its systemic absorption via capillaries. It is hypothesised that the salubrious effects of sulphur baths on the rheological properties of blood may be intricately linked to endothelial cells, which harbour the capacity to modulate the release of nitric oxide (NO), a potent vasodilatory and anti-inflammatory signaling molecule [24, 25].

**Mud therapy.** A traditional treatment for knee osteoarthritis (KOA) which has its historical roots in Europe. This natural approach involves the application of mud containing a variety of organic and inorganic substances [26]. Mineral water

and peloids are natural resources utilized in therapeutic applications. Healing mud, comprising primarily clay of geologic origin, is combined with natural mineral water and organic compounds to create packs for localized or full-body application, including specific areas such as joints. After an appropriate maturation period of six months, during which organic compounds and chemical elements transfer from the water to the mud, the mixture is directly applied to the skin at a temperature of 45°C – 50°C for 20 – 30 minutes [27, 28]. Full-body baths, involving immersion in hot medical mineral water at a temperature of 36°C – 38°C, sourced from natural springs, are also administered. These baths may include agitated states, such as whirlpool or hydromassage baths. The use of mineral water and healing mud facilitates the transfer of chemical elements to the human body through the skin [29,30,31]. A recent study has demonstrated that mud therapy may alleviate inflammatory responses and exhibit an immune-modulating effect [32]. Following mud therapy, a notable decrease in the levels of proinflammatory cytokines such as IL-1 $\beta$ , TNF- $\alpha$ , IL-8, IL-6, and TGF- $\beta$  has been observed, while the anti-inflammatory cytokine IL-10 exhibited an increase. Furthermore, the combination of mud and mineral baths, known as mud baths, offers the advantage of being cost-effective and convenient [15, 33]. A study conducted on patients with osteoarthritis revealed a notable decrease in the functional capacity of circulating neutrophils, specifically in terms of their ability to engulf and destroy bacteria. Interestingly, this reduced activity showed significant improvement following mud therapy. Furthermore, changes in the percentage of circulating regulatory T cells have been linked to the anti-inflammatory effects of balneotherapy, which are believed to be mediated by cytokines [34,35]. Research studies have documented a reduction in the circulating levels of prostaglandin E2 (PGE2) and leukotriene B4 (LTB4), which are crucial mediators of inflammation and pain in patients with osteoarthritis or fibromyalgia following treatment with mud baths or balneotherapy [36, 37].

**Therapeutic mineral waters enriched with radon.** A therapy utilising low levels of radioactivity, presenting a potential therapeutic hormetic strategy [38]. Although high doses of ionizing radiation have been demonstrated to be carcinogenic, exposure to small doses can induce beneficial biological effects [39]. Mechanisms of radiation-induced damage encompass the activation of DNA repair, scavenging of free radicals, elimination of damaged cells through apoptosis, synthesis of stress proteins such as Hsp, and stimulation of the immune response [40]. Studies have indicated that spa radon treatment influences the fraction and resorption activity of mOCs, the concentration of RANKL in serum, and the subtypes of T lymphocytes prevalent in peripheral blood, specifically the Treg cell population. Treg cells are known to suppress both immune activity and osteoclastogenesis [41]. During radon therapy, a reduction in the quantity of collagen fragments is observed, signifying decreased bone resorption by osteoclasts. Furthermore, diminished visfatin levels and a consistent tendency toward an increase in the count of regulatory T cells in the peripheral blood are noted, indicating a mitigation of inflammation [42].

Teległow et al. conducted a study involving 48 individuals afflicted with degenerative joint disease, among whom 35 subjects received 15 sulphur baths at the Solec Zdrój



Health Resort in south-east Poland. Blood samples were collected from all participants before and after three weeks of treatment. The results revealed a decrease in the levels of WBC, particularly neutrophils, in patients undergoing sulphur baths, potentially influencing the mitigation of chronic inflammatory responses. Moreover, an enhancement in the deformability and aggregation of RBC was observed, contributing to improved oxygen and carbon dioxide transport [43].

