

Balneotherapy/Spa Therapy: Potential Of Nigerian Thermal Hot Spring Waters For Musculoskeletal Disorders And Chronic Health Conditions

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Abstract: Musculoskeletal disorders and chronic health conditions are leading causes of death and disability all over the world. The prevalence of such disorders pose great social and economic burden due to the wide variety of the pathological conditions. Complementary/integrative interventions are commonly utilized to improve quality of life and productivity in such conditions. One approach often recommended is the use of thermal mineral water from hot springs known as balneotherapy/spa therapy. This practice is prevalent in Turkey, Hungary, Romania, Germany, Portugal, Japan, Poland, Spain, Italy, and France. Its therapeutic potentials being reported for various rheumatic diseases, multiple sclerosis, type 2 Diabetes, dermatitis, fibromyalgia, chronic low back pain, cardiovascular disease, chronic venous insufficiency, stress, psoriasis as well as metabolic and respiratory conditions. There are several known and unknown thermal springs in Nigeria which could be effectively utilized for balneotherapy/spa complementary therapy in various prevalent pathological conditions. Among the available thermal springs in the country, only 2 have been developed for leisure and tourism, with none offering spa facilities for therapeutic purposes. This stipulates that such practice is not well-known in the country. This study therefore aims to provide insights into this significant but neglected healthcare option for musculoskeletal disorders and other chronic health conditions based on the physicochemical data of the thermal springs obtained from literatures. Nigerian thermal springs, if investigated and developed into modern health resort, can promote the health/economic development of the Nation by providing cost effective therapy in various pathological conditions.

Keywords: balneotherapy, chronic health conditions, musculoskeletal disorders, Nigeria, thermal mineral water.

1. Introduction

Musculoskeletal disorders are major global health problem with diseases and injuries of the musculoskeletal system affecting people across the life-course in all regions of the world. Musculoskeletal disorders are the highest contributor of disability worldwide and since it was first mentioned in 1990, low back pain remained the single leading cause of disability [1]. Current treatment includes pharmacological approaches involving the use of acetaminophen, non-steroidal anti inflammatory drugs (NSAIDs), selective COX-2 inhibitors, opioids, duloxetine and topical drugs and non-pharmacological approaches such as education, exercise, diet, and lifestyle changes [2]. Musculoskeletal disorders are frequently followed by depression and chronic health problems. Due to the social and economic burden of these pathologies, complementary/integrative treatment options have been considered with the use of thermal mineral waters

(TMWs), natural peloids and mud, natural sources of hydrogen sulphide, radon and carbon dioxide gases (generally referred to as balneotherapy or spa therapy) becoming popular in recent times. In modern terms, TMWs are ground waters which have therapeutic effect on the human body, due to the increased content of their ionic, gas and biologically active components. They are complex multicomponent solutions which have a diverse composition and different mineralization, making it possible to vary the treatment depending on the phase of the disease, the severity of the pathological process and associated pathology [3]. Different common methods for balneotherapy include whole body immersion or bathing of body parts in peloids or gases, mineral water, application of mud/peloid packs to body regions, inhalation of gases or by drinking mineral water. In modern medicine, complementary cure using mineral waters has evolved into a medical specialty [4]. These waters are sourced from hot springs traditionally available in several

Nations of the world or from ground waters. Applications and research on their medicinal potential appears to be prevalent in Turkey, Hungary, Romania, Germany, Portugal, Japan, Poland, Spain, Italy, and France. Its effects on rheumatic diseases (osteoarthritis, rheumatoid arthritis, ankylosing spondylitis); multiple sclerosis; type 2 Diabetes; dermatitis; fibromyalgia; chronic low back pain; cardiovascular disease, chronic venous insufficiency, stress, psoriasis as well as neurological, metabolic, respiratory and psychiatric conditions and other skin diseases have gained popular attention [5]. In Nigeria, no such practice exists despite the availability of several TMWs with balneotherapeutic potential in many parts of the country. If developed however into modern health resorts, they can provide a cost-effective complementary option for the treatment of musculoskeletal disorders and other chronic health problems in the Nation. This study therefore aims to provide insights into this significant but unpopular healthcare option which may revitalize research on these TMWs to provide more scientific data and evidences that will substantiate their uses as complementary healthcare option in Nigeria.

