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Review

Seawater Pools Versus Freshwater Pools to Treat Inflammatory Skin Diseases and Rheumatic Conditions: A Scoping Review

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Abstract: Seawater is a long-standing remedy against a number of skin or rheumatic conditions since ancient times, now popular in many countries, where spa, thalassotherapy and seawater pools have considerably boomed. Exposure to seawater and sunlight is an essential component of thalassotherapy, defined by any controlled interaction with marine environments and their natural elements, even in the absence of skin applications of algae, sands or muds. Seawater pools therefore offer the opportunity of thalassotherapy to patients unable to go the beach or during the winter months. The evidence from various studies seems to converge on combined exposure to solar radiation and seawater as a more effective approach than irradiation alone or bathing in freshwater followed by irradiation to reduce symptoms of inflammatory skin diseases or rheumatic conditions. An unwanted consequence of chlorine-based treatment of seawater is the formation of disinfection-by-products (DBPs) due to reactions of disinfectants with organic matter of anthropogenic origin released by bathers. Whilst chlorination of freshwater predominantly generates chlorinated DBPs, the prevailing species produced by chlorination of seawater pools are brominated DBPs, reportedly more genotoxic. However, despite greater toxicity of brominated DBPs, there is evidence that DBPs concentration in freshwater pools is significantly higher (probably due to the larger number of users) compared to seawater pools. Containing the number of bathers could therefore reduce the risk of exposure to DBPs in both types of pool. The outdoor location of pools can further contribute to reducing the risk of genotoxicity thanks to volatilization, airborne dispersion and photodegradation of some DBPs.

Keywords: seawater; freshwater; thalassotherapy; balneotherapy; swimming pools; spa; psoriaris; dermatitis; psoriatic arthritis

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1. Introduction

Spa treatments, thalassotherapy and seawater pools are booming today. This article focuses on identifying the benefits and risks of using seawater pools versus traditional freshwater pools for the management of chronic inflammatory skin diseases or rheumatic conditions. The present study was designed as a scoping review with the following general aims [1]:

- identifying the scientific evidence available from various fields;
- examining how research was conducted on a certain topic or field.

2. Methods

Scoping reviews are still a relatively new methodology, proposed by the JBI Scoping Reviews Methodology Group in 2022 [2].

In general, scoping reviews are commonly used for "reconnaissance"—to clarify working definitions and conceptual boundaries of a topic or field. Due to their name, scoping

reviews aim to identify and map the evidence available on a particular topic or concept. As such, scoping reviews are exploratory in nature and aim to address wide-ranging questions such as "*What evidence exists?*", as opposed to more focused questions such as "*What is effective?*". Scoping reviews are also flexible in their approach in terms of their focused area and allow to investigate various topics, concepts or issues across different sources of evidence. Following the JBI guidance, a key requirement of scoping reviews is to stipulate the "concept" reviewers are interested in. The concept (e.g., to compare seawater pools versus freshwater pools to treat inflammatory skin diseases or rheumatic conditions) details the focus and scope of the review in terms of its topic and may include the elements of a standard systematic review, such as interventions, phenomena of interest and outcomes. Scoping reviews are particularly useful when the evidence is extensive and widely dispersed (i.e., different types of evidence). Since they are agnostic in terms of the type of evidence, scoping reviews can be used to bring together heterogeneous literature—including both empirical and non-empirical evidence—across different disciplines within and beyond human health [3].

The following evidence from different scientific scopes was therefore considered for the present scoping review.

- Clinical-epidemiological (Sections 3.1–3.3);
- Microbiological (Section 3.4);
- Toxicological (Section 3.5).

The most appropriate publication for each scope was selected, reporting in detail the respective background, methods and findings.

In all sections PubMed and Google Scholar were the sources of evidence; the results of various studies were not pooled by statistical analysis.

