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External application of sulfide mineral water in the restorative treatment of patients with osteoarthritis – pilot study

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Abstract

Introduction and Objective. A study was conducted of the effectiveness of underground sulfide mineral waters from well No. 516-re of the village of Brusnytsia, Vyzhnytskyi district, Chernivtsi region, Ukraine, applied externally to villagers with osteoarthritis.

Materials and Method. The main group of 60 villagers (30 people) received baths with sulfide mineral water, the control group (30 people) the dynamics of pain syndrome was assessed using the visual analog pain scale (VAS) and the Leken algofunctional index, quality of life, using the standardized EuroQol-5D and 'WAM' (well-being, activity, mood) questionnaires.

Results. In patients of the main group, joint pain during movements, as measured on the VAS scale, decreased by 2.2 times, while pain at rest significantly reduced, whereas in the control group, this decrease was only 1.2 times ($p< 0.05$). In the main group, the total score on the Leken algofunctional index decreased almost twice, on the 'WAM' scale in the activity and mood categories, there was an improvement of 1.4 times, while in the control group, only 1.4 times and 1.2 times, respectively ($p<0.05$). Assessment of quality of life on the EuroQol-5D scale showed significant positive dynamics in all indicators of vital activity in patients of the main group.

Conclusions. A course of external use of baths with underground sulfide boric medium-mineralized hydrocarbonate-chloride sodium waters in villagers with osteoarthritis of large joints contributed to increasing the effectiveness of rehabilitation treatment, and improving the quality of life.

Key words

osteoarthritis, balneotherapy, sulfide mineral waters, villagers, restorative treatment

INTRODUCTION

Degenerative-dystrophic joint diseases continue to occupy a leading position in the category of temporary disability and causes of disability in people of working age. Osteoarthritis (OA) – the most common disease in this group – and is among the ten most disabling diseases in the modern world, and is associated with an increased risk of mortality [1, 2]. In a systematic analysis of the Global Burden of Disease study, the prevalence of osteoarthritis worldwide in 2020 was 595 million people, which is equal to 7.6% of the world population. Also, according to this global study, compared to 2020, an increase in cases of osteoarthritis of the knee joints by 74.9%, osteoarthritis of the hand joints by 48.6%, and hip joints by 78.6% is predicted by 2050 [3]. This is especially true for categories of people whose professional activities are accompanied by high physical exertion, which increases the risk of developing, in particular, osteoarthritis of the hip and knee joints [4, 5, 6].

A large number of rural residents have osteoarthritis-related disability and a lower quality of life [7, 8]. Living conditions and occupational activities are also important risk factors, and correlate with overall health [9]. Rural residents have socio-economic disparities that impair their quality of life and lead to a significant number of chronic diseases with a complex and progressive course [9, 10]. An important difference in the course of osteoarthritis in rural residents is also insufficient access to services related to a healthy lifestyle, including a small number of medical specialists, which leads to long waiting times and long distances to travel to a doctor, low accessibility of pedestrian communication in the area, and limited availability of sports and recreational facilities [7, 8, 11]. Patients with OA suffer from joint pain, stiffness, and functional impairment, which significantly affects their quality of life [12]. According to a study by Messier et al., adult patients with obesity and knee osteoarthritis living in rural areas have more severe pain, poorer joint function and mobility, and a more pronounced decline in physical health-

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related quality of life than their urban peers [11]. Therefore, an important direction of the therapeutic approach for this category of patients is the search for effective methods of comprehensive recovery.

OA results from mechanical and biological influences that destabilize the normal process of degradation and synthesis of chondrocytes of articular cartilage, extracellular matrix, and subchondral bone. Pathological changes affect the entire joint, including articular cartilage, subchondral bone, pericapsular muscles, capsule, and synovial membrane. They initiate reactive inflammation (synovitis), which enhances degenerative changes in all joint structures and surrounding articular tissues. In the development of reactive synovitis, changes in chondrocyte activity, namely their proliferation, production of inflammatory cytokines, response to signalling molecules and structures of the extracellular matrix, play a leading role. The condition leads to cartilage loss, sclerosis of the subchondral bone, and the development of osteophytes and subchondral cysts [13, 14].

The WHO has declared 2021–2030 as the Decade of Healthy Aging, emphasizing the need to control diseases such as osteoarthritis, osteoporosis, etc., which greatly affect a person's functional capabilities and quality of life. [3].

