

EFFICIENCY OF CONTEMPORARY BALNEOLOGICAL INTERVENTIONS IN PATIENTS WITH OSTEOARTHRITIS

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Abstract: Osteoarthritis (OA) can be defined as a chronic joint disease that causes pain, permanent disability and functional limitation. However, with the advances in contemporary medicine, conservative and/or surgical treatment options are increasing, which also raises the cost of treatment, considering that more and more people need therapy. Balneotherapy is commonly used in rehabilitation programs for the prevention and treatment of osteoarthritis of various joint localizations (more commonly knee and hip joints). The aim of this report is to present the possibilities of treatment, prevention and rehabilitation of patients with osteoarthritis by means of Balneology. For this purpose, a comprehensive review of published articles in the available databases (Google Scholar, Pubmed, Science Direct, PEDro), which contain information on balneotherapy, in particular application of mineral waters and healing mud in patients with degenerative joint diseases, was performed. The search was conducted using keywords that are directly related to the topic of this article: mineral water balneotherapy, thermal waters, naturally aerated mineral waters, healing mud, osteoarthritis, knee joint, hip joint, small hand joints, pain, muscle weakness, muscle imbalance, stiffness, daily activity, functional limitation, rehabilitation. The review included articles containing information on randomized and non-randomized clinical trials, meta-analyses and scientific reviews regarding the use of balneotherapy in patients with osteoarthritis. Evidence was found that showed osteoarthritis to be highly disabling in large groups of people. On the other hand, evidence was found for the beneficial effects of mineral waters and healing mud in improving the long-term symptoms of osteoarthritis. Balneotherapy could have a credible effect in reducing pain, stiffness and functional impairment. Some therapies are effective in terms of reducing inflammatory activity and have a stimulating anti-inflammatory effect. Although this type of treatment is centuries old, it nowadays requires a scientifically sound explanation of the mechanisms by which the angiogenesis effect is achieved and this is why research in this field continues. The application of balneotherapy (mineral waters and healing mud) is probably a therapeutic strategy with a very positive effect in patients with osteoarthritis. The negative goods of the complaint may be successfully reduced by balneotherapy and mud therapy. Prophylaxis and treatment with natural mineral waters and healing mud have the ability to reduce symptoms and improve functional activity in patients with osteoarthritis. Principally, these goods are enhanced by the chemical, physical and thermal characteristics of the balneological factors. However, research regarding their mechanisms of action is ongoing, allowing for a more precise definition of the pathways by which balneotherapeutic interventions work in patients with osteoarthritis.

Keywords: balneotherapy, thermal waters, SPA-therapy, peloid-therapy, osteoarthritis, degenerative joint diseases

1. INTRODUCTION

Osteoarthritis (OA) is one of the most widespread diseases of the musculoskeletal system, which is mainly associated with degenerative processes Steinmetz, Jaimie D. et al. (2021). The progression of the disease is mainly dependent on the development of: degeneration in the cartilage and surrounding joint structures; the concomitant processes of inflammation due to the alteration and repair of the affected tissues. It can be defined as a chronic joint disease that causes pain, permanent disability and functional limitation. Long H. et al. (2022); Hunter D.J. &, Bierma-Zeinstra S. (2019); Kolasinski S.L. et al. (2021); Courties, A. et al. (2024)) OA can affect any joint of the body and does so with varying frequency. According to the literature, one of the most commonly affected joints is that of the knee, followed by that of the hands and hip joints. OA can be asymptomatic for a long time and cause advanced changes in articular cartilage, subchondral bone and adjacent tissues. When the clinical symptomatology is exacerbated, symptoms such as pain, stiffness, limited range of motion, crepitations, and muscle weakness become apparent. These symptoms reduce the cases' quality of life. It is accepted that OA is directly related to abnormally high mechanical loads in the joints, overweight and/or excess weight, gender, hormonal disorders, age, traumatic injuries. Chronic pain and reduced functional activity require long-term treatment. In most cases, this treatment (pharmacological or surgical) is accompanied by an increase in the financial cost of its implementation (O'Neill T.W. et al. (2018); (GBD 2019); Steinmetz, J.D. et al. (2023).