3. Results

3.1. Thalassotherapy: The Evidence of Efficacy

The therapeutic uses of seawater date back to ancient Egypt and has now progressively become a long-standing remedy in many countries against a number of conditions. "*Thalassotherapy*", a Greek term combining the words "*thalassa*" (sea) and "*therapy*", is still empirically recommended today for patients with certain skin, rheumatic, osteoarticular or respiratory disorders. In general, thalassotherapy includes not only bathing in sea or sea-like salt water but also skin applications of algae or sand, exposure to sunlight, inhalation of marine aerosol and, more generally, any controlled interaction with marine environments and their natural elements for health promotion purposes [4]. Exposure to salt water and sunlight, environmental conditions offered by outdoor seawater pools, is therefore an essential component of thalassotherapy, even in the absence of skin applications of algae, sands or muds.

A recent literature review summarized the clinical efficacy of various applications of thalassotherapy [5]. The latter research was conceived as a narrative review of the scientific literature. PubMed was searched through 15 July 2021 for clinical studies on the efficacy of controlled exposure to marine or marine-like environments (e.g., salt lakes) for any health condition. The MeSH term "*thalassotherapy*" was used to retrieve relevant articles, narrowing down the study aims. The following PICOS criteria were chosen as inclusion and exclusion searching criteria:

- **P (population):** healthy subjects or patients with any disease diagnosed in accordance with international guidelines.
- **I (intervention**): thalassotherapy, defined as any controlled interaction with marine or marine-like environments and their natural elements for health promotion purposes.
- **C (comparison):** any type of comparison, including no controls.
- **O (outcome):** any measurable clinical improvement, including changes in symptom scores and health-related quality of life.

- **S (study design):** any type of clinical study involving human subjects. In vitro and in vivo laboratory experiments, as well as opinions, technical reports and literature reviews, were excluded.

Additionally, articles were ruled out when their full-text version was not available/not retrievable or their respective abstract in English was not available. Studies published before 1980 were also excluded, since they were considered outdated. The evidence collected was then summarized and critically discussed.

Overall, 560 articles were found, but only 152 studies were published after 1980. Eligible studies according to the PICOS criteria were 14 (Table 1), where clinical effectiveness of thalassotherapy was tested against the following health conditions:

- **Chronic skin disorders,** mainly psoriasis, but also atopic dermatitis and vitiligo;
- **rheumatic disorders**, such as fibromyalgia and ankylosing spondylitis.

Thalassotherapy included a combination of seawater balneotherapy (BT), climatotherapy (CT), controlled exposure to sunlight, physical exercises and rehabilitation programs. Treatment sessions were held in a variety of locations, from the Dead Sea (a highly salty lake) to the Atlantic Ocean. The duration of treatment was rather heterogeneous, with an average length ranging from 3 to 6 weeks. The results highlighted how thalassotherapy could significantly improve the severity of symptoms and quality of life of several health conditions. Only six studies employed a control group, while others had an observational or pre-post design.

Table 1. Summary of the evidence of studies on the efficacy of thalassotherapy against various conditions (Antonelli 2021 [5]).

Study Population (Author Year [Reference])	Intervention	Place	Control	Length of Treatment	Outcome	Study Design
Psoriasis						
18 adults (Emmanuel 2020 [6])	C-BT	Dead Sea	/	4 weeks	↓ disease severity	Pre-Post
254 adults (Wahl 2015 [7])	C-BT	Sea, Canary Islands	/	3 weeks	↓ disease severity	Pre-Post
17 children (Ben-Amitai 2009 [8])	C-BT	Dead Sea	/	2 weeks	↓ disease severity	Pre-Post
85 adults (Cohen 2008 [9])	C-BT	Dead Sea	/	>5 days	↓ disease severity	Pre-Post
64 adults (Harari 2007 [10])	C-BT	Dead Sea	/	4 weeks	↓ disease severity	Pre-Post
70 adults (Cohen 2005 [11])	C-BT	Dead Sea	/	>5 days	↓ disease severity	Pre-Post
10 adults (Nissen 1998 [12])	C-BT	Dead Sea	/	4 weeks	↓ disease severity ↑ encephalin levels	Pre-Post
Atopic dermatitis						
116 children (Marsakova 2020 [13])	C-BT	Dead Sea	Steroid	4 weeks	↓ disease severity	RCT
30 adults (Proksch 2005 [14])	BT with Dead Sea minerals		Tap water	6 weeks	↓ TEWL ↓ skin inflammation	RCT
Vitiligo						
436 adults (Czarnowicki, 2011 [15])	C-BT	Dead Sea	/	Variable	↑ skin pigmentation	ORS
Ankylosing spondylitis						
107 adults (Staalesen 2011 [16])	RT	Sea, Turkey	Same program in Norway	4 weeks	↑ spinal mobility ↓ symptoms	RCT

