



## The Implementation Potential of Innovative Technologies in Czech Spa Care

<sup>1\*</sup>Magdalena VERESKOVA, <sup>2\*</sup>Alexandra ZACHOVÁ TICHÁ, <sup>2</sup>Marek MARÁČEK, <sup>3</sup>Alina HUSEYNLI

<sup>1</sup> Medical and healthcare sciences coordinator, Institute of Spa and Balneology, Závodní 353/88, 360 06 Karlovy Vary, Czech Republic

<sup>2</sup> Researcher in medical sciences, Institute of Spa and Balneology, Závodní 353/88, 360 06 Karlovy Vary, Czech Republic

<sup>3</sup> Director of Institute of Spa and Balneology, Závodní 353/88, 360 06 Karlovy Vary, Czech Republic

\*Corresponding authors: [vereskova@i-lab.cz](mailto:vereskova@i-lab.cz); [ticha.zachova@i-lab.cz](mailto:ticha.zachova@i-lab.cz)

### SUMMARY/ABSTRACT

**Starting point:** Czech spa medicine is deeply rooted in history and holds a prominent position within the European context. Nevertheless, in recent years it has been facing increasing challenges, including an ageing traditional clientele, staffing shortages, limited funding, and growing competition from wellness facilities that do not utilize natural healing resources. These developments highlight the importance of innovation and the implementation of modern technologies as a way to ensure sustainability, improve competitiveness, and meet the changing demands of healthcare and tourism.

**Methods:** This article is designed as a narrative review study focusing on the potential integration of modern technologies into the spa care sector in the Czech Republic. Database searches were conducted in PubMed, Scopus, Web of Science, ScienceDirect, and SpringerLink focusing on peer-reviewed journal articles and reviews published between 2015 and 2025.

**Results:** The review identified technologies with the highest therapeutic and application potential for spa care: high-intensity laser therapy, magnetotherapy, robotic mechanotherapy, virtual reality, telemedicine, and wearable devices. These modalities show positive effects in the treatment of musculoskeletal and neurological disorders, pain reduction, rehabilitation outcomes, and mental health support.

**Conclusions:** A promising way forward lies in the synergistic integration of traditional balneotherapeutic procedures with modern technologies, which may enhance the effectiveness, individualization, and attractiveness of spa care. This integrated approach can contribute to long-term sustainability, address staffing challenges, and improve competitiveness in both domestic and international healthcare and wellness markets. Future research should focus on generating evidence from spa-specific clinical studies, validating synergistic therapeutic effects, and supporting strategic innovation investments through interdisciplinary collaboration.

\*\*The German version of the abstract is attached at the end of the text.

### KEYWORDS

Spa medicine; physical therapy; balneotherapy; laser therapy; HILT; magnetotherapy; virtual reality; telemedicine; health innovation; health tourism.

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## 1 INTRODUCTION

The Czech spa sector represents not only a vital component of the national public healthcare system but also serves as a cultural, historical, and economic pillar of a distinct form of tourism. Despite its relatively small size, the Czech Republic has long ranked among the European leaders in balneology. This strong position is attributed to the country's extensive capacity for spa treatment, abundance of natural healing resources, well-developed infrastructure, and the unique integration of therapeutic practices with architecture, landscape, and social life<sup>1</sup>. The consistently high quality of spa-based medical care and the richness of natural resources have established the Czech Republic as a key actor within the broader European spa tradition<sup>1,2</sup>.

In recent years, however, Czech spa institutions have faced a growing range of challenges that have affected both the structure and sustainability of this sector. These include limited funding from public health insurance providers, a decreasing proportion of insured clients—which has prompted a gradual shift toward a higher reliance on self-paying clientele—a persistent shortage of qualified personnel, an ageing client base, and increasing competition from wellness facilities that do not utilize natural healing resources<sup>1</sup>. These trends threaten the stability of the spa industry and necessitate a search for new approaches that can ensure its future relevance and competitiveness.

