

The Role of Salus Per Aquam (Spa) Therapy in Specific, Systemic Conditions and Disorders

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Abstract

Salus per Aquam (Spa) therapy (or medicine) uses “healing” waters as part of its treatment regimen—in particular, sulfate mineral water (containing predominantly sulfate anion SO_4^{2-}). The therapy generally incorporates hydrotherapy, therapeutic drinks, medical massage, water jet massage, bathing, and physical therapy in thermal water. Over many centuries, countries have used Spa therapy to treat various diseases and promote overall wellness. The mechanisms by which broad spectrums of diseases respond to Spa therapy incorporate chemical, thermal, and mechanical effects. Spa mineral waters are chemically classified as sulfurous, sulfate, arsenical-ferruginous, and bicarbonate. Clinical treatment typically uses sulfate mineral waters with sulfate anion SO_4^{2-} as the predominant element. Spa therapy techniques primarily prevent, treat, and rehabilitate musculoskeletal conditions. However, they have also shown promise for several other indications, including treating or rehabilitating dermatological, immuno-inflammatory, chronic pain syndrome, cardiac, metabolic, and neurological diseases. Here, we describe the antioxidant and therapeutic role of thermal or Spa mineral water in specific health conditions and disorders and its improvement of quality of life (QoL).

Keywords: Cardiovascular Disorders; Chronic Pain Syndrome; Medical Mineral Water; Natural Remedies for Skin Conditions; Physical Therapy; Sulfate Mineral Water

Abbreviations

AD: Atopic Dermatitis; ADL: Activities of Daily Living; BP: Blood Pressure; GSH: Glutathione; H₂S: Hydrogen Sulfide; MDA: Malondialdehyde; NO: Nitric Oxide; OA: Osteoarthritis; PD: Parkinson's Disease; PSO: Psoriasis; QoL: Quality of Life; RA: Rheumatoid Arthritis; ROS: Reactive Oxygen Species; SBP: Systolic Blood Pressure; SMW: Sulfate Mineral Water; Spa: Salus Per Aquam; TMPRSS2: Serine Two Transmembrane Protease; WHO: World Health Organization

Introduction

A prime and fundamental distinction must be made regarding spa (for bathing or immersing a body part) and Spa therapy (or medicine) that relies on sulfate mineral waters with a predominance of sulfate anion SO₄²⁻ for numerous applications—known as salus per aquam (Spa) therapy or medicine.

Spas have been in existence for a very long time. In reality, this has been thousands of years [1]. The Walloon word for fountain, “*espa*,” is believed to be where the term “spa” originated. This term was derived from the name of the Belgian Town Spa, where “Collin le Loup” discovered a therapeutic thermal spring in the fourteenth century. The spa may also be an abbreviation for the Roman phrase “*Salus per Aquam*” (health through water), or it may come from the Latin word “*spare*” (to scatter, sprinkle, or wet) [2]. Water was addressed scientifically in the fourth century BC in the first recorded medicinal work (Corpus Hippocraticum). Later, humanity learned about the health benefits of water, including its curative and disease-preventive effects [3]. In addition, water has also historically been used in Egypt for hygiene and cosmetic purposes [4].

According to historians, Greeks practiced communal bathing practices in about 500 BC, including hot air baths called “*Laconica*” for therapeutic purposes [5]. Ancient Greeks were well aware of the health benefits of sulfur springs, particularly for curing skin conditions and easing joint and muscle discomfort. *Hesiod* and *Homer's poems may contain many allusions to therapeutic baths*. Moreover, prominent Greek philosophers, including *Hippocrates* and *Plato*, favored hydrotherapy. In his book, “*De is, a Quiz at Loci*,” Hippocrates discussed water's chemical and organoleptic properties and the physiological effects of hot and cold baths. The philosopher proposed the hypothesis that all human diseases began with an imbalance of bodily fluids. Changes in behavior and environment, such as bathing, perspiring, walking, and massages, were prescribed to restore equilibrium [6].

The Romans created hot baths near mineral and thermal springs, inspired by the Greeks. Spas were used as places for healthy soldiers to relax and unwind, in addition to helping injured men recover. The Romans valued baths more than just gymnastics, unlike the Greeks, who bathed after strenuous physical activity. Medical treatment was widely used with purification, exercise, socializing, rest, and prayer. Traditional Spa therapy included drinking much water, applying water to the affected body areas, and submerging the entire body (particularly for rheumatic and urogenital disorders) [2,6].

A Greek physician named Asclepiades (124 BCE), who worked in Rome, developed widespread hydrotherapy and drinking remedies as forms of medicine. He advised taking a bath both for therapeutic and preventive reasons. Several types of water were given varied qualities and suggestions for healing by Pliny the Elder (CE 23–79). Galen (CE 131–201) also promoted using water to cure various diseases. Over the ensuing ages, this preference for cold water was frequently re-examined [7,8].

The popularity of spas diminished with the fall of the Roman Empire and the emergence of Christianity, and therapeutic bathing was finally abandoned in favor of spiritual cleaning. Meanwhile, in the East, Turkish baths and Arabic Hamams developed complex medicinal uses of water transferred to Europe when Arabs conquered Spain in the medieval era [5]. At the same time, clinicians continued to research the many forms of water, focusing on their distinct medicinal purposes (e.g., sulfurous water for skin diseases, while salsobromiodic for female sterility) [6].