2. Thermal Mineral Waters in Nigeria

There are several known and unknown thermal springs in Nigeria. They include: Ikogosi (in Ekiti State), Wikki (in Bauchi state), Rafin Rewa (in Plateau State), Akiri, Ruwan Dumi, Ruwan Zafi, Taganrahu, Keana, Ribbi, Kanje and Ruwan Zafi Numan (in the Middle Benue Trough of Nassarawa State). The major ones known are Akiri, Wikki, Ikogosi and Ruwan Zafi springs as shown in fig. 1 [6-8].

Matz et al. [10] proposed that hot springs waters may be classified as cold (<20°C), hypothermal (20–30°C), thermal (>30– 40°C) or hyperthermal (>40°C); low mineralized (0.6– 2 g/l), mildly mineralized (>2–10 g/l) or highly mineralized (>10 g/l). They are also said to be hypertonic when salinity exceed 14g/l or hypotonic/isotonic when chlorosodic concentration does not exceed 10-14g/l [11].



Fig. 1: Location of thermal springs in Nigeria.

Table 1: Physicochemical properties of Known thermal Mineral Waters from Nigerian Hot Springs

Parameter	IK	WK	RZN	RR	AK	RD	RZ	TG	BT
Temp	35.6	32.9	44.2	42.2	53.5	35.8	39.5	34.0	42.7
Min (mg/l)	93.66	66.03	442.63	ND	5863.4	6701.45	9010.24	8578.05	9015.14
EC	95.7	67.07	0.5133	ND	10.197	11.49	15.09	13.688	15.087
pH	6.35	6.14	7.38	8.1	6.91	6.92	6.95	6.65	6.66
Cations (mg/l)									
Ca ²⁺	8.82	6.01	9.62	1.5	110.22	108.22	40.08	40.10	44.10
NH ₄ ⁺	0.04	0.04	0.04	<0.05	110.22	108.22	40.08	40.10	5.00
K ⁺	1.07	1.56	10.00	1.64	67.20	54.70	71.90	73.45	75.25
Mg ²⁺	5.35	1.94	2.43	0.06	20.66	20.05	43.75	36.46	38.90
Fe ²⁺	<0.01	0.15	<0.01	0.03	0.15	0.25	0.10	0.35	0.15
Mn ²⁺	0.01	0.01	0.01	0.001	0.12	0.01	0.10	0.05	0.08
Na ⁺	2.00	4.94	93.34	0.09	2000.00	2335.00	3270.00	3100.00	3225.00
Anions (mg/l)									
SO ₄ ²⁻	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
F ⁻	0.17	0.06	0.69	7.54	0.87	0.68	0.77	0.79	0.78
Cl ⁻	3.89	6.38	20.20	6.17	3155.00	3615.00	4963.00	4697.12	965.00
Br ⁻	<0.05	<0.05	<0.05	<0.05	0.03	<0.05	<0.05	<0.05	<0.05
HCO ₃ ⁻	53.70	29.50	273.8	207.0	268.40	408.08	263.10	263.10	263.10
NO ₃ ⁻	1.30	2.87	0.88	1.73	21.96	20.59	15.10	14.20	<0.88
Undissociated Substances									
H ₂ SO ₃	17.36	12.77	17.36	90.2	39.68	35.96	31.00	31.93	31.93
HBO ₂	<0.50	<0.50	<0.50	0.093	<0.05	<0.05	<0.05	<0.05	<0.05

Temp: Temperature; Min: Mineralization; EC: Electrical Conductivity. ND: No Data

IK: Ikogosi; WK: Wikki; RZN: Ruwan Zafi Numan; RR: Rafin Rewa; AK: Akiri; RD: Ruwan Dumi; RZ: Ruwan Zafi; TG: Taganrahu; BT: Bitrus (Groundwater).