The main recommendations for the management of osteoarthritis are a combination of non-drug methods (physical therapy, lifestyle modification, education, pharmacological approaches (e.g., non-steroidal anti-inflammatory drugs), and surgical treatment options. However, when using pharmacological treatments, problems arise with drug interactions, contra-indications, side-effects, and drug intolerance, which necessitates the search for effective non-drug approaches, including the use of natural factors, including balneotherapy [2, 15, 16, 17]. The effectiveness of balneotherapy in patients with osteoarthritis of various localizations is actively discussed in many clinical studies that provide pathogenetic justification and clinical effectiveness of the specified factor in the complex treatment of osteoarthritis [2, 18]. In this aspect, the recreational use of natural mineral waters at resorts is of particular value, which is associated with (or is due to) the peculiarities of their physico-chemical composition. These are thermal mineral waters, radon mineral waters, sulfide mineral waters, and mineral waters with an increased content of organic substances [16, 19, 20].

OBJECTIVE

The aim of the study was to estimate the potential therapeutic effects of the external application of underground mineral waters (MW) of well No. 516-re, Brusnytsia village, Vyzhnytskyi district, Chernivtsi region, Ukraine, in villagers with osteoarthritis.

MATERIALS AND METHOD

Clinical studies were conducted at Sanatorium and Health Complex in the village of Brusnytsia, Vyzhnytsia district, Chernivtsi region (Ukraine) and at the State Non-Profit Ukrainian Research Institute of Rehabilitation and Balneology, Ministry of Health in Odessa, Ukraine. The study was performed according to the Declaration of Helsinki of the World Medical Association (Ethical Principles of Medical Research Involving Humans), approved by the Institutional Bioethics Commission under Protocol No. 3 of 05/03/2024 from the Bioethics Commission of the Ukrainian Research Institute of Medical Rehabilitation and Balneology of the Ministry of Health in Odesa, Ukraine).

Participants. The study involved 60 villagers. The first main group consisted of 30 patients, and a second control group, also 30 patients, with osteoarthritis of the large joints – 32 women (53.3%) and 28 men (46.7%) aged 56–67 years. Most patients were diagnosed with knee joint damage: 34 patients (56.7%), 16 patients (26.7%) had hip joint damage, and in the remaining cases the respondents (16.7%), had oligoarthritis (knee and hip joints affected). Unilateral osteoarthritis was present in 42 patients (70.0%), respectively, bilateral lesions were observed in 30.0% of cases. Usually, osteoarthritis was primary or secondary post-traumatic and dysplastic. Stage I osteoarthritis, diagnosed in most patients – 41 respondents (68.3%), stage II was diagnosed in 15 patients (25.0%), the rest showed manifestations of stage III, there were no patients with stage IV in the observation groups (Tab. 1).

Table 1. Characteristics of patients with osteoarthritis in the main and control groups

Categories	Main group N = 30	Control group N = 30
Age, years, (M±m)	59.5±1.57	62.3±1,64
Men, n (%)	12 (40.0)	16 (53.3)
Women, n (%)	18 (60.0)	14 (46.7)
Osteoarthritis of knee joints n (%)	16 (53.3)	18 (60.0)
Osteoarthritis of hip joints n (%)	8 (26.7)	8 (26.7)
Oligoosteoarthritis n (%)	6 (20)	4 (13.3)
Unilateral osteoarthritis, n (%)	22 (73.3)	20 (66.7)
Bilateral osteoarthritis, n (%)	8(26.7)	10(33.3)
Radiological stage I, n (%)	21 (70.0)	20 (61.1)
Radiological stage II, n (%)	7 (23.3)	8 (26.7)
Radiological stage III, n (%)	2 (6.7)	2 (6.7)

The criteria for inclusion of patients in the observation groups were as follows: patient consent, adult patients under 75 years of age, osteoarthritis of large joints (knee and/or hip) stages I-III in remission, patient's ability to exercise, and self-care. Exclusion criteria: osteoarthritis stage IV, osteoarthritis in the exacerbation stage, severe concomitant diseases in the decompensation stage (type 2 diabetes mellitus, arterial hypertension blood, chronic heart failure, chronic kidney disease, use of intra-articular injections).

All patients signed a written informed voluntary consent to participate in the clinical study. (Protocol No. 3 of 05/03/2024 from the Bioethics Commission of the State Institution «Ukrainian Research Institute of Medical Rehabilitation and Balneology of the Ministry of Health of Ukraine»).