Table 1. *Cont.*

Study Population (Author Year [Reference])	Intervention	Place	Control	Length of Treatment	Outcome	Study Design
Fibromyalgia						
46 Adults (de Andrade 2008 [17])	C-BT + exercise	Sea, Brazil	Same program but in pool	12 weeks	↑ QoL ↓ pain ↑ mood	RCT
134 adults (Zijlstra 2007 [18])	C-BT + Standard of care	Sea, Tunisia	Standard of care	2 weeks 1/2	↑ QoL ↓ pain	RCT
58 adults (Zijlstra 2005 [19])	C-BT + exercise	Sea, Tunisia	Standard of care	2 weeks 1/2	↑ QoL ↓ pain ↑ mood	RCT

Note: BT: balneotherapy; C-BT: climato-balneotherapy; PASI: Psoriasis Area Severity Index; QoL: quality of life; RT: rehabilitation therapy (in a thalassotherapy center); TEWL: trans-epidermal water loss. ↑: significantly increase; ↓: significantly decrease; RCT = randomized controlled trial; Pre-Post: pre-post study design; ORS = observational retrospective study.

In conclusion, thalassotherapy was associated with clinical improvements against some conditions, with benefits lasting up to 90 days after treatment in the case of psoriasis. Some concerns were expressed on the long-term clinical safety of this therapeutic practice—in particular, due to risk of skin cancer from exposure to sunlight associated with outdoor bathing. In this regard, it is essential to undergo a medical check-up before a thalassotherapy treatment course, strictly following the recommendations of healthcare professionals to avoid excessive exposure to ultraviolet (UV) radiations.

3.2. Artificial Regimes Mimicking Natural Climatic Conditions

There is evidence to support thalassotherapy for the improvement of several conditions, particularly chronic inflammatory and degenerative disorders, with benefits attributable to the combined action of different natural components (seawater and climatic conditions). Since thalassotherapy is linked to specific natural environments, treatment regimens combining synthetic saline solutions or saline thermal water and artificial ultraviolet B rays (UVB) have been developed to replace natural climatic conditions and treat moderate or severe psoriasis. In balneophototherapy (BPT), seawater at different concentrations and mineral compositions is applied in the form of hot water baths during (simultaneous application) or before (sequential application) UVB irradiation.

Only a few controlled studies, featured by a limited number of patients, evaluated the effectiveness of CT/BPT compared to exposure to sun/UVB alone against psoriasis. Three non-randomized controlled studies (non-RCT) identified the superiority of CT [20] or BPT over sun exposure/UVB alone [21,22], while two randomized controlled trials (RCTs) reported no benefit [23] or only a marginal benefit of BPT using highly concentrated salt water versus UVB alone [24].

Three studies on very limited samples, comparing saltwater baths at different concentrations (including tap water), showed no higher beneficial effect with increasing saline concentration of water [21,25,26]. Another RCT on 30 patients reported greater effectiveness of Dead Sea saltwater baths composed of different minerals, including magnesium, potassium and calcium, compared to common sodium chloride baths at the same osmolality [27]. Another small RCT on 40 patients with psoriasis and atopic dermatitis reported a 15% higher efficacy of Dead Sea BPT compared to 3% sodium chloride BPT [28]. A systematic review published in 2000 suggested that BPT is more effective than UVB alone to treat psoriasis, regardless of salt concentration or mineral composition [29].