Despite the pharmacological therapy advances, the incidence of OA has been increasing in recent years (GBD 2019). Furthermore, dragged input of pharmacological agents increases the threat of adverse responses. Treatment with natural factors, which are part of the Physical Medicine Factors, can provide effective non-pharmacological

interventions that have fewer side effects and are low cost. The application of natural factors in the form of balneotherapy and mud therapy can provide a number of benefits for the prevention and treatment of patients suffering from OA.

Balneotherapy is often used for prevention and treatment of osteoarthritis with different joint localization (prevalently knee and hip joints). In clinical practice, balneotherapy is applied through various balneological procedures with thermal waters and healing mud (Fioravanti A. et al. (2017); Stelmach P. et al. (2025)). Mineral waters (naturally obtained or artificially saturated with healing substances) are applied in two basic ways. First, the waters are applied externally by immersing the body in various baths and/or bathing and gymnastics in pools, etc. And the second method of application is the internal application, whereby the water treatments are conducted through dosed water drinking or aerosol therapy in the form of inhalations. Balneotherapy is usually carried out in spa resorts, which are located in areas with different climatic characteristics. It is most appropriate to combine therapy with mineral waters and/or therapeutic mud with mountain or sea climate therapy. In these resorts, rehabilitation for musculoskeletal and neurological disorders is usually carried out both on its own and in combination with spa procedures (Masiero S. (2008); Masiero S. et al. (2018); Bernetti A. al. (2020); Poplawska N.A. et al. (2024); Onik G. et al. (2025)).

Although the healing mechanisms of balneotherapy are still subject to additional clarification, the specific chemical, thermal and mechanical factors of the balneological resources are most likely of great importance. These factors interact with each other, causing the observed general and specific effects of the application of thermal waters and healing mud. In recent years, a large amount of reliable evidence has been accumulated to confirm the beneficial effects of spa treatment in patients with OA. The results of controlled and randomized clinical trials provide support for this claim. Balneotherapy can positively influence and result in long-term pain reduction, improved functional activity and quality of life (Fioravanti A. et al. (2017)).

The aim of this report is to present the possibilities of treatment, prevention and rehabilitation of patients with osteoarthritis by means of Balneology – mineral waters and healing mud.

2. MATERIALS AND METHODS

For this purpose, a comprehensive review of published articles in the available databases (Google Scholar, Pubmed, Science Direct, PEDro), which contain information on balneotherapy, in particular application of mineral waters and healing mud in patients with degenerative joint diseases, was performed. The search was conducted using keywords that are directly related to the topic of this article: mineral water balneotherapy, thermal waters, naturally aerated mineral waters, healing mud, osteoarthritis, knee joint, hip joint, small hand joints, pain, muscle weakness, muscle imbalance, stiffness, daily activity, functional limitation, rehabilitation.

3. RESULTS

The review included articles containing information on randomized and non-randomized clinical trials, meta-analyses and scientific reviews regarding the use of balneotherapy in patients with osteoarthritis. Evidence was found that showed osteoarthritis to be highly disabling in large groups of people. On the other hand, evidence was found for the beneficial effects of mineral waters and healing mud in improving the long-term symptoms of osteoarthritis. Balneotherapy could have a credible effect in reducing pain, stiffness and functional impairment. Some therapies are effective in terms of reducing inflammatory activity and have a stimulating anti-inflammatory effect. Although this type of treatment is centuries old, it nowadays requires a scientifically sound explanation of the mechanisms by which the sangigenesis effect is achieved and this is why research in this field continues.

4. DISCUSSIONS

Osteoarthritis can be pointed to as one of the significant and primary causes of the increase in the number of years accompanied by disability in patients with musculoskeletal disorders. Often, pain and reduced motor function are chronicized, which leads to a reduction in daily activity, suffering and psycho-emotional distress. Diet, nutrition, physical activity and regular exercise are important to maintain a healthy weight, to maintain and increase muscle mass and strength, and can probably reduce complaints in patients with OA. Drug therapy is an important and integral part of the treatment plan in these patients. However, medications may have undesirable side effects, which may reflect on other comorbidities. In advanced stages of joint damage, joint arthroplasty is recommended in order to reduce pain and restore mobility (GBD (2019); Steinmetz, J.D. et al. (2021)); Courties, A. et al. (2024)).