Innovation has emerged as a key instrument in this process. In spa care, as in other areas of healthcare, innovation can enhance competitiveness, improve resilience in crisis situations, and allow more efficient utilization of available resources. Innovations may yield benefits not only at the procedural and economic levels but also in legislation, regulation, and strategic management. Considering the growing demands of clients, the increasing incidence of lifestyle-related chronic conditions, and the ongoing modifications in spa care reimbursement schemes, the capacity to adapt and innovate has become an essential prerequisite for the sustainable development of Czech spa medicine<sup>3</sup>.

The present article therefore focuses on identifying and analyzing the key challenges and opportunities related to the implementation of modern technologies into Czech spa care. Special attention is devoted to the potential for long-term sustainability, the ongoing process of digitalization, and the growing expectations of clients. The review seeks to systematically assess the implementation potential of innovative technologies in Czech spa medicine, with a particular emphasis on therapeutic methods. The focus is on physical therapy modalities (therapeutic lasers, magnetotherapy, robotic mechanotherapy), the applications of virtual reality in rehabilitation, telemonitoring of clients' health status, and the integration of these modern tools with traditional balneotherapy.

Although only a limited number of scientific studies currently address innovative technologies specifically within the context of spa care, several emerging approaches suggest that combining traditional balneotherapeutic procedures with modern therapeutic modalities could generate synergistic effects. However, a lack of robust clinical evidence from spa-specific settings remains a critical gap. This article therefore aims to serve as a starting point for further research and development on the role of innovative technologies in spa medicine, particularly in relation to their synergistic potential when combined with traditional therapeutic approaches.

## 2 METHODS

This article is designed as a narrative review study focusing on the potential integration of modern technologies into the spa therapeutic care sector in the Czech Republic. Its primary objective was to identify technological approaches that appear both relevant and potentially beneficial for spa medicine, particularly in terms of sustainability, efficiency, accessibility, and competitiveness.

Systematic searches were conducted in PubMed, Scopus, Web of Science, ScienceDirect, and SpringerLink databases on June 2025. The search period was restricted to articles published between 2015 and 2025. Emphasis was placed on peer-reviewed journal articles and review studies. Additional sources included publicly available documents such as statistics from the Czech Statistical Office (CSO), the Institute of Health Information and Statistics (IHIS), relevant grey literature, and applicable legislation. Older publications were included selectively if they provided foundational theoretical contributions or enduring conceptual relevance.

The following search terms and their combinations were applied: spa; spa treatment; balneology; balneotherapy; modern technologies in rehabilitation; telemedicine; telemonitoring; high-intensity laser therapy;

magnetotherapy; virtual reality in physiotherapy; robotic mechanotherapy; innovation in spa care; Czech spa.

Inclusion criteria: Studies addressing modern technological applications in rehabilitation, physical therapy, spa medicine, or balneology; articles in English or Czech; original research, systematic/narrative reviews, or meta-analyses; studies with direct relevance for spa care. Exclusion criteria: Publications prior to 2015 (except foundational references), studies unrelated to healthcare or rehabilitation technologies, non-peer-reviewed articles (excluding grey literature of regulatory or statistical relevance).

A total of 86 sources were selected based on relevance, scholarly quality, and direct connection to the topic. Of these, 52 publications derived from clinical studies and original investigations, while 31 were review articles. Sixty-three of the included sources were published between 2020 and 2025, reflecting the currency of available evidence.

The review focused on technologies presumed applicable within spa therapeutic environments, including High-Intensity Laser Therapy (HILT), magnetotherapy, virtual reality (VR), robotic mechanotherapy, telemedicine and telemonitoring, and wearable technologies. Balneotherapeutic methods were reviewed separately, with attention to their limitations under Czech legislation (Act No. 164/2001 Coll., Spa Act). Each technology was examined in terms of its usability in spa settings, potential patient benefits, and alignment with the current challenges facing Czech spa medicine.

The study did not aim to provide quantitative outputs but rather developed a conceptual framework for the potential transformation and innovation of Czech spa therapeutic care. Findings were synthesized narratively, with emphasis on clinical applicability, feasibility of integration into spa practice, and identification of barriers and opportunities for further development.

This methodological approach allows for a broad yet systematic understanding of the innovation potential of modern technologies in Czech spa care, forming a foundation for subsequent applied research.