Finally, a RCT evaluated the effectiveness of low-concentration saline thermal water baths followed by UVB (sequential treatment) compared to UVB rays alone (controls) on 164 patients with psoriasis, randomized as follows: 81 assigned to the group intervention and 83 to the control group [30]. The intervention involved three weekly sessions of low-concentration saline thermal water baths followed by UVB or three weekly sessions of UVB

alone until remission or for a maximum of 6 weeks of treatment. The concentrations of sodium chloride from natural sources ranged between 4.5% and 12%. Conventional UVB (broadband UVB or selective UVB phototherapy) was used for irradiation [30]

The Psoriasis Area Severity Index (PASI) is a clinical and internationally accepted outcome measure to assess the severity of psoriasis, considering the body surface area affected by the disease and a semi-quantitative estimate of erythema, skin infiltration and desquamation. PASI is by far the most common tool to assess psoriasis in clinical trials and real life. PASI-50 (50% improvement in PASI) is commonly considered a relevant clinical achievement.

Since a double-blinded study was not feasible (due to the nature of interventions), a study blinded to PASI assessors (who therefore were unaware of the assignment of patients to the study group) was conducted. Whilst photo-therapists of wellness centers knew the assignment of each patient, both patients and photo-therapists were instructed not to inform PASI assessors or other staff about the study group [30].

The primary outcome measure was PASI-50 during the intervention period.

The increase in absolute benefit (experimental event rate minus control event rate) of PASI-50 was calculated by study subgroup, light source, salinity, season and blindness condition of treatment. Subgroup–treatment interactions were tested via logistic regression [30].

At the end of the intervention, patients assigned to sequential treatment (BT followed by UVB irradiation) achieved an increase in absolute benefit of 73% (=58/79) compared to 50% (=32/64) observed in patients assigned to UVB only ($p = 0.01$). The health benefit persisted for up to 3 months.

The results by subgroup were as follows [30].

- **Light source.** A 30% (0.65–0.35; N = 66) increase in absolute benefit (ABI) for patients irradiated by selective UVB phototherapy compared to 28% (0.64–0.36; N = 73) in those irradiated with broadband UVB.
- **Salinity.** A 35% ABI (0.64–0.29; N = 65) in patients who had bathed in saline thermal water at a concentration of 4.5–10% against 18% (0.65–0.47; N = 78) ABI in patients bathing in 12% saline thermal water.
- **Season**. Better clinical outcome (ABI: 36%; 0.68–0.32; N = 27) in patients treated during the summer compared to those treated in the winter (ABI: 26%; 0.63–0.37; N = 133).
- **Blindness to the study group**. For the subgroup of patients whose PASI assessors were unaware of their treatment assignment, the ABI in the sequential treatment group was 34% (0.70–0.36; N = 65) compared to the controls, whereas it was 28% (0.60–0.32; N = 64) for the group of patients whose PASI assessors knew the treatment assignment.
- **Interaction test**. Subgroup–treatment interaction tests yielded no significant effects (p-values ranging from 0.33 to 0.43).
- **Safety**. Adverse events were reported in six patients, three in each group. No serious or irreversible adverse reactions were observed.

According to the above findings, the additional benefit of thermal saline water baths was not influenced by the type of UVB source. Patients receiving 4.5% to 10% saline thermal water baths benefited more from BFT than those receiving 12% saline thermal water baths, a finding difficult to interpret because the different mineral compositions of natural springs were likely sources of distortion. Surprisingly, BFT was more effective during the summer than winter, probably reflecting under-dosed therapy in winter months [30].