Spas and hydrology were given new significance during the Renaissance (sixteenth century). More scientific investigations have been conducted, and Spa treatments for various medical problems have become more specialized and precise [2,6]. *De Balneis Omnia qua extant*, an encyclopedia that included a summary of ancient and contemporary literature on the use of therapeutic water, was published in 1553. Bacci authored *De Thermis* in 1571, where he taught the bathing technique from *Galen* and the *Aristotelians*. Minardo produced a compendium about the two *Caldiero* baths in Verona in 1594. The first bath was used to drink and bathe, while the second was used for washing animals and rinsing off medicinal mud. According to an assessment, these baths could benefit 78 ailments [9].

In France, spas had been rediscovered by the 17th century. There were two different types of spas: hot springs for bathing and drinking and cold springs for drinking exclusively [10]. The laicality of medical thermalism was strengthened during illuminism and solidified in the 18th and 19th centuries. Medical hydrology is now more of an experimental science than an empirical one due to scientific advances. The biochemical investigations of mineral water highlighted its qualities and therapeutic applications. Physicians were convinced that there was an appropriate medicinal source for each disease. According to this theory, Sebastian Kneipp and Vincent Priessnitz are the founding fathers of contemporary balneotherapy and hydrotherapy [2,6,11]. Simultaneously, the French began to utilize the therapeutic effects of the sea, which was rich in trace elements and minerals, in addition to sodium chloride [12].

In several European nations, renowned academies and significant scientific institutes were established during this time to investigate thermalism. As a result, thermalism evolved into a social type of hydrotherapy accessible to a broader audience, and thermal remedies were incorporated into the national health system's therapeutic program [13].

Water regained prominence at the beginning of the twentieth century due to the therapeutic experiences of medical professionals and new research in hydrology, pharmacology, and biochemistry [14,15]. In particular, due to the contributions of Chinese, American, and Spanish research, thermal therapy has gained significant importance as a preventive, therapeutic, and rehabilitation in various disorders (e.g., collagen vascular disease [6]).

Discussion

Spa therapy is a multidimensional and multimodal treatment that employs mineral water quickly supplied at the point of application (through showers, direct jet, pools, dry inhalers or humid fog, and drinks). The water is collected directly from a natural source. The water can be used alone or mixed with different types of clay and then applied to the skin as mud, peloids, or cataplasms. Mineral water, such as massage jets, may also be used as a massage tool [16,17]. Spa medicine has been incorporated into the World Health Organization (WHO) 2014-2023 Traditional Medicine Plans and Objectives [17].

Spa therapy includes a variety of techniques, such as climatotherapy, thalassotherapy, balneotherapy, heliotherapy, ichthyotherapy, hydrotherapy, fangotherapy, and crenotherapy (Figure 1) [17-20]. In addition, they can be categorized into mechanical, thermal, and chemical (Figure 2) [21-24].

The mineral waters of the spas were among the first treatments used by humankind. With the growing scientific understanding, their sound pharmacological effects have been documented, leading to the conclusive clinical approval of using spa mineral waters in medical practice. Spa mineral waters work similarly to common medications by stimulating chemical reactions in living things. However, unlike drugs, which often have a single active chemical fingerprint, spa mineral water is a complex solution of anions, cations, and trace elements that work together to create a unique "pharmacological" composition [17]. Spa mineral waters can be distinguished from other types of water by their physical characteristics, such as source temperature, osmolarity, radioactivity, pH, and chemical characteristics. These physical characteristics may be related to the potential therapeutic effects of the waters (Box 1) [17,25-31].

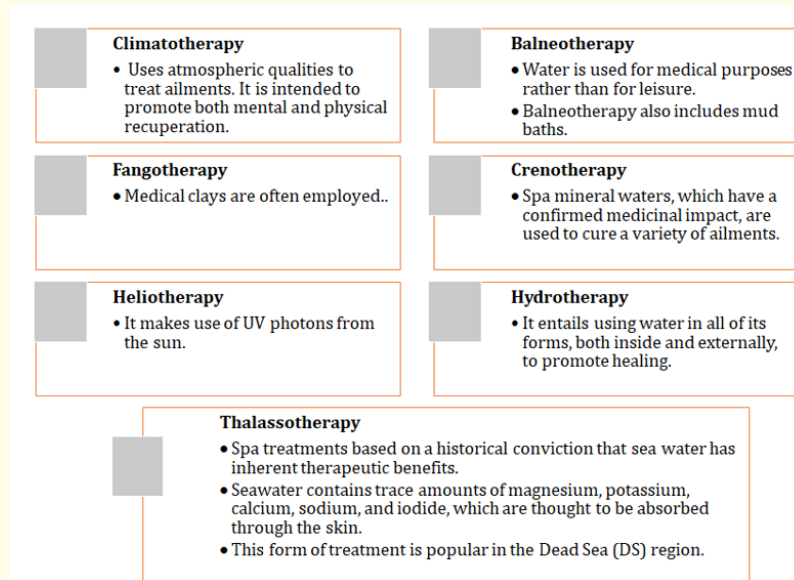


Figure 1: Different forms of Spa therapy [17-20]