While Ikogosi and Wikki springs have been developed for leisure and tourism, the others have gotten no attention of such. Noteworthy also is the fact that none of the springs offered any therapeutic application, a popular global practice in other nations of the world. The physicochemical properties of the mineral waters according to Garba et al. [6] and Nghargbu et al. [9] are elucidated in Table 1 indicating the chemical nature of these hot spring waters. With mineralization ranging from 93.66mg/l - 9015.14mg/l as observed from Table 1, these complex multicomponents TMWs in Nigeria are the hypotonic/isotonic TMWs types and range from the warm lowly mineralized mineral waters to the very hot mildly mineralized type. The Akiri thermal waters are the very hot mildly mineralized (saline) chlorosodic mineral waters (53.5°C) while the Ruwan Dumu mineral waters are warm moderately mineralized (saline) chlorosodic waters. Ruwan Zafi is the hot mildly mineralized (saline) chlorosodic mineral waters while the Taganrahu thermal waters are the warm mildly mineralized (saline) chlorosodic mineral waters.

3. Methodology of Application of Thermal Mineral Water

Bathing cures are the most common external application methods of different TMWs types [11]. Baths may be followed by mud baths or physical exercise. Baths may be general body baths or partial baths for body parts such as legs, hands or head. Jonker [12] submitted that baths are thought to elicit their effects in thermal, chemical and mechanical modes of actions. Komatina [13] indicated isotonic mineral waters having mineralization of 5g/l - 14g/l (such as the Akiri, Ruwan Dumu, Ruwan Zafi, Taganrahu TMWs) to be suitable for therapeutic bathing cures. Baths could be indicated for ameliorating pains of traumatic musculoskeletal disorders, chronic gynecological disorders, degenerative rheumatism, skin diseases, extra pulmonary tuberculosis and endocrine disorders [11]. Komatina [13] further indicated that hypotonic mineral waters with mineralization not exceeding 5g/l (such as the Ikogosi, Wikki and Ruwan Zafi spring waters) may be consumed in drinking or internal cures. Such method may be especially indicated for use in endocrine dysfunction, digestive, metabolic and urinary tract disorders [11]. Pharmacodynamic action is believed to be exerted on the gastric mucosa to stimulate intestinal motility and gastric secretion [11]. Mineral water containing gases such as CO₂ or H₂S are used in inhalation therapies or as sprays/aerosols and may be applied in disorders of the lungs, otolaryngological disorders and gynecological inflammations [11]. Doctors now recognize and recommend the utilization of sulphurous, saline/chlorosodic, radioactive, ferrous, arsenic, bicarbonate and other mineral water types for use in preventive and curative medicine in various conditions of pathology [12].

4. Biochemical Action of Thermal Mineral Waters

Insights into the molecular basis underlying the therapeutic effects of thermal mineral waters have been a major subject of discussion. The therapeutic potential oftentimes is linked to chemical, mechanical, immunomodulatory and thermal effects manifested in the different physiological changes. Molecular mechanisms by which balneotherapy/spa therapy elicit biological action is rather complex as wide variations

in various metabolomics data are often encountered [14]. Although these are not fully understood, several physiological changes have been reported after balneotherapy in these medicinal waters providing insights into their possible mechanism of action. According to Xu et al. [15], some of these changes include hemodilution, diuresis, reduction in muscle/bone load and increase in insulin-like growth factor-1 (IGF-1) which transforms growth factor- β (TGF- β), a very potent immune modulating/anti-inflammatory cytokine. TMWs influence the metabolism of lipids, carbohydrates and proteins [11]. In a study to evaluate the effect of a 21-day balneotherapy program on blood cell counts, ponogen levels, and blood biochemical indexes in servicemen in sub-health condition [15], beneficial effects of balneotherapy based on the biochemical indices changes were reported. Murakami [14] reported decreased serum glycoalbumin levels - a glycemic control index, upregulation of glycolysis, and suppression of proteolysis in both human and murine models after consumption of Nagayu, Hijiori and Shiobara hot spring waters. Lowered plasma cholesterol level, lowered LDL (low-density lipoprotein), suppression of reactive oxygen species (ROS) and increase in insulin sensitivity were also reported [14] providing insight into the use of TMWs in chronic states. Evidence was also provided for decreased levels of cortisol, a stress biomarker after balneotherapy/spa therapy [2]. In musculoskeletal syndromes, the hot stimuli influences muscle tone and pain intensity and help to relief muscle spasm, aches and fatigue [16]. Decreased muscle tone effectively helps eliminate muscle, body fatigue and joint movement disorders caused by joint diseases, such as paralysis and neuralgia [17]. Mineral ions present in the mineral water such as sodium ion (Na⁺), chloride ion (Cl⁻), sulphate ion (SO₄²⁻), bicarbonate ion (HCO₃⁻), magnesium ion (Mg²⁺), calcium ion (Ca²⁺), ammonium ion (NH₄⁺), cupric ion (Cu²⁺) and fluoride ion (F⁻) can make biochemical exchanges within the body thereby stimulating nerve endings in the skin, peripheral vascular expansion, blood flow acceleration hence promoting the excretion of ponogens (pyruvic acid, lactic acid and CO₂) [14]. Microbes present in these thermal mineral waters may also contribute to therapeutic effects [15]. Hence microbiome, metatranscriptome and bioinformatics analysis of microbial profile can provide information on genes expressed and functional profile of the microbial community in hot springs. Biochemical assays can reveal the several microbial enzymes playing key roles in these molecular mechanisms of action of balneotherapy. Information obtained can provide insight into how mineral waters influence microbial composition in healthy and diseased subjects.