In conclusion, there is evidence that a 6-week treatment course of thermal saline water baths followed by conventional UVB is more effective than conventional UVB alone for the treatment of moderate/severe psoriasis. Mechanisms of action of high-concentration salt water or salt components other than sodium chloride, including magnesium, have been hypothesized. However, the beneficial mechanism of action of BFT with water at a low concentration of sodium chloride remains unclear.

3.3. Phototherapy After Bath with Salt Water, Tap Water or Water with Psoralen

A milestone in the treatment of psoriasis was photo-chemotherapy (FCT) with psoralen-UVA (oral PUVA) irradiation introduced by Parrish and colleagues [31], who exploited the photosensitizing effect of methoxsalen and consecutive irradiation with UVA. Oral PUVA, which has become the therapeutic standard, especially against severe psoriasis can, however, be accompanied by various systemic adverse effects, such as nausea, vomiting, headache or hepatotoxic effects induced by methoxsalen, as well as from the risk of photo-carcinogenesis, cataract formation and generalized photosensitization lasting approximately 24 h and requiring photo-protection [32,33].

Fischer and Alsins [34] developed the so-called PUVA bath, in which psoralen derivatives as trimethoxypsoralen or methoxsalen are dissolved in a hot water bath. Bath administration of psoralen prevents systemic adverse effects associated with oral PUVA. A PUVA bath has the advantage of selective and shorter photosensitization [35], significantly reducing the cumulative exposure to UVA rays [36] and avoiding the typical variations in the therapeutic effect of psoralens due to inter-individual differences in their gastrointestinal absorption [37,38]. A large Scandinavian retrospective analysis reported that PUVA bathing with trimethoxypsoralen only marginally increased the risk of long-term carcinogenicity [39,40]. In recent years, PUVA bathing has increasingly replaced oral PUVA in Germany and other European countries [41].

The efficacy of psoralens dissolved in a hot water bath, followed by exposure to UVA (PUVA bath), was evaluated by comparing salt water immersion followed by UVB phototherapy (salt water phototherapy, SW-UVB) versus tap water bath followed by UVB phototherapy (tap water phototherapy, TW-UVB) or UVB irradiation alone [41]. The aforementioned study was multicenter, prospective, randomized, controlled with four parallel groups and was conducted in 102 dermatology clinics on a total number of 1241 patients with stable psoriasis vulgaris, using a PASI score ≥ 7 as relevant clinical endpoint. As mentioned above, the interventions in the four parallel groups were UVB, TW-UVB, SW-UVB or PUVA baths four times a week, with baths preceding UV irradiation for up to 8 weeks. Patients were photo-tested before photo-treatment, adapting the UV dose to the erythematous response [41]. The primary outcome was a PASI-50 during the intervention period [41].

The median PASI reduction was 44% for UVB (IQR: 18–72%; N = 264), 62% for TW-UVB (IQR: 33–82%; N = 272), 76% for SW-UVB (IQR: 51–91%; N = 291) and 84% for PUVA bath (IQR: 57–93%, N = 297). PUVA baths and SW-UVB were comparably effective against psoriasis, both proving superior compared to TW-UVB or UVB irradiation alone [41].

3.4. Pathogens in Seawater, Rivers and Swimming Pools

The human skin is populated by microorganisms, especially Gram-positive bacteria (cocci) such as *Staphylococcus aureus* and fungi. Immersion in water can spread these microorganisms in the aquifer medium, with possible transmission to other susceptible bathers, especially in the presence of skin lesions or vulnerability conditions. Furthermore, intestinal bacteria such as Escherichia coli can also be released into water [42]. That is why disinfectants such as chlorine are used in swimming pools [43].

A number of factors can influence the ability of microorganisms to colonize new hosts, including the volume of water (dilution factor), frequency of pool refilling, number of bathers, nature of the skin wound/dermatitis and level of microbial contamination of the water [43]. However, water salinity seems not to play a role in the inactivation of pathogens, as highlighted by a study in vitro [42].