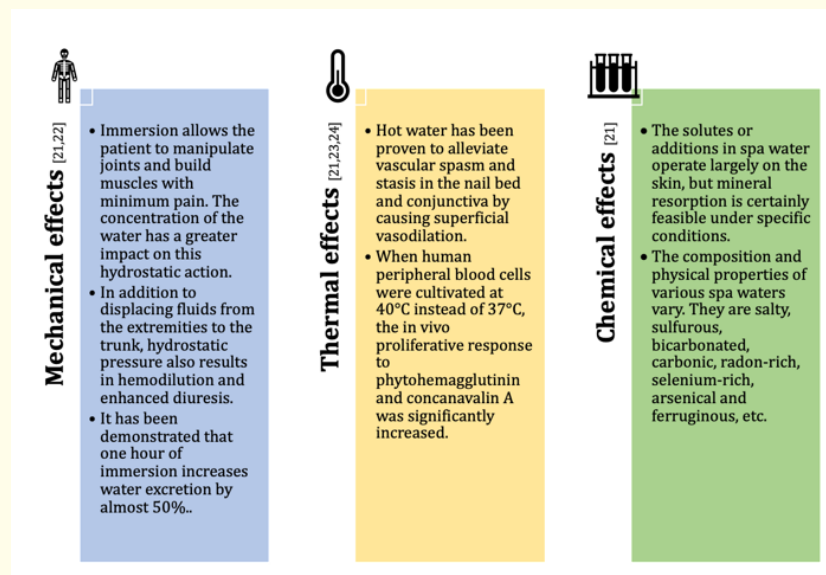


Figure 2: The effects of Spa therapy [21-24]

Box 1: Therapeutic action of the mineral rich water

- Sodium chloride-rich mineral waters: Beneficial for digestive disorders [26].
- Salty and sulfur waters: Beneficial for dermatological applications [27], or sulfate mineral waters appear as a medical resource used for several disorders, such as gastroenteric, musculoskeletal, skin, and respiratory disorders [17,28]—types of symptoms presented by post-COVID-19 patients.
- Carbohydrate metabolism is triggered. It has been shown in animal models that this type of mineral water increases tolerance to stressful conditions and may stimulate the trophic effects of insulin and gastrin, with a considerable reduction in peptic ulcer size [29,30].
- Patients with functional dyspepsia or irritable bowel syndrome benefit from the digestive advantages of mineral water supplementation during thermal treatment, with improvements on the stomach acid output and transit time in particular, as well as a decrease in the many other symptoms [31].

Box 1

Beneficial effects of Spa application

Spa therapy can treat cardiovascular disease, musculoskeletal disorders, neurological disabilities, gastroenteric disorders, skin disorders, and neurological disabilities. Heat induction associated with mineral water ingestion, in particular, is the primary physical stimulus capable of producing analgesia advantages through relaxing and stretching actions, as well as activating the hypothalamic-pituitary-adrenal axis, resulting in an elevation in plasma levels of endorphin and cortisol (Figure 3) [16,17].

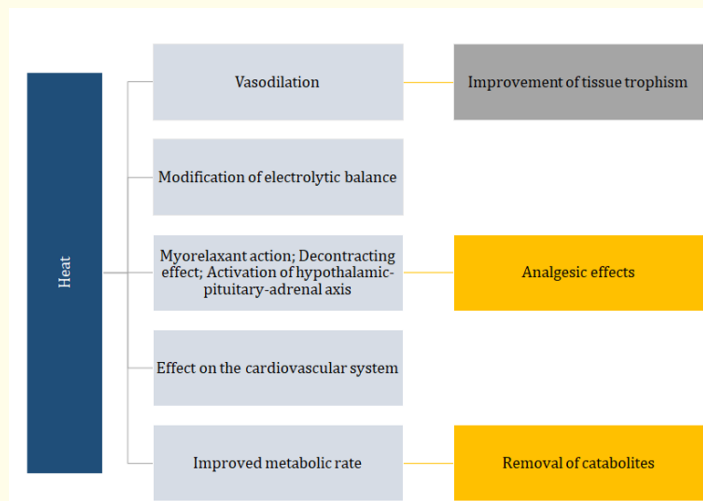


Figure 3: Main therapeutic effects derived from heat during Spa therapy [16,17]

Cardiovascular benefits of Spa therapy

Healthy individuals widely tolerate spa treatments, which are safe for most patients. The positive effects of frequent spa treatment on the heart are well supported by scientific evidence. Thermal treatments administered as a “spa course” severely affect the autonomic control of heart rate,” increasing heart rate variability. This result strengthens the heart and supports cardiovascular health [32].

Spa therapy helps reduce stress and anxiety. Stress can result in elevated blood pressure, contributing to heart disease; reducing stress can help improve heart health [33]. Toda., *et al.* discovered in their study that an hour spent in a spa at 40°C decreases salivary cortisol levels as well as levels of chromogranin A, a physiological stress marker [32].