Methods. The dynamics of pain syndrome (joint pain) was assessed using the visual analog scale of pain (VAS) and the Lequesne total algofunctional index. Assessment of the intensity of pain syndrome by VAS, in points, allowed determining the severity of the pain syndrome (0 points –

no pain, 10 points – the most severe pain). To determine the severity of osteoarthritis of the knee and hip joints, The Lequesne algofunctional index is an open questionnaire for self-completion by patients. The following sections were assessed: characteristics of the pain syndrome or discomfort, maximum distance when walking without pain, and functional activity. The maximum sum of points for each section is 8 points, the total sum of points is 24, and the minimum – 0 points. The severity of osteoarthritis was assessed according to the resulting sum of points: 1–4 points – mild osteoarthritis, 5–7 points – moderate severity, 8–10 points – severe osteoarthritis, 11–13 – very severe osteoarthritis, 14 or more points – extremely severe osteoarthritis [21].

Also, the effectiveness of the use of MW of well No. 516-re in the complex treatment of patients with osteoarthritis was assessed using standardized questionnaires of quality of life, EuroQol-5D-3L [22, 23] and WAM (well-being, activity, mood) [24]. The EuroQol-5D-3L questionnaire contains 15 questions that assess the overall quality of life index and quality of life according to 4 factors: physical (mobility, self-care); social (domestic activities); pain and psychological (anxiety, depression). The patient independently assessed his condition according to 5 parameters: mobility (mobility), self-care, usual daily activities, pain and discomfort, anxiety, and depression. For each category of questions, the patient provided one answer out of 3 options: 1 – no problem, 2 – there is a problem, 3 – a significant problem. The total number of points was calculated [22, 23].

The quality of life of the respondents was also assessed using the standardized psychological method WAM (well-being, activity, mood), a questionnaire containing 30 pairs of opposite characteristics by which the subject's condition is assessed. Each pair represents a scale (3, 2, 1, 0, 1, 2, 3), on which the patient determines the degree of severity (in numbers) of the characteristic of his condition. The results of the study were converted into points (1–7) on a correspondence scale, and the functional state determined by the averaged scores for each category of signs, and the nature of the relationships between them. The average score of the scale is 4. Scores above 4 points indicate that the patient feels well and is in a favourable state, while result below 4 points indicate an unfavourable state. A low level of these indicators indicates a maladaptive state of the patient.

The sum of the points for specific questions was calculated according to the key to the test for each category of the questionnaire. The total score for each category ranges from 10–70, which is the assessment of the functional state at a given time: less than 30 – low score, 30–50 – average score, more than 50 – high score [24].

The stage of osteoarthritis was determined according to the radiological classification of D. Kellgren-Laurence: 0 – no stage of change; Stage I (minor changes) – significant narrowing of the joint space, the beginning of osteophyte formation; Stage II (minimal changes) – slight narrowing of the joint space, small osteophytes; Stage III (moderate changes) – moderate narrowing of the joint space, multiple osteophytes, slight subchondral sclerosis, moderate deformation of the articular surfaces; Stage IV (pronounced changes) – sharp narrowing of the joint space, multiple osteophytes, pronounced subchondral sclerosis, pronounced deformation of the articular surfaces [25].

Procedures. Depending on the type of rehabilitation treatment, patients were divided into 2 observation groups: the first (main) group included 30 (50.0%) patients who were given a course of baths with MW of well No. 516-re to the basic course of rehabilitation treatment (physiotherapy, massage, therapeutic gymnastics). The water temperature in the bath was 36–38 °C, duration of the procedure – 15 minutes. The procedures were performed for 2 consecutive days with a day off; course of treatment – 12 baths.

Underground MW of well No. 516-re are characterized as sulfide (strongly sulfide, hydrosulfide), boric medium mineralized hydrocarbonate-chloride, sodium chloride, weakly alkaline-alkaline (pH 7.50–9.05), cold (T 14.0–16.0°C). Total mineralization of the well – 4.24 g/l – 5.49 g/l, hydrogen sulfide content (H2S+HS) – 130 mg/l-228 mg/l, boron content in the form of (H3BO3) – 42 mg/l-105 mg/l.

The second (control) group also included 30 (50.0%) patients who received a course of restorative treatment, in which instead of baths with MW of well No. 516-re, baths with fresh water were used according to a similar dosage regimen as for baths with MW.