On the other hand, considering that OA causes chronic suffering and develops slowly, it would be appropriate to add therapeutic interventions involving the application of natural physical factors to the treatment plan for these patients. Balneotherapy can be performed in all phases of the disease, but it is most appropriate for patients with mild to moderate symptoms. Balneotherapy, which is carried out in sanatorium conditions, is often applied by specialists in

physical and rehabilitation medicine to patients in the subacute and chronic phases of the disease. It is most appropriate to start during the recovery phase after suffering from certain infectious and non-infectious diseases. The individual characteristics of each patient must be taken into account. The rehabilitation programs combine natural and preformed physical factors, motor activity, nutrition, and diet (Mratskova G. (2023); Koleva I. Yoshinov B. (2022)).

The main factors involved in mineral water remedy are chemical, thermal, and mechanical. Mineral waters have specific and non-specific effects on the body depending on the method of application. Water procedures involving partial or complete immersion of the body in water (baths, showers, and swimming pools) have a non-specific effect of reducing muscle tone, decreasing pain, and improving tissue elasticity (Popławska N.A. et al. (2024)). These effects are the result of the thermal action of the water, which causes vasodilation and active hyperemia of the peripheral blood vessels. They promote muscle relaxation, accelerated blood flow, and faster removal of inflammatory products from the pathological focal area. On the other hand, thermal mineral waters improve the functional state of patients, which is a consequence of pain reduction, reduced spasticity (rigidity) of muscles, and improved tissue elasticity (Protano C. et al. (2023)).

Another significant effect of the thermal factor is that heat (without changing the circadian rhythm) can increase the secretion of adrenocorticotropin, cortisol, prolactin, including growth hormone, thus contributing to the observed positive effects of balneotherapy. At the same time, heat probably also leads to a change in the secretion and increases the production of β -endorphins. In this way, heat may also have an analgesic and immunosuppressive effect (Fioravanti A. et al. (2017)).

The natural buoyancy of water should not be overlooked. The submerged body part loses some of its weight. This also facilitates movement in an aquatic environment. Hydrostatic pressure, on the other hand, gives stability to the body submerged in water. If we add mechanical movements of the water, such as water jets, this enhances tactile stimulation and increases the effect of the mechanical factor. In some cases, in patients with concomitant diseases, the mechanical action requires increased attention. This action can be controlled by the size of the area of the body that is submerged under water, the procedures type and duration.

The water chemical composition is the reason for the main and specific effect of mineral water in balneotherapy. Depending on their chemical composition, mineral waters are divided into several categories. Gaseous mineral waters (carbonated, containing sulphide and radon) contain carbon dioxide, hydrogen sulphide and radon, respectively. Carbon dioxide (CO_2) is a gas that can be absorbed through the skin from thermal water. Its absorption causes vasodilation and active hyperemia, which improves peripheral blood circulation, promotes better oxygen saturation of tissues, relieves painful muscle spasms, reduces muscle imbalance, and at the same time contributes for lowering arterial blood pressure (Nishimura N. et al. (2002); Dogaru G. & Radulescu A. (2015)). In addition, the temperature of the water has an additional effect and contributes to improving the therapeutic effect of carbonated mineral water.

Waters containing hydrogen sulfide (H_2S) have antioxidant properties. According to some researchers, these waters have the ability to influence oxidative stress by reducing the negative effects of certain reactive oxygen species (ROS) and reactive nitrogen species (RNS). It is likely that this gas can also increase the activity of certain antioxidant enzymes. Corsello T et al. (2018) found in a study that it is possible to activate the nuclear transcription factor (NRF2) and thereby reduce oxidative stress (Corsello T et al. (2018)).

According to some authors, hydrogen sulfide may have effect on normal or damaged chondrocytes. This effect is probably achieved through inhibition of nitric oxide release, reduction of prostaglandin PGE_2 secretion, metalloproteinase enzymes, tumor necrosis factor $\text{TNF-}\alpha$, interleukins (IL-6 and IL-8), and reducing the activation of nuclear factor- κB (Kloesch B. et al. (2012)).