5. Chronic Musculoskeletal Effect

Balneotherapy in saline thermal mineral waters is recommended in various musculoskeletal disorders including those affecting the joints such as osteoarthritis (OA), rheumatoid arthritis, psoriatic arthritis, gout, ankylosing spondylitis & arthrosis and those affecting the spine (back and neck) [18]. In the first double-blind trial of the effectiveness of balneotherapy in Puspokladany thermal waters on arthrosis of the knee joint in 62 patients in Hungary [19], the treatment group bathed in the saline thermal water while the control group bathed in tap water. The thermal water treated group experienced decreased pain in movement and tenderness of the knee compared to the

control group. The results observed proved trials in the saline thermal waters to be suitable for knee osteoarthritis treatment. In another study to evaluate the clinical efficiency of TMWs of Harkany spring on 53 patients with primary knee osteoarthritis by Nusser and Horvath [20], the treatment group was administered TMWs of Harkány spring, while the control group received heated tap water therapy for a period of 3 consecutive weeks. The result of the study observed statistically significant improvement in the parameters of the TMWs water treated group at the end of the treatment as well as after 12 weeks- follow-up assessment. No significant alterations in the evaluation indices were found in the control group. Tefner et al. [21] in a randomized-controlled, single-blind, follow-up pilot study of 60 patients investigated the effect of spa therapy in chronic low back. The treatment group received balneotherapy with TMWS while the control group bathed in tap water and changes were evaluated. The study revealed reduction in pain, improvement in quality of life as well as decreased need for medication. The study further demonstrated the beneficial effect of balneotherapy with thermal mineral on chronic low back pain. With several hospital-based studies having shown musculoskeletal disorders to be prevalent in Nigeria with knee osteoarthritis being the most commonly experienced accounting for 65%-78% of cases [22], the balneotherapeutic potentials of the hot spring waters in the country, if investigated, may therefore provide complementary option to improve quality of life of these patients.

6. Metabolic and Endocrine function

Dumitrascu [11] disclosed that saline TMWs act on the metabolism of carbohydrates, lipids and proteins after intestinal reabsorption resulting in hypoglycemic activity. He noted further that this may be attributed to the stimulation of insulin secretion directly under the influence of chloride ions; hence circulating blood glucose concentration reduces and is excreted in urine. It is in this view that saline or chlorosodic waters are often recommended for use in diabetic diets as the water also enhance the effect of drug treatment [11]. Metabolic changes also reported in the study included lowered plasma cholesterol level, lowered LDL (low-density lipoprotein) level and reduction in the concentration of uric acid (therefore helpful in treating gout and hyperuricaemia). This effect could be as a result of the increase, by osmotic mechanism, in the synthesis of serum cholesterol from the 7- α -hydroxylase pathway and subsequent increase in intestinal bile acid excretion [23]. Further observed is increased urea excretion in urine which in this way can be used in treating people with urea retention tendencies but without liver damage. In another study by Munteanu [24], improvement of lipid metabolism and decrease postprandial glucose after consumption of sodium-rich TMWs were noted. This gives support to the utilization of these waters in cardiovascular diseases and metabolic syndromes. In a study by Schoppen et al [25] to determine whether mineral water rich in sodium change insulin sensitivity in postmenopausal women, it was disclosed that there was an increase in insulin sensitivity after consumption of this TMWs. The authors recommended that these waters should form part of a healthy diet to prevent cardiovascular disease and insulin resistance. In a clinical trial and animal experiment to elucidate the effect of consuming TMWs types on clinical blood parameters by Murakami [15], beneficial effect on glycemetic control as a result of the alteration in