Statistical analysis. The processing of statistical data was performed using the XLSTAT 2016 statistical software package. Compliance of the distribution of clinical trial data with the normal distribution law was checked using the Shapiro-Wilk test. To compare the quantitative data of the 2 groups, the Student's t-test was used. To describe the data, the mean value and the error of the mathematical mean (M±m) were used. The results of the comparisons were considered reliable if the error probability value was less than $p<0.05$.

RESULTS

Analysis of the study results showed the advantages of using a complex restorative treatment with baths with MW of well No. 516-re for patients with osteoarthritis. Thus, a decrease in the manifestations of pain syndrome during movements, at rest, and during palpation was determined in patients of both observation groups. However, in patients of the first group, in whom baths with the study MW were used in the complex restorative treatment, the dynamics of the pain syndrome was more pronounced: pain in the joints during movements according to VAS decreased by 2.2 times, while in the control group the improvement in the patients' condition occurred only by 1.2 times. Also, in patients of the second group, a slight decrease in the intensity of the pain syndrome was observed at rest and during palpation, while in the main group, patients determined a significant improvement in the condition of the joints and a pronounced decrease in the pain syndrome, especially at rest ($p<0.05$). Under pain syndrome elimination conditions, patients' functionality was restored and the volume of active movements in the joints improved. Improvement was determined to a greater extent in patients with osteoarthritis of the knee joints of radiological stages I and II. Accordingly, in patients with hip joint damage and with oligoosteoarthritis (knee and hip joint damage), a decrease in the manifestations of pain syndrome was determined at stage I of the disease (Tab. 2).

Arthrological status was assessed using the Lequesne algofunctional index. In both groups, the severity of osteoarthritis was assessed before and after the use

Table 2. Dynamics of pain syndrome according to VAS in patients with osteoarthritis of the main and control groups, points, (M±m)

Indicators	Main group N = 30		Control group N = 30	
	before	after	before	after
Joint pain during movement	6,9±1,2	3,2±1,1*	6,8±1,3	5,6±1,1
Joint pain at rest	6,7±1,1	2,4±1,3*	6,8±1,2	5,3±1,2
Joint pain on palpation	6,5±1,2	2,5±1,2*	6,3±1,1	5,4±1,2

* – p≤0.05, compared with the indicators of control group patients after treatment

of restorative treatment. Before treatment, patients in both observation groups were diagnosed with moderate osteoarthritis. Pathological changes were observed in all categories of the questionnaire: patients noted the presence of pain syndrome, decreased motor and daily activity.

Assessment of the Lequesne index in patients with osteoarthritis of large joints revealed the benefits of using MV baths as part of a comprehensive restorative treatment, and improved the condition of patients. When assessing the categories of the first section of the questionnaire (characteristics of pain or discomfort), a decrease in night pain, pain when walking and sitting was determined to a greater extent; in the second group of indicators, the maximum distance of pain-free walking increased and the functional activity indicators of patients improved. In the control group, the severity of osteoarthritis was assessed as moderate, despite improvements in all categories of the questionnaire. In the first group, patients experienced significant improvements in the functional activity category (Tab. 3).

Table 3. Dynamics of the Lequesne index in patients with osteoarthritis, of the main and control groups, (M±m)

Indicators	Main group N = 30		Control group N = 30	
	before	after	before	after
Characteristics of pain or discomfort	2.7±0.2	1.3±0.1	2.8±0.2	1.9±0.1
Maximum distance when walking without pain	1.8±0.2	0.8±0.1	1.8±0.2	1.6±0.2
Functional activity	3.2±0.2	1.8±0.2	3.1±0.2	1.9±0.2
Total points	7.7±0,2	3.9±0.2*	7.7±0.2	5.4±0.2

* – p≤0.05, compared with the indicators of control group patients after treatment

Changes in the functional state of patients during the study were assessed using the WAM questionnaire in the categories of well-being, activity, and mood. Patients in both groups had an average assessment of functional status; however, during the observation period, patients in the first group in the activity (mobility, speed, pace) and mood (emotional state) categories experienced significantly significant improvements (1.5 times), and the score was already high compared to the functional status of patients in the control group, in whom the improvement was only 1.2 times, and the overall score remained average. In the category of well-being (strength, health, and drowning), improvements were also found in patients in both groups, but to a greater extent in patients in the first group (Tab. 4).