Some research has revealed that regular Spa therapy can help people with hypertension reduce blood pressure (BP). In particular, three 10-20 minute sauna/hot-water immersion sessions spaced several days apart would lower a person’s resting systolic blood pressure (SBP) by up to ten points. In other trials, regular sauna therapy (such as twice a week) over a few months resulted in a 20-point reduction in SBP [12,34]. In addition, heat-induced dilation of blood vessels in a warm tub or sauna decreases BP and improves blood circulation [33,35].

In people with chronic venous insufficiency, balneohydrotherapy improves QoL [36]. An analysis of a two-week retrospective study that indicates improvements in cardiac function, mainly left ventricular ejection fraction, establishes the effectiveness of balneotherapy in chronic heart failure. Nitric oxide-induced vasodilation, decreased levels of interleukin-6 and heat-sensitive C-reactive protein, and other factors were the main culprits of the benefit [37].

The vascular endothelium is a crucial component in maintaining the integrity of the cardiovascular system. A wide range of cardiovascular conditions, including atherosclerosis, aging, hypertension, obesity, and diabetes, can be exacerbated when the endothelium behaves abnormally [38]. Treatment in a spa could improve endothelial performance. To determine the impact of Spa therapy on endothelium damage indicator ADMA (asymmetric dimethylarginine) and L-arginine levels, L-arginine/ADMA ratio, Karaarslan., *et al.* (2017) conducted pilot research (n = 40 patients). The study found that Spa therapy dramatically increases plasma L-arginine levels and the L-arginine/ADMA ratio while posing no risk to the vascular endothelium through ADMA. Furthermore, a high L-arginine/ADMA ratio has been associated with improved endothelial function and a reduced risk of cardiovascular events [39].

Sulfur baths have been shown by Leibetseder., *et al.* (2004) to have positive effects on plasma homocysteine [40]. Spa In addition, plasma homocysteine is a risk factor for cardiovascular disease [41]. A treatment group of 40 participants received stationary spa therapy and daily sulfur baths, while the control group received only Spa therapy. The groups were randomly assigned to two equal groups. The results showed that plasma homocysteine decreased considerably in the sulfur bath group after a three-week stay in the spa and increased insignificantly in the control group [40].

Chronic stroke patients suffer from difficulties in daily life even after discharge from the hospital. Cardiovascular fitness (VO₂ max), maximum workload, muscular strength, maximum load, and fitness at the peak heart rate of stroke patients and patients with late poliomyelitis have all been shown to be improved by water exercises, according to Lee., *et al.* (2010) [42]. In a Cochrane Review, Mehrholz., *et al.* (2011) thoroughly analyzed and compared the effects of water and land treatments on activities of daily living (ADL), such as walking or exercise after stroke) in patients and discovered that water-based workouts increased strength and ADL [43].

Regular sauna use has also been beneficial for congestive heart failure, a condition linked to the weak pumping ability of the heart. In addition, routine sauna use consistently improves symptoms and heart rhythm problems [12]. Jiang., *et al.* (2015) found in a meta-analysis of ten trials involving 77,821 patients with coronary heart disease that increased magnesium levels in drinking water could reduce the risk of mortality from coronary heart disease [44].

Spa application in metabolic disorders

The effects of Spa treatment on metabolism are significantly influenced by water temperature. According to Ohtsuka, *et al.* (1994), 10 minutes of submersion in water at 42°C caused oxidative stress by raising the levels of lipid peroxides and lowering glutathione peroxidase activity in erythrocytes. Furthermore, it has been noted that taking a 10- to 15-minute bath in water that is at least 42°C would significantly raise blood viscosity and improve the blood coagulation system [45].

The anti-diabetic effects of sulfurous water were evidenced by increased serum concentrations of insulin, C-peptide, and IGF-1 and reduced glucose and glycated hemoglobin levels, indicating a return to normal conditions [46]. Platelet glutathione metabolism is impaired in diabetic individuals with increased platelet aggregability. Ohtsuka, *et al.* (1996) showed that four weeks of twice or three daily balneotherapy in a spa, with water temperature between 39 and 40°C, partially improved platelet glutathione metabolism. This study involved 12 patients with type-2 diabetes. They concluded that people with diabetes mellitus and coronary heart disease, which weaken the platelet antioxidant defense system, benefited from balneotherapy [47].

Spa treatments have also been investigated for their potential to reduce lipid levels. According to Strauss-Blasche, *et al.* (2003), 395 patients with chronic musculoskeletal pain over 2 years experienced a mild reduction in total cholesterol, HDL cholesterol, and LDL cholesterol after undergoing a 3-week Spa therapy regimen consisting of mud packs, CO₂ baths, massage therapy, and exercise therapy [48]. Mineral waters containing magnesium sulfate and sulfur have been shown to have excellent hypocholesterolemic action and a preventive impact against oxidative lipid damage [49,50]. A study examining the effect of Montecatini spa mineral waters on bile acid extraction, lipid, and apolipoprotein blood levels revealed that treatment with salt-rich spring water lowers serum LDL levels in people with moderate hypercholesterolemia through a mechanism of enhanced excretion of fecal bile acid sterols [17,51].