Radon mineral waters are specific thermal waters that are rich in radon (Rn). They are low radioactive, which explains the mechanism of their action. Small doses of radioactivity can cause beneficial biological effects, while high doses of ionizing radiation have a damaging effect on the body (Maier A. et al. 2020). According to some researchers, radon water therapy can lead to biological changes with significant reduction in the receptor activator of $\text{NF-}\kappa\text{B}$ ligand and reduced differentiation of osteoclast cells (OCs) in the serum of patients are observed. On the other hand, however, the authors do not observe changes in some of the markers for bone resorption and bone formation, including some adipokines (visfatin and leptin) that may affect osteoclastogenesis. According to the authors, after treatment with radon mineral waters, quantitative changes in T cells may also be observed, as well as changes in the rate between different types of T cells, without changing the position of Th17 cells. According to these researchers, it is not only radon that affects bone metabolism, although the changes are more pronounced after therapy with radon mineral waters compared to hydrotherapy with plain water (hydro-thermo-therapy) (Eckert D. et al. (2024)).

Although it is difficult to determine the exact effect of balneotherapy procedures, due to the fact that they are often combined with electrotherapeutic modalities and underwater gymnastics, it has been established that immersion procedures lead to significant improvements in patients with osteoarthritis (Passali D. et al. (2017)). In fact, a number of authors report a significant reduction in the intake of symptomatic medications (nonsteroidal anti-inflammatory drugs, acetaminophen) after balneotherapy (Fioravanti A. et al. (2017)).

The application of mineral waters is sometimes combined with mud therapy, while in other cases it can be used as a single therapeutic factor. Peloid remedy is a generally used remedial intervention grounded on treatment with natural factors. She has a stimulating effect on natural processes and has regenerative and trophic parcels. Mud has a stimulating effect on biological processes and has regenerative and trophic properties. Depending on their content, muds can have a predominantly organic (peat, etc.) or inorganic content (liman, mineral spring mud, etc.). The rates of the healing mud (chemical, physical, natural) depend on the characteristics of the water body in which it is formed. Suitable muds are sulphide peloids, which are used in the complex sanatorium treatment of patients (Valiullina & Pogonchenkova (2020)) with particular benefits for musculoskeletal diseases.

In salty coastal lakes (limans), liman mud is formed as a result of the sedimentation process. Its chemical composition is dominated by inorganic substances. Organic substances account for less than 10% and are produced by the decay and destruction of algae and marine animals that are found or accidentally fall into the lake. Sulfate-reducing bacteria (*Vibrio desulfuricans*) play a major role in the formation of mud and the formation of iron hydrosulfide. The peloid is black in color and has specific remedial parcels, which are largely due to the iron hydrosulfide ($\text{Fe}(\text{HS})_2$). In addition to the formation of iron hydrosulfide ($\text{Fe}(\text{HS})_2$) and hydrogen sulfide (H_2S), a number of other microbiological and chemical processes also occur during mud formation. Liman lake substance has a fine structure, an alkaline response, and good malleability. It has a characteristic smell of hydrogen sulfide but is almost free of contaminants. (Grozeva A. (2019); Grozeva A. (2022)).

Peloid therapy is a method that has been used since ancient times and is also successfully applied in modern balneology. However, the mechanisms by which the remedial effect is achieved are not yet completely discovered. It is likely based on the complex action of the chemical, physical, and biological factors of the mud, which have the ability to potentiate each other.

The thermal factor is determined by exogenous heat, which improves blood circulation, trophism, and metabolism. The chemical factor of peloids is determined by the chemical composition of the mud. Depending on its type, it may contain: colloids, gases, organic substances, sulfur, iodine, chlorine, calcium, phosphorus, and other substances in the form of ions. These factors can enter the body through the process of penetration after immersion through healthy skin. In order for this penetration process to take place, it is important, on one hand, to consider the functional state of the blood circulation and, on the other hand, the physical and chemical characteristics of the peloids. The methodology used to perform the therapeutic interventions plays an important role. Biologically active substances, micro- and macro-elements act as activators of extero- and interoceptors, which influences the processes in the nervous system, resulting in the sanogenic effect being realized through the nervous-reflex pathway. The mud applied to the body mechanically irritates the tactile receptors and can lead to an acceleration of venous and lymphatic flow. Radiant energy, due to the content of radioactive substances in the peloids, is another possible mechanism by which mud exerts a therapeutic effect (Grozeva A. (2022)).