According to the assessment of the quality of life on the EuroQol-5D scale, patients of both observation groups showed positive dynamics in all indicators of vital activity (walking, self-care, daily activity, pain/discomfort, anxiety/depression) under the influence of the applied treatment complexes. At the end of balneotherapy, patients of the main group had significantly better indicators of 'Walking', 'Pain/discomfort', and 'Anxiety/depression' on the EuroQol-5D scale, compared to the data of patients of the control group ($p<0.05$). In the categories of the questionnaire 'Self-care' and 'Daily activity', improvements were also determined to a greater extent in patients of the first group (Tab. 5).

Table 4. Dynamics of assessment of quality of life using the WAM questionnaire, in patients with osteoarthritis of the main and control groups, points, (M±m)

Indicators	Main group N = 30		Control group N = 30	
	before	after	before	after
Well-being assessment	32.4±1,2 average	43.7±1.2* average	29.6 ±1.1 low	36.6±1.3 average
Activity assessment	33.4±1,4 average	51.1±1.0* high	32.7±1.5 average	38.8±1.3 average
Mood assessment	32.8±1,4 average	50.5±1.1* high	34.4±1.9 average	40.5±1.6 average

* – p≤0.05, compared with the indicators of control group patients after treatment

Table 5. Dynamics of quality of life assessment according to the EuroQol-5D scale, in patients with osteoarthritis of the main and control groups, points, (M±m)

Categories	Main group N = 30		Control group N = 30	
	before	after	before	after
Mobility	2.0±0.13	1.2±0.12*	2,0±0,16	1.8±0.11
Self-care	1.8±0.14	1.4±0.12	1.9±0.18	1.7±0.11
Normal daily activities	1.6±0.12	1.7±0.13	1.7±0.13	1.5±0.12
Pain/discomfort	2.6±0.18	1.4±0.13*	2.5±0.2	1.9±0.14
Anxiety/depression	1.9±0.11	0.7±0.12*	1.9±0.13	1.3±0.11

* – p≤0.05, compared with the indicators of control group patients after treatment

The results indicate that the course of external application of MW has a positive effect on the clinical course of the disease and functional indicators in patients with osteoarthritis of the knee and hip joints, and improves the quality of life.

DISCUSSION

The obtained therapeutic effect can be associated with both the general and specific effects of the applied natural therapeutic MW. The general effects of balneotherapy are considered to be thermal, mechanical (hydrostatic), and chemical effects on the human body [20]. The chemical composition of chloride-sodium waters has its specific properties, namely, when applied externally the physico-chemical properties of the cellular elements of the skin and the mechanoreceptors located in it change. This leads to a decrease in excitability and neuro-reflex conductivity, a decrease in tactile and pain sensitivity, activation of factors of the blood anti-coagulant system, normalization of the activity of the sympatho-adrenal system, acceleration of oxidative phosphorylation, accumulation of the number of macroergs in internal organs, and a decrease in sodium reabsorption from primary urine, which contributes to an increase in diuresis [26]. Sodium chloride MWs contain specific biologically-active components and compounds

in various concentrations: bromine, iodine, orthoboric acid, metasilicic acid, hydrogen sulfide, carbon dioxide. It is believed that the physiological and therapeutic effect of MWs on the human body, when applied externally, is determined by both their macro-component composition and the presence of specific biologically-active components and compounds [27, 28].

The trace element boron, which is part of the chemical composition of the MWs used in the current study, determines their specific effect [29, 30, 31] and affects the functioning of joints, helps prevent the development of osteochondrosis, osteoarthritis, and osteoporosis in adults and the elderly, and has an anti-inflammatory effect. A low boron profile has been associated with a poor immune response, the development of osteoporosis, deterioration of cognitive functions, and even premature mortality [30]. This element is especially important for women during menopause, the population group most prone to the development of osteoarthritis and osteoporosis.

The close interaction of boron with other minerals, in particular, magnesium, calcium, and fluorine, is associated with its biological role in the body [31]. Boron is involved in the regulation of calcium-phosphorus metabolism, has a beneficial effect on functions such as calcium reproduction and metabolism, bone formation, brain function, insulin and energy substrate metabolism, immunity and the function of steroid hormones (including vitamin D and estrogens), and promotes the transition of the inactive form of vitamin D to the active one under the influence of sunlight [31, 32]. Signs of boron deficiency in the body are similar to the phenomena of hypovitaminosis and osteoporosis: slight pain in the joints during exercise, increased development of degenerative-dystrophic pathology of the spine and joints, and decreased immunity. More often, boron deficiency is chronic, without the manifestation of clear symptoms and worsens the course of other pathological processes, deepening dystrophic processes in connective and bone tissues in degenerative-dystrophic pathology of the spine and joints.