Spa application in gastroenteric disorders

Sulfate mineral waters (SMW), especially those high in sodium and magnesium sulfates, have a purgative-laxative effect due to hypertonia. As a result, they pass quickly through the stomach and into the intestines, where they recall the presence of water. In this way, fecal excretion is facilitated with an increase in volume and a marked decrease in consistency and improved both the number of evacuations and colon motility, as reported by Dupont, *et al.* (2014) in a randomized, double-blind clinical trial involving women with functional constipation [52].

In an *in vitro* investigation, Ikarashi, *et al.* (2011) found that magnesium sulfate might increase aquaporin three expression levels and modify the osmotic pressure in the colon [53]. Recent research by Bothe, *et al.* (2017) has demonstrated the benefits of consuming mineral waters daily to promote good digestion and improve constipation symptoms, regular bowel movements, and stool consistency [54]. Chloride sulfate waters promote intestinal motility and are used to treat chronic constipation, as well as other gastrointestinal and liver biliary problems [55]. Sulfate bicarbonate-calcium-magnesium mineral waters, provided as hydro-pinotherapy, are beneficial for biliary tract problems; These waters are primarily practical due to anions that exert choleric and cholagogue effects, helping to remove hypomotility from the gallbladder and correcting the predisposition to gallstones [56].

Magnesium competes with calcium due to its inhibitory effect on the release of stomach acid. This effect supports the clinical evidence that calcium sulfate waters have a hypersecretive action and are not well tolerated by patients with gastroduodenal ulcers and hypersecretory gastropathy but are recommended for digestive insufficiencies characterized by gastric hyposecretion and hypomotility irrespective of the spastic component [17,28].

Spa application in musculoskeletal disorders

Spa treatment has been used for ages to treat chronic musculoskeletal conditions. SMW delivered by balneotherapy, mud therapy, and mud balneotherapy has effectively treated various chronic locomotor system problems. According to epidemiological data, people with

respiratory illnesses are the subsequent most frequent users of spa services, followed by those with osteoarthritis (OA). In patients with osteoarthritis, Fortunati, *et al.* (2016) have demonstrated that balneotherapy and mud therapy reduce pain, improve muscle function, and improve QoL. Furthermore, clinical benefit has also been shown to last long after treatment [57]. Scalabrino, *et al.* (1994) discovered increased peptides and opioid hormones after a single bath of mud with alkaline-saline-sulfate waters [58]. Forestier, *et al.* (2010), in a large multicenter study of 451 knee osteoarthritis patients, found that bath treatment had favorable benefits for pain, stiffness, and general well-being, especially when combined with physical or pharmaceutical therapy, and these improvements persisted throughout a 6-month follow-up [59].

Similarly, Paoloni, *et al.* (2017) used the Delphi technique to poll respondents to establish the suitability and effectiveness of spa therapy for musculoskeletal problems. Eight experts contributed to this consensus. Specialists concluded that thermal water hydrotherapy could be considered beneficial for the following conditions: OA, articular and extraarticular rheumatologic diseases, degenerative/over-use periarticular pathologies, as well as in recovery from orthopedic surgery, and subacute or chronic post-traumatic rehabilitation [16].

Another non-inflammatory musculoskeletal condition that benefits from Spa therapy's immediate and long-term benefits is low back pain [21,60]. Pittler, *et al.* (2006) conducted a meta-analysis of randomized controlled studies. They reported that spa therapy might help treat people with low back pain with reduced discomfort compared to waiting lists and control groups [61].

Rheumatologic disorders have also been successfully treated with spa treatment. For example, Sukenik, *et al.* found that daily sulfur baths, daily baths in the Dead Sea, or a combination of the two led to improvements in clinical indices such as grip strength, the number of active joints, and the duration of morning stiffness in 36 patients with rheumatoid arthritis (RA) during a 3-month follow-up [62].

Spa therapy has been associated with improved pain, general health, and tender-point count in fibromyalgia patients [63]. According to a systematic review, spa therapy may be a safe and effective adjunct to pharmaceutical therapy in fibromyalgia, with favorable effects on mood and depressed state [64]. Physical modalities mixed with mineral-rich water immersions have been linked to substantial improvements in the dyspnea scale and spirometric measures in patients with fibromyalgia after therapy and 6 months [65]. Similarly, a comprehensive study indicated that spa therapy might be a secure and valuable addition to pharmacological therapy for fibromyalgia, with benefits for mood and depressed state [64].

Spa application in respiratory disorders

Inhalations, aerosols, and nasal showers are just a few examples of Spa therapy mainly directed at the respiratory system and recommended for treating respiratory diseases. They are well known for their therapeutic and preventive effects, promoting immunological responses and respiratory tract resistance to harmful bacteria. Unfortunately, this beneficial effect is often based on the subjective experience of the patient's well-being, while clinical changes are more difficult to document [66,67].

In vivo and *in vitro* research in patients with COPD has shown that inhaling sulfur-rich water increases mucociliary clearance, lowers the production of pro-inflammatory cytokines, lessens inflammation and inflammatory mucosal infiltration, and decreases the amount of elastase that neutrophils generate [67,68]. Additionally, thermal water therapy containing salt, bromide, and iodine has been shown to have a minor anti-inflammatory impact on the airways in patients with COPD. Treatment with Salsojodic mineral water inhalation has vasodilating effects on the bronchial mucosa and increases IgA secretion and mucociliary clearance [68]. One of the current theories explaining how inhalation therapies work is that they can replenish or enhance glutathione (GSH), which reduces the oxidative stress associated with inflammation in lung diseases and the formation of reactive oxygen species (ROS) [67]. Whole-body heat generated during water immersion may benefit the respiratory system by altering innate and acquired immune responses [65,66,69,70].