metabolic dynamics and intestinal environments was reported. He further added that microbial profile of thermal waters influences gut microbiota manifesting in beneficial outcomes. In the same study, it was noted that the beneficial effect on glycemetic control by consumption of TMWs may be as a result of the increase in intestinal short chain fatty acids (butyrate and pentanoate) which enhance incretin secretion and insulin sensitivity in liver and muscle. Short chain fatty acid concentrations were noted to significantly increase after drinking cure with thermal water. Butyrate suppresses colonic inflammation and induces regulatory T-cell differentiation; therefore TMWs consumption may have beneficial effect in type-2 diabetes mellitus, allergic disease and inflammatory bowel disease.

7. Respiratory Diseases

In a study to investigate the effectiveness of the use of saline water aerosols in airways diseases by Fischer [26], saline water were indicated for use in inhalation therapy to relieve bronchitis, rhinitis, bronchial asthma, chronic rhynosisinusitis and cystic fibrosis. As a new technology, haloaerosoltherapy, using saline medicinal water, was indicated to be effective in asthmatic patients [27] and in community acquired pneumonia [28]. Nica et al. [29] in a study to evaluate the effect of saline halotherapeutic treatment of sensitized wistar rats on xanthine oxidase reported the inhibition of xanthine oxidase, hence suppression of reactive oxygen species in the lungs. This provides evidence for the use of saline mineral water for use in respiratory disorders. Positive influence of microbial profile of TMWs on gut microbiota [15] may provide evidence for the use of TMWs to treat putrid diseases, malignant sore throat and scarlet fever.

8. Gynecological and Dermatological applications

Franke [30], in a randomized controlled trial (RCT) study on the effect of saline TMWs on psoriasis, noted that when these waters are diluted, they can be used as wash to relieve various cutaneous diseases and itching. In a report by Altman [31], drinking and bathing cures in saline TMWs were noted to therapeutically alleviate pediatric enuresis, respiratory infections and hypotrophy. Further indicated in the study was that in adults, saline waters heal certain skin diseases, gynecological disorders and disease of the central and peripheral nervous system.

9. Saline Thermal Mineral Water Balneotherapy and Hypertension

Generally, individuals are often recommended to reduce their salt intake in order to control hypertension. Low salt intake however, according to some data, increases cholesterol levels, which implies increased cardiovascular risk [32]. Hence a low-salt diet in conjunction with saline/chlorosodic mineral water may have beneficial biological effect on calcium homeostasis. In a randomized double-blind crossover trial by Schorr et al. [33], blood pressure reduction induced by dietary salt restriction can be abolished after consumption of saline/chlorosodic mineral waters. This gives evidence that in conditions of low-salt intake, sodium-chloride-rich mineral water consumption provides a beneficial biological response to the ensuing increased cardiovascular risk.

10. Conclusion

Use of thermal mineral water is a very rich historical therapeutic remedy having developed into a popular therapy in many countries of the world. The biochemical action of the water is usually linked to chemical, thermal, immunomodulatory and mechanical effects. Physicochemical data of the Nigerian spring waters revealed that these TMWs hold great promise for utilization in complementary cure for musculoskeletal disorders and other chronic diseases. There is need however to re-evaluate the properties of these hot springs using modern technologies. Major and minor elements need to be reanalyzed in-depth as well as testing for the presence medicinal gases such as hydrogen sulphide (H₂S), carbon dioxide (CO₂), mercury (Hg), methane (CH₄) and medicinal radioactive particles (e.g Ra) .

11 Conflict of Interests

The authors declare no interest conflicts.

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