Mud therapy is applied using various methods, mainly through local and general mud applications, mud baths, the Egyptian method, etc. Depending on the method of application, the therapeutic effect of liman mud depends on the chemical, physical, thermal, and electrical properties of the mud. In different procedures, the mud is applied in different concentrations, temperatures, locations, durations, and numbers of mud procedures. The dosage of peloid therapy depends on the individual characteristics of the patient, which include the patient's age, stage and severity of the pathological process, physical condition and physical fitness, and concomitant diseases.

According to studies, mud baths can reduce the level of certain substances that potentiate inflammation (prostaglandin E2, leukotriene B4, interleukin-1 β , and tumor necrosis factor- α). These substances play a crucial part in inflammation and cartilage damage in osteoarthritis. Mud baths may also be useful for increasing insulin-like growth factor-1. This factor is important for the normal functioning of cartilage because it has a stimulating effect on its metabolism. Another factor that can be influenced by balneotherapy is transforming growth factor- β . It acts as an anti-inflammatory cytokine and has an immunomodulatory effect. According to some authors, combining mineral water therapy with therapeutic mud could reduce serum adiponectin and resistin levels in patients with knee osteoarthritis. This is associated with an improvement in the condition of these patients, as adipokines play a significant role in the onset and progression of OA (Bender T. et al. (2007); Fioravanti A. et al. (2017); Ciani O. et al. (2017); Dischereit G. et al. (2019); Mennuni G. et al. (2021)). The benefits of balneotherapy for osteoarthritis have been demonstrated in a number of studies (Bender T. et al. (2014); Branco M et al. (2016); Karagülle M. et al.

(2016); Fraioli A. et al. (2018); Teległów A. et al. (2023); Protano C. et al. (2023); Ortega-Collazos, E. et al. (2024)).

Evidence of the effects of balneotherapy on degenerative musculoskeletal diseases has also been found in several systematic studies and meta-analyses. Matsumoto H. et al. (2017) report on the positive effects of balneotherapy in OA patients, which are expressed in clinical pain and stiffness reduction and functional activity increase, as measured by the WOMAC index. On the other hand, they found high heterogeneity among the patients studied and emphasized the need for further research (Matsumoto H. et al. (2017)). Antonelli M et al. (2018) report that balneotherapy leads to a significant improvement in quality of life (QoL) in patients with knee OA and may also lead to a reduction in medication use (Antonelli M. et al. (2018)). In a recently published meta-analysis including 17 articles, Protano C. et al. (2023) report reduction in pain and improvement in quality of life after balneotherapy. They express the opinion that these effects are probably due to the physical and physicochemical properties of the balneological resources used, but on the other hand, the authors believe that further research is warranted (Protano & Fontana (2023)).

According to data from Grozeva A. (2019), Bulgaria has therapeutic mud of diverse composition and origin, and in significant quantities (Grozeva A. (2019)). The coastal lakes (limans) are the main sources of predominantly inorganic peloid. Suitable resorts are Balchishka Tuzla (Monova H. et al. (2022)), Rusalka (Taukliman), Pomorie, and others. An advantage of Bulgarian mud therapy is the possibility of combining peloid therapy with therapy using marine climatic factors, thalassotherapy, heliotherapy, sea bathing, psammotherapy, or therapy with warm sea sand (Grozeva A. (2022)).

5. CONCLUSIONS

The application of balneotherapy (mineral waters and therapeutic mud) is likely to be a therapeutic strategy with a very positive effect on patients with osteoarthritis. The negative goods of the complaint may be successfully reduced by balneotherapy and mud therapy. Prophylaxis and treatment with natural mineral waters and therapeutic mud have the ability to reduce symptoms and improve functional activity in patients with osteoarthritis. For the most part, these effects are facilitated by the chemical, physical, and thermal properties of balneological factors. However, research into the mechanisms of action is ongoing, which will enable a more precise definition of the pathways through which balneological therapeutic interventions act in patients with osteoarthritis.

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