Keller, *et al.* (2017) discovered in a meta-analysis of 13 prospective clinical trials that nasal application of heated water improves mucociliary clearance time, nasal flow, nasal resistance, and IgE concentration [71]. Similarly, nasal cytological evaluations performed on elderly patients with chronic rhinosinusitis treated with sodium chloride sulfate hyperthermal water showed statistically significant increases in ciliary motility and neutrophil count 1 month after treatment [72].

Passariello, *et al.* (2012) reported that Spa therapy consisting of inhalations of sulfate-sodium chloride mineral water aerosol (15 min/day) elicited a substantial improvement in symptoms such as nasal obstruction, nasal discharge, sense of smell, and a reduction in TNF alpha, calprotectin, and human β -defensin two concentrations in pediatric patients suffering from chronic rhinosinusitis [73]. Thermal pool exercise is more effective for COPD patients than gym exercise and may encourage socialization [68]. Thermal baths have also been demonstrated to enhance biochemical parameters in exhaled breath condensate of heavy smokers. Sulfurous thermal water inhalation affects the catabolic intermediates of arginine in airways cells, moving their metabolic balance toward a decrease in inflammatory activity, potentially providing advantages for smokers, according to the cohort research by Carubbi, *et al.* (2019) on 504 smokers present and past smokers [67].

Regarding the prevention and treatment of SARS-CoV-2, the potential benefits of hydrogen sulfide (H_2S) naturally found in some natural mineral waters have been described. H_2S has been shown to drastically lower the serine two transmembrane protease (TMPRSS2), one of the two essential host proteins implicated in the entry of SARS-CoV-2 cells [74,75]. To verify whether this hypothesis is correct, Pozzi, *et al.* (2021) examined the *in vitro* effects of H_2S donors on the expression of TMPRSS2 and ACE2 in human upper and lower airway epithelial cells. According to the findings, inhaling natural sources of H_2S might inhibit SARS-CoV-2 from entering respiratory epithelial cells and, as a result, could stop the virus from spreading to the lung and lower respiratory tract [76].

Spa application in neurologic disorders

Water therapy is a popular treatment technique for people with neurological problems who want maximum functional independence. The physical aspects of fluid dynamics—such as buoyancy, viscosity, and thermodynamics—support movement in impaired people [77]. A nonrandomized controlled trial and five before-and-after investigations found that water treatment improved Timed Up and Go test scores in people with stroke, multiple sclerosis, Parkinson's disease, and cervical dystonia [78-83].

In a randomized controlled pilot experiment, Noh, *et al.* (2008) found that the aquatic treatment group showed more significant gains in Berg Balance Scale scores and forward and backward weight-bearing skills on the afflicted side than the conventional therapy group. The Berg Balance Scale score improved (17.6%) after aquatic treatment, somewhat more than the range of improvements previously noted in stroke patients after fitness, mobility, stretching, and community group activities [84]. In one RCT, stroke patients who had 24 sessions of water treatment had improved gait speeds than those who underwent 24 upper extremity exercises on land [85].

The thermal aquatic exercise combines the physical benefits of immersion with the chemical effects of minerals. The inherent high temperature of thermal water (32-36°C) helps people with Parkinson's disease (PD) manage their discomfort and stimulates the release of muscular tension, which are common secondary symptoms that influence their psychosocial well-being. No decrease in daily living activities was observed in the study by Di Marco, *et al.* after therapy, raising the idea that spa exercise could prevent the impairments from getting worse [86]. Rodriguez, *et al.* (2013) measured stride length and the proportion of single to double support in individuals with PD and found improvements after 20 aquatic therapy sessions [87].

The Functional Independence Scale was used by Da Silva, *et al.* (2005) to assess functional mobility in people with spinal cord injuries who were receiving water treatment. The results revealed that after 30 sessions of a swimming program, the transfer subscores of functional independence measures improved considerably compared to a control group [88].

Berger, *et al.* (2008) evaluated the short- and long-term effects of mobilization in hot spa water on older adults' static and dynamic balance. Twelve more senior volunteers were assessed for pain (on a visual analog scale, VAS), static balance (as determined by the center of foot pressure, or COP), and dynamic balance. TUG time decreased after the Spa therapy session(s) ($p < 0.01$, Pre-B1 versus Post-B1 and Pre-B4 versus Post-B4), according to the findings. The VAS score decreased after sessions B1 and B4 ($p < 0.05$, PreB1 versus PostB1 and PreB4 versus PostB4). Unfortunately, none of the postural indicators showed a significant difference after Spa therapy. The TUG test showed that Spa therapy sessions improved dynamic balance and reduced pain perception, but postural stability was not altered [89].

Spa application in chronic inflammatory skin diseases

Atopic dermatitis (AD) and psoriasis (PSO) are two dermatological conditions commonly and successfully treated by balneotherapy. Other disorders treated with balneotherapy include pruritus, rosacea, lichen planus, seborrheic dermatitis, and xerosis. The critical characteristic of spa water that benefits skin health is its high mineral content [3]. Figure 4 depicts the elements of the spa waters used in dermatology [17,28].