Several clinical studies have shown a positive effect of boron compounds in patients with osteoarthritis by reducing symptoms of the disease due to the anti-inflammatory effect [33]. According to the data presented, the normalization of boron levels in the body is a component of the overall therapeutic effect of MW. Hydrogen sulfide (H_2S) also plays an important role in the therapeutic effect of MW. It is one of the mediators that can induce/inhibit immunological reactions (immunomodulatory effect), playing a role in inflammatory and autoimmune diseases, neurological disorders, and bronchial asthma. Both endogenous and exogenous H_2S modulate numerous important cellular signalling pathways [34]. In monocytes, polymorphonuclear and T cells, H_2S affects activation, survival, proliferation, polarization, adhesion pathways, and modulates cytokine production and sensitivity to chemokines, i.e. plays the role of a natural buffer capable of maintaining a functional balance between Th1, Th2, Th17 immunological responses over time which, in turn, has an anti-inflammatory effect that leads to a decrease in pain, an increase in the volume of movements in the joints, and an improvement in the quality of life [35]. In addition, the literature provides data on the high therapeutic effects of the use of hydrogen sulfide MWs in diseases such as myalgia, rheumatic diseases (osteoarthritis, rheumatoid arthritis, fibromyalgia), as well as respiratory, dermatological and cardiovascular diseases [36].

It was also found that after balneotherapy with sulfuric water in rheumatic diseases, oxidative stress decreased, which can contribute to a decrease in inflammatory and catabolic status, which indicated the clinical effectiveness of sulfuric MWs in the treatment of patients with osteoarthritis and rheumatoid arthritis [37].

In this aspect, the concept of hormesis should be mentioned. The biological mechanisms of the restorative effect of external application of MW in the rehabilitation of some pathologies have not yet been fully studied. During balneotherapy, neuroendocrine and immunological reactions are involved, which cause anti-inflammatory, analgesic, anti-oxidant, chondroprotective and anabolic effects in the aggregate of neuroendocrine-immune regulation in various pathological conditions. Hormesis can play a crucial role in all these biological effects and mechanisms of effectiveness. The hormesis effects of balneotherapy can be associated with non-specific factors, such as heat, which causes a heat shock reaction (synthesis and release of heat shock proteins), as well as with specific biochemical components, for example, H_2S in sulfuric water [38, 39, 40]. This means that hormesis can play a leading role in the biological mechanisms of the corrective action of sulfide MW. The overall therapeutic effect of the MWs used in the current study can be described by the concept of hormesis, i.e. it is a two-phase 'dose-response' phenomenon in which the impact on a cell or organism of a low dose of a chemical agent (in this case, hydrogen sulfide and boron), or conditions (temperature, pressure, radiation) causes stimulation or adaptive beneficial effects, while higher doses, or higher temperature, or longer duration of procedures cause inhibition or toxic effects [38].

The data presented on the biological effects of the components of sulfide MWs indicate the pathogenetic validity and feasibility of using sulfide MWs in balneological and clinical practice, including in chronic joint diseases.

CONCLUSIONS

Rural residents with osteoarthritis have more severe pain, poorer joint function and mobility, and a more pronounced decline in physical health-related quality of life than urban residents. Rural residents have socio-economic disparities that worsen their quality of life, and lead to a significant number of chronic diseases, including osteoarthritis. Threy also have insufficient access to services related to a healthy lifestyle, a small number of medical specialists, poor accessibility for pedestrian traffic, and limited access to sports and recreational facilities.

The course of external use of baths with underground sulfide boron medium mineralized hydrocarbonate-chloride sodium waters in patients with osteoarthritis contributes to increasing the effectiveness of restorative treatment of the specified contingent of patients.

Balneotherapy with the studied mineral water in the complex restorative treatment of patients with osteoarthritis of large joints contributes to more effective restoration of the patient's functionality and improvement of the volume of active movements in the joints, which leads to a reduction in pain syndrome during movements by 37.0% and at rest – by 43.0% according to VAS.

The inclusion of baths with sulfide mineral water in the complex restorative treatment of patients with

osteoarthritis of large joints significantly improves the quality of life of patients (according to the EuroQol-5D-3L scale), and contributes to increasing the adaptability of the body. According to the Lequen algofunctional index, the improvement in the condition of patients in the main group occurred by 19.5%, compared to the data of the control group, and according to the SAN questionnaire, the functional condition of patients in the categories 'Activity' and 'Mood' had a high score ($p<0.05$).

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