In a more recent study in vitro, 14 different strains of Methicillin-resistant *Staphylococcus aureus* (MRSA) responsible for nosocomial (HA-MRSA) or community (CA-MRSA) outbreaks were inoculated into different water microcosms until obtaining log10 (105) colony-forming units. The samples were then stored in the dark at room temperature for 14 days. None of the 14 MRSA strains were able to survive in chlorinated water at a concentration of 2.90 ppm, but all could survive up to 14 days in river water or seawater [43]. There

were no significant survival differences between CA-MRSA and HA-MRSA in any aquatic environment, but all MRSA died off more rapidly in rivers than in seawater, with decimal reduction (D10) scores of 3.53 and 7.4 days for rivers and seawater, respectively [43]. The latter study confirmed that both seawater and river water can serve as a potential reservoir of HA- and CA-MRSA, if such mediums are contaminated by these pathogens [43]. However, swimming pool chlorination allows to remove this biological risk.

3.5. Disinfection and Genotoxicity Byproducts in Freshwater or Seawater Swimming Pools

Seawater pools can be found in thalassotherapy resorts, a rapidly expanding sector of spa tourism [44]. Whilst originally involving the therapeutic use of seawater and natural marine environments, modern thalassotherapy resorts now offer swimming pools filled with seawater treated with disinfectants, similar to freshwater swimming pools, to remove water-borne pathogens and prevent potential outbreaks [45,46]. In France, regulations recommend a level of free residual chlorine in water ranging between 0.4 and 1.4 mg/L when sodium hypochlorite (common bleach) or chlorine gas is used as a disinfectant, regardless of type of water in the swimming pool [47].

An unwanted consequence of water chlorination is the formation of disinfection by-products (DBPs), due to reactions between the disinfectant and organic matter of anthropogenic origin present in swimming pool water. The speciation of DBPs varies depending on the nature of the water in swimming pools. Although all pools use chlorine for disinfection, brominated DBPs are the predominant species formed in seawater pools, whereas chlorinated DBPs are the prevailing species in freshwater pools. Chlorine oxidizes bromide ions to form hypo-bromous acid and hypo-bromite ions, which, in turn, react with organic matter to form brominated DBPs [48]. Bromine reacts 10 times faster with organic matter than chlorine [49]. Seawater swimming pools featuring concentrations of bromide ions up to 65 mg/L are therefore more likely to generate brominated DBPs as the predominant species after chlorine treatment [50].

Brominated DBPs have demonstrated substantially greater toxicity than chlorinated analogs [51–54]. In particular, chronic exposure to high levels of DBP is associated with adverse effects, including irritation of mucous membranes (eyes, skin, nose and throat) [55,56] and detrimental repercussions on the reproductive system [57,58]. Many identified DBPs have also been reported as genotoxic and carcinogenic [52], increasing, for instance, the risk of bladder cancer [59,60].

Since data on the presence of DBPs and mutagenicity of the water in swimming pools are very scarce; some investigations were conducted to assess the presence of DBPs in swimming pools filled with freshwater, identifying more than 100 species [60–64]. Indeed, one study reported that water samples obtained from chlorinated and brominated freshwater swimming pools in Barcelona had mutagenic activity at Ames test against Salmonella [65].

Given concerns about the toxicological risk associated with exposure to brominated DBPs and the paucity of data on their presence in seawater pools, one study examined three seawater pools and one freshwater pool to qualitatively and quantitatively estimate the DBP concentration and assess their respective genotoxic risk by Salmonella test (Ames test) [66]. The latter study was conducted in two thalassotherapy resorts, called E1 and E2, located on the French Riviera (Southeastern France). Resort E1 had one outdoor pool filled with freshwater and one indoor pool filled with seawater, whereas E2 had two indoor pools filled with seawater. All seawater pools were filled with water from the Mediterranean Sea. Disinfection treatment involved automated addition of sodium hypochlorite (NaOCl) to maintain a constant level of free residual chlorine in the pools. The swimming pools were equipped with sand filters in order to remove particulates and pollutants [66].