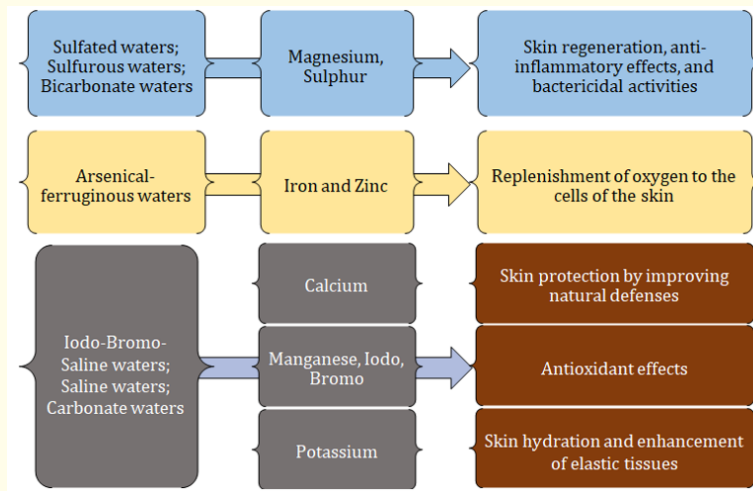


Figure 4: Potential effects on the skin of chemical elements [17,28]

The methods by which thermal water can treat various diseases have yet to be fully understood. The neuroendocrine and immunological reactions induced by balneotherapy are involved in its therapeutic efficacy due to anti-inflammatory, analgesic, antioxidant, chondroprotective, and anabolic effects and neuroendocrine-immune regulation. In addition, depending on the constituents of the thermal waters, they may have a target action against chronic inflammatory skin [90].

Evidence of an oxidant environment in systemic and local psoriasis has been extensively described in the literature. This situation is characterized by a large production of ROS from immune system cells, particularly neutrophils; it is typical of inflammatory processes and is mediated by cytokines (TNF α , in particular) [91]. For example, Joly, *et al.* (2014) showed the advantages of sulfate-carbonate-calcium-magnesium-rich waters in reducing ROS-induced damage [92]. Furthermore, patients with psoriasis have considerably higher plasma levels of nitric oxide (NO) and malondialdehyde (MDA), whose synthesis is directly related to an increase in ROS [93].

These data highlighted the pivotal role that standard redox balance alterations played in psoriasis etiology [94]. As a result, Spa treatments, which have been shown to exhibit antioxidant activities, may be effective Spa in the treatment of plaque psoriasis [28,95].

In patients with plaque psoriasis, Tsourelis-Nikita, *et al.* (2002) have shown a possible anti-inflammatory benefit of balneotherapy using sodium chloride sulfate mineral water, as evidenced by a substantial decrease in the area and severity of psoriasis (PASI index) [96]. Beylot-Barry, *et al.* (2022) found that short-term and long-term Spa therapy improves the QoL and relieves specific symptoms of psoriasis in a multicenter, controlled, open-label, randomized experiment [97]. Similarly, an *in vivo* investigation on a murine model of psoriasis indicated that, compared to distilled water administration, balneotherapy with mineral waters rich in carbonate-thiols sulfates is efficient in creating immunomodulatory effects and results in a significant decrease in cytokines involved in psoriasis and skin erythema pathogenesis, including IL-23, IL-17, IL4, and IL [98].

Mineral waters rich in bicarbonate, calcium, and magnesium improve skin regeneration, according to research by Faga, *et al.* (2012) using an animal model [99]. Furthermore, Casas, *et al.* reported how these spa mineral waters benefit people with chronic dermatosis by reducing inflammation and irritation on their skin. Gleichzeitig, there was a significant reduction in inflammation and colonization by *Staphylococcus aureus*, whose toxins can cause AD and psoriasis [100].

Spa therapy's effect on the reproductive system

Spa therapies can help improve circulation throughout the body. This increased blood flow can support general health and function by nourishing and oxygenating reproductive tissues. For example, Aguwa, *et al.* (2022) found that warm water baths at 30°C and 35°C did not reduce sperm count in an animal investigation using Wistar rats. However, spermatogenesis was negatively affected at 40°C [101].

Radon water baths affect hormonal regulation in both women and men. According to a review by Pawlik-Sobeck, *et al.* (2021), radon-sulfide water increases endocrine gland activity, lasting up to three months. Moreover, it raises the levels of luteinizing and growth hormones in blood serum. It also increases the concentration of testosterone, estradiol, estriol, and cortisol. Menopausal women benefit from higher levels of estradiol and follicular maturation hormone, while men's sperm count and motility improve [102]. Furthermore, sulfate is a crucial vitamin for fetal growth and development, especially in the later stages of pregnancy, when the demand for sulfate is highest. As a result, pregnant women may find sulfate mineral waters a good substitute for other foods in their diet [103,104].

Studies on the potential advantages of Spa treatment on the reproductive system must be completed.