Branco et al. conducted a randomized, assessor-blind, controlled trial with 140 participants diagnosed with knee osteoarthritis and chronic knee pain. The participants were stratified into three groups: one group received treatment with sulphur water, another with non-sulphur water, and a control group received no treatment. Each participant underwent a regimen of 30 thermal baths. Prior to and after treatment, assessments were made on pain levels using the VAS scale, physical function, and analgesic drug use. The findings of the trial indicated that both types of thermal baths were efficacious; however, individuals treated with sulphur baths exhibited prolonged benefits in comparison to the non-sulphurous group [44].

Varzaityte et al. conducted a randomized, single-blind, controlled trial of 92 people with knee OA. The participants were divided into three groups, the first of which was subjected to 10 hot mud treatments and physiotherapy, the second group was subjected to 10 mineral baths in sodium chloride and physiotherapy, and the third group participated only in physiotherapy. All patients were assessed for pain intensity on the VAS scale, walking speed, time for five squats, limb circumference, range, and strength of flexion and extension before the examination, after all treatments, and one month after the therapy. The research findings indicate that both intervention groups 1 and 2 demonstrated improved parameters post-treatment and at the one-month follow-up. Specifically, participants reported reduced pain, diminished joint stiffness, increased range of motion, and enhanced walking speed. [45].

In a prospective, controlled study, Gileva et al. investigated the impact of a 10-day balneotherapy regimen on patients suffering from knee osteoarthritis at a spa facility. The therapeutic procedure involved the application of mud to the entire body at a temperature of 40 -42°C, followed by exposure to a solarium. Subsequently, the patients took a mud bath comprising mud and mineral-medical water, which was then removed using thermal water. Prior to and upon completion of the mud therapy cycles, blood samples were taken, and clinical assessments administered. Following the therapy, improvements were noted in knee range of motion, reduced pain sensation, and enhanced physical functions as per the WOMAC questionnaire. Furthermore, a decline in the concentration of IL-8 and TGF- $\beta$  was observed. The percentage of CD4, CD25, and FOXP3 regulatory T cells decreased, while CD8 and CD28 regulatory T cells exhibited an increase. Additionally, the percentage of phagocytic neutrophils and phagocytic activity (MFI) increased. These findings suggest the anti-inflammatory effects of balneotherapy [46].

Angoni et al. conducted a study aimed at evaluating serum changes in a comprehensive panel of proteins in patients with chronic OA-related back pain following spa therapy. The study encompassed 66 patients, with 20 in the control group. Twelve patients underwent daily mud compresses

and baths in mineral water with alkaline bicarbonate, 16 received rehabilitation via thermal hydrotherapy, and 18 underwent a combination of both treatments. Clinical variables were assessed at baseline, two weeks, and 12 weeks after therapy. All groups undergoing spa treatments exhibited clinically significant improvement, as indicated by notable enhancements in Roland Morris Disability Questionnaire (RMDQ) results, VAS pain scores, and Neck Disability Index (NDI) values at both time intervals. Post-spa treatment, significant increases were observed in serum proteins INHBA, ACVR2B, ANGPT1, B2M, GDF10, CXCL5, FGF2, FGF12, OLR1, and MMP13. Three proteins were found to be significantly reduced: Apoc3, IL23A, and SDC1. The study confirmed the efficacy of spa therapy in treating chronic back pain and its influence on proteins involved in gene expression differentiation, modulation, angiogenesis, tissue repair, and chronic and acute inflammatory response [47].

## CONCLUSIONS

In recent decades, there has been a notable increase in preclinical and clinical studies providing compelling data on the potential of balneotherapy in the management of osteoarthritis. Spa therapy has demonstrated efficacy in alleviating pain, reducing stiffness, and enhancing functional status in individuals with knee osteoarthritis and osteoarthritis of the spine. Balneotherapy also has anti-inflammatory and antioxidant properties. Moreover, the use of spa therapy reduces the amount of painkillers consumed.

In summary, substantial clinical evidence suggests that BT represents an effective and well-tolerated adjunctive therapy for OA. Furthermore, it represents a viable alternative for patients who are intolerant to traditional pharmacological treatments, such as acetaminophen or non-steroidal anti-inflammatory drugs.

Further research is imperative to elucidate the potential mechanisms of action and the therapeutic effects associated with the application of mud-therapy, sulphur baths, and other balneological interventions.

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