In the above study, the predominant DBPs identified in freshwater pool were chlorinated species and included trichloroacetic acid, chloral hydrate, dichloro-acetonitrile, 1,1,1-trichloropropanone and chloroform. In seawater pools, brominated DBPs were the prevailing species and included dibromo-acetic acid, bromoform and dibromo-acetonityl. In both types of pools, haloacetic acids were the most prevalent chemical form of DBPs

detected. The distribution of other DBP groups varied depending on the type of pool [64]. Overall, freshwater pools (948 µg/L) exhibited a much higher DBP concentration than seawater pools (208 µg/L, SD = 31) [66]. Since the management of swimming pools is similar, as reported by operators of the same facilities, the difference in DBP concentration seems attributable to different rates of users of the two types of pools. In particular, users of freshwater pools significantly outnumbered bathers of seawater pools. Recently, Keuten et al. estimated significant releases of anthropogenic organic matter and nitrogen-containing compounds in the water from bathers of swimming pools [67]. It is known that the continuous introduction of organic matter into swimming pools from bathers increases the formation of DBP [68], and a significant positive correlation was observed between the number of users in swimming pools and DBP concentrations [69].

Regarding genotoxicity, water samples from freshwater pools showed higher mutagenic activity (3.7 rev/mL-Eq) than seawater pools, which was found to be weakly mutagenic (0.4 rev/mL-Eq). Although brominated DBPs are generally known to be more genotoxic than chlorinated ones [52,53,70,71], the higher mutagenicity of freshwater pools should not be surprising. This type of pool, mainly containing chlorinated DBPs, exhibited significantly higher DBP contents than the seawater pools, mainly containing brominated DBPs. As confirmed by chemical analysis, the freshwater pool had approximately six times higher DBP molar content (total DBP molar concentration: 5.69 µMol/L) than the seawater pools (total DBP molar concentration: 0.91 µMol/trihalomethanes (THM).

Furthermore, the water genotoxicity can be influenced by location of the pool, since an outdoor environment reduces the genotoxic properties of waters due to volatilization and photodegradation of some DBPs [72,73]. However, despite the outdoor location, the freshwater pool exhibited a greater mutagenicity risk than an indoor seawater pool due to the higher number of users. This suggests that, by influencing DBP concentrations, the attendance rate of swimming pools is a key determinant of water genotoxicity, prevailing over other risk factors such as type of water or location of the pool (outdoor versus indoor) [66].

Containing the number of bathers could therefore decrease the risk of exposure to DBPs in both types of pool. Furthermore, in order to further reduce the release of organic matter and subsequent DBP concentration, users should be clearly recommended to adequately shower before entering the pool, avoiding also urinating while bathing.

4. Discussion

4.1. Summary of Evidence

Seawater is a long-standing remedy against several inflammatory chronic skin disorders or rheumatic conditions since ancient times, now popular in many countries, where spas, thalassotherapy and seawater pools have considerably boomed.

There is evidence that thalassotherapy, defined as any controlled interaction with seawater and natural elements of marine environments for health promotion purposes, is effective against a range of conditions, particularly chronic inflammatory and degenerative disorders, with beneficial effects lasting up to 90 days in the case of psoriasis, thanks to a combined activity of different components (seawater as well as climatic conditions).

The efficacy of seawater against psoriasis was confirmed by experimental studies (RCT) using sequential exposure to artificial agents such as salt water baths and UVB. The combined treatment of seawater and UVB for 6 weeks exhibited higher efficacy than irradiation alone or bathing in freshwater combined with irradiation. A multicenter RCT with four parallel study groups, conducted across 102 dermatology clinics for a total number of 1241 patients, showed that the efficacy of salt water baths followed by UVB was not significantly inferior to PUVA baths.