Adverse effects and contraindications to Spa therapy

Despite its tolerance and positive advantages for many people, there are some potential side effects to consider. Figure 5 shows particular adverse effects. In addition, spas can be a significant source of infection and other health risks for people. Several bacteria, including *Legionella*, *Pseudomonas*, and *Mycobacteria*, as well as protozoa, such as amoebas, algae, and other microbes, can naturally multiply under the conditions found in thermal waters and, if properly handled, can pose a risk to users [19,75,105,106].

Several general contraindications to Spa therapy should also be taken into account. These contraindications include severe psychiatric disorders, acute alcoholic states, tumors, unstable or poorly controlled diseases (severe heart failure, advanced kidney insufficiency, cardiac dysrhythmias, uncontrolled hypertension, cirrhosis), inadequate balance, severe varicose veins, open wounds, respiratory insufficiency, uncontrolled liver disorders, unstable metabolic disorders, medically unresponsive epilepsy, urogenital infections, incontinence, infections of the skin, and hypersensitivity to mineral baths [19,21,107]. In addition, the risk of erysipelas is most likely increased by Spa treatments [108]. Extreme caution is also suggested when treating particularly vulnerable people, such as children, pregnant women, and the elderly, whose clinical outcomes from spa-based therapy may be less predictable. Moreover, it may be more prone to more severe side effects [19].

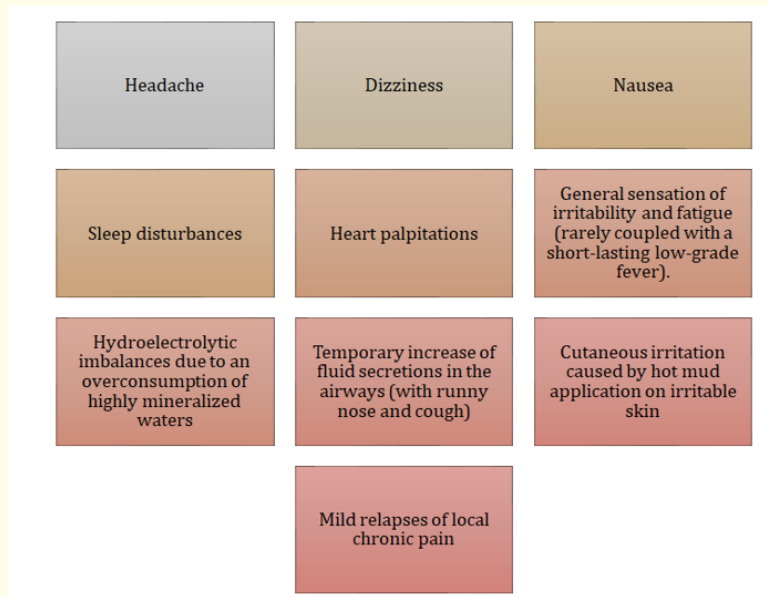


Figure 5: Potential adverse effects of Spa therapy [19,75,105,106]

Due to these factors, medical examination and supervision are highly recommended before prescribing any spa-based therapies. This recommendation will ensure that the treatments are as safe and tolerable as possible and that they are prescribed appropriately based on the characteristics and diseases of the patient [19].

Future perspectives

Spa therapy is a successful adjunct treatment for metabolic and musculoskeletal diseases and various illnesses associated with stress and low-grade inflammation. However, despite the drugs’ proven clinical and symptomatic benefits, their place in contemporary medicine is still debatable, mainly because the biochemical processes behind these advantages have yet to be fully understood. Unquestionably more research is required in the context of these illnesses to understand better the mechanisms of efficacy involving the stress response and, as a result, how it interacts Spa with the inflammatory response [46].

Another noteworthy component is that in addition to its positive benefits, therapy with SMW is well tolerated, with fewer adverse effects compared to medications commonly used in gastroenteric, musculoskeletal, skin, and respiratory disorders. However, there are several circumstances in which spa therapy is not advised, such as during the acute stage of a disease or under challenging patients with malignancies, heart failure, severe respiratory failure, or epilepsy. To firmly establish the therapeutic effects of Spa treatments in the many medical fields, well-documented scientific data, and focused experimental procedures are required. Randomized clinical trials with strong methodological requirements, in particular, should be conducted better to assess the long-term positive effects of Spa mineral waters [17].

Conclusion

The data collected indicates that spas can benefit individual and community well-being. Spa medicine’s advantages are widely acknowledged because of the combination of physical (heat, mechanical action of the water, osmotic phenomena) and chemical (presence

of active ions) qualities, as well as psychological effects (feeling of well-being, hydration, relaxation from everyday stress). Higher-quality investigations support using spa-related therapies for osteoarthritis, RA, psoriasis, fibromyalgia, rhinosinusitis, chronic back pain, and chronic venous insufficiency or Covid-19. In particular, Spa therapy may help to reduce the duration and dose of therapies, especially in elderly patients. Spa treatment, however, has several pertinent limitations described above, particularly about unstable or poorly managed disorders. As a result, more high-quality clinical studies and observational research should be undertaken to validate the therapeutic benefits of Spa treatment and fully quantify its usefulness in real-world clinical practice outside of experimental settings.

Conflict of Interest Statement

The authors declare that this paper was written without any commercial or financial relationship that could be construed as a potential conflict of interest.

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