### **3 STARTING POINT, OBJECTIVE, TASKS**

Currently, more than 30 towns and municipalities in the Czech Republic hold the status of a spa location, with a total of 36 sites offering spa-based therapeutic and rehabilitative care<sup>2</sup>. Spa locations in the Czech Republic are unevenly distributed, primarily depending on the presence of natural therapeutic resources. The highest concentration of spa towns is found in the southeastern part of the country, particularly in the Olomouc Region, which is home to seven officially recognized spa sites. The second most significant concentration is located in the western part of the country, especially in the Karlovy Vary Region, known for the so-called West Bohemian Spa Triangle. This includes the towns of Karlovy Vary, Mariánské Lázně, and Františkovy Lázně, which have been inscribed on the UNESCO World Heritage List. Smaller numbers of spa towns are also situated in southern and northern Bohemia and across the Moravian regions<sup>2</sup>.

The Czech Republic possesses a broad range of natural healing resources, including various types of mineral waters (cold, thermal, carbonated, sulfuric, ferrous, etc.), peloids (peat and mud), natural carbon dioxide springs, and specific climatic conditions<sup>4</sup>. These resources are considered state property, and their extraction, use, and protection are regulated by law<sup>5</sup>.

Spa therapeutic rehabilitative care (spa care) represents a comprehensive physician-supervised therapeutic approach, implemented within a spa location and utilizing local natural healing resources. This care is typically supplemented by medical rehabilitation, physiotherapeutic methods, dietary management, climato-therapy, necessary pharmacotherapy, psychotherapy, and elements of health education<sup>6</sup>.

Spa care in the Czech Republic is an integral component of the public health insurance system, with its financing legislatively defined through the so-called Indication List for Spa Therapeutic Rehabilitative Care<sup>7</sup>. Two primary reimbursement models are distinguished: Comprehensive Spa Care, which is fully covered by public health insurance and includes treatment, accommodation, and meals, typically for a period of 21–28 days; and Contributory Spa Care, in which only the medical treatment component is reimbursed by the health insurance provider, while accommodation and board are paid by the patient. Both must be prescribed by a general practitioner or a medical specialist. A third category comprises self-paying clients, who cover the full cost of care and typically attend spa stays without a physician's referral<sup>8</sup>.

According to data from the Czech Statistical Office, a total of 287,958 clients received treatment in Czech spas in 2023. Of these, 95,585 patients were treated under public health insurance, while 192,373 were self-paying clients, including 101,228 foreign visitors. However, self-paying guests typically have shorter stays compared to those reimbursed by health insurance, with the average length of stay ranging from 7 to 10 days<sup>9</sup>.

### 3.1 CHALLENGES AND TRANSFORMATIONAL PRESSURES IN CZECH SPA CARE

Despite its deep-rooted tradition and stable institutional framework, the Czech spa sector has faced a number of significant challenges over the past decade, influencing both its strategic direction and day-to-day operations. One of the key issues is the ongoing personnel crisis, particularly concerning medical staff, for whom employment in spa facilities is often not considered attractive. The shortage of qualified physicians, physiotherapists, and nurses limits the sector's ability to expand and modernize services. Another pressing problem is the insufficient pace of digitalization in spa operations and administrative processes. The lack of digital integration and implementation of modern technologies reduces operational efficiency, diminishes the appeal of services in both domestic and international markets, and undermines overall competitiveness<sup>10</sup>.

A major threat to the sector is the high degree of dependency on public health insurance reimbursements, which limits financial autonomy and constrains innovation capacity. A critical factor for long-term sustainability lies in shifting strategic focus toward self-paying clients—both domestic and international—whose expectations often differ significantly from those of patients whose spa treatment is funded by health insurance. Furthermore, the absence of systematic research and the lack of scientifically validated evidence on the therapeutic effects of spa care—grounded in the principles of evidence-based medicine—continue to hinder the integration of spa treatments into modern medical practice<sup>1</sup>.

An important source of competition for traditional spa facilities in the Czech Republic comes from so-called wellness hotels. The concept of wellness as part of the accommodation strategy began to emerge in the Czech Republic in the 1990s and has been developing dynamically ever since. The popularity of wellness continues to grow, making it a promising field for entrepreneurial activity<sup>2</sup>. Many spa facilities now offer these services in the form of so-called medical wellness programs, which incorporate natural healing resources and traditional therapeutic approaches into wellness packages.