4.2. Limitations

No Phase IV studies have been conducted so far on safety of the therapeutic use of seawater against inflammatory skin or rheumatic conditions, because recruiting a large and

diverse patient population and maintaining their treatment compliance over long periods of time can be a hurdle.

Some health risks can occur following exposure to seawater and/or UV irradiation. In particular, chlorination of seawater pools remains an essential intervention to prevent colonization of water by pathogens released by swimmers. An unwanted consequence of chlorine-based treatment of seawater is the generation of DBPs due to the reaction of disinfectants with organic matter of anthropogenic origin released by bathers. Whilst chlorination of freshwater predominantly generates chlorinated DBPs, the prevailing species produced by chlorination of seawater pools are brominated DBPs, more (geno)toxic. Despite greater toxicity of brominated DBPs, there is evidence that the DBPs concentration in seawater pools is significantly lower (probably due to smaller number of users) compared to freshwater pools. Containing the number of bathers could therefore reduce the risk of exposure to DBPs in both types of pool. Moreover, the outdoor location of pools can contribute to decrease the risk of genotoxicity thanks to volatilization, airborne dispersion and photodegradation of some DBPs. Pool users should be clearly advised (also with signals) to adequately shower before entering the water, refraining also from urinating while bathing.

A medical check-up before any thalassotherapy treatment course, strictly following recommendations by healthcare professionals, is essential to avoid excessive exposure to UV radiations.

Some patients with psoriasis develop a relatively stable clinical pattern, whereas several others experience flares during the summer. A flare develops when skin inflammation increases and symptoms of psoriatic disease worsen, spreading also to other body areas. Flares—triggered by different factors varying from person to person—can be long or short in duration, mild or severe and frequent or rare.

Whilst warm weather typically contributes to improved psoriasis symptoms, reducing joint pain and stiffness in patients with psoriatic arthritis, some outdoor activities performed under warm weather conditions such as walking, hiking or swimming, may trigger disease flares. According to the National Psoriasis Foundation (NPF), swimming in salt water can help remove dead skin and improve the clinical pattern of psoriasis. Rinsing off and moisturizing the skin after swimming reduces the dryness developed after exposure to salty and chlorinated water. However, soaking in the pool for too long can worsen psoriasis symptoms. Likewise, whilst moderate exposure to UV sun radiation (max 10–15 min each time) can improve psoriasis symptoms, prolonged exposure time can worsen skin lesions [74]. Therefore, the spontaneous development of acute symptoms may limit the length of exposure to salt water and radiation in seawater swimming pools.

5. Conclusions

The above evidence supports seawater against freshwater pools for the treatment of chronic inflammatory skin disorders or rheumatic conditions.

The risk of exposure to either DBPs or UV radiation in outdoor seawater pools seems negligible and outweighed by the beneficial effects of salt water against skin and rheumatic conditions.

Seawater pools offer the opportunity of exposure to salt water for treatment purposes during the winter months or to patients or individuals unable to go the beach.

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Abbreviations

ABI	Absolute Benefit Increase
BPT	Balneophototherapy
BT	Balneotherapy
CA-MRSA outbreaks	Community-associated MRSA outbreaks
C-BT	Climato-balneotherapy
CT	Climatotherapy
DBP	Disinfectant-by-products
FCT	Photochemotherapy
HA-MRSA outbreaks	Healthcare-associated MRSA outbreaks
IQR	Interquartile range
MRSA	Methicillin-resistant Staphylococcus aureus
NPF	National Psoriasis Foundation
ORS	Observational retrospective study
PASI	Psoriasis Area Severity Index
PsA	Psoriatic arthritis ()
PUVA	Psoralen Ultraviolet A rays
RCT	Randomized Controlled trial
RT	Rehabilitation therapy
SCORAD	Scoring Atopic Dermatitis
SW-UVB	seawater (followed by) UVB phototherapy
TEWL	Trans-Epidermal Water Loss
TW-UVB	Tap water (followed by) UVB phototherapy
UVA	UVA rays
UVB	UVB rays

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