One of the most significant recent challenges was the COVID-19 pandemic, which served as a major disruptive factor for tourism development and also influenced local and regional development processes<sup>11</sup>. The spa sector was unprepared for such a crisis, which exposed structural vulnerabilities and triggered major disruptions in operational, personnel, and financial management. Key reactive measures adopted in response included the reorganization of human resources, often involving reductions in staff across all levels of spa operations. Budget cuts were also implemented, particularly in marketing communication, and strict epidemiological standards were introduced<sup>12</sup>.

At the same time, this destabilizing period created an opportunity to re-evaluate traditional approaches and initiate innovation processes. The crisis accelerated the need for strategic changes and the adoption of modern tools in the spa sector<sup>11</sup>. The necessity to adapt to new circumstances highlighted the importance of

innovation not only in medical procedures but also in operational management, digital communication, and service delivery.

To continue fulfilling its dual role in healthcare and tourism, and to maintain service quality, client loyalty, and appeal for new clientele, the Czech spa sector must respond to these challenges with a comprehensive and forward-looking approach. Investments in development are essential. A pleasant environment, qualified personnel, modernization of technologies, and overall service quality are fundamental to customer satisfaction and, therefore, to maintaining competitiveness<sup>13</sup>.

## 4 REVIEW OF MODERN AND INNOVATIVE TECHNOLOGIES IN SPA CARE

One of the most fundamental and distinctive features of Czech spa care is its complexity.<sup>4,6</sup> Innovation potential therefore arises naturally within each of these therapeutic components. Although spa care encompasses a broader spectrum than health services alone, spa therapy remains its most unique product and the primary attraction for clients.

Innovations in spa care mirror global trends in healthcare, including new treatment protocols, digitalization of health services, and advances in physical and rehabilitation medicine and physiotherapy. Spa care is also increasingly informed by modern dietetics, which emphasizes a holistic approach to health<sup>4</sup>. A particularly dynamic field is the integration of modern technology, which, when applied synergistically with traditional therapeutic methods, offers a key source of innovation across the entire spa sector<sup>14</sup>.

Physical therapy methods are a core element of spa care. Techniques such as transcutaneous electrical stimulation and ultrasound therapy support the effects of balneotherapy and allow for relatively rapid therapeutic outcomes.<sup>15</sup> The technological development of physiotherapeutic devices continues, with modern systems offering significantly improved performance compared to earlier generations<sup>16</sup>.

In the Czech Republic, musculoskeletal disorders represent the most common indication for spa treatment, accounting for 58.6% of all cases<sup>17</sup>. Highly effective physical treatment methods include magnetotherapy<sup>18,19</sup> and laser therapy<sup>20</sup>. Additionally, emerging technologies such as virtual reality<sup>21</sup> and telemedicine<sup>22</sup> are being tested in rehabilitation and broader healthcare contexts.

### 4.1 LASER THERAPY

High-Intensity Laser Therapy (HILT) has been confirmed by numerous studies as an effective analgesic treatment for musculoskeletal conditions, including lower back pain<sup>23</sup> and neck pain<sup>24</sup>. A systematic review of randomized clinical trials demonstrated significant pain reduction and improved functional outcomes, with the strongest effects observed in knee and shoulder joints<sup>16</sup>.

Beyond pain relief, HILT exhibits anti-inflammatory effects, reducing biomarkers such as C-reactive protein, neopterin, interleukins, and prostaglandins<sup>25</sup>. This makes it suitable for autoimmune diseases such as lupus erythematosus. In patients with hand arthropathy, HILT combined with physiotherapy significantly reduced swollen, tender, and painful joints<sup>26</sup>, with no adverse effects reported<sup>16,26</sup>.

Choi et al. found that HILT was more effective than conventional physiotherapy in chronic lower back pain, leading to pain reduction and improved functionality after just four weeks<sup>27</sup>. Similarly, in lateral epicondylitis (tennis elbow), longitudinal studies confirmed statistically significant long-term improvements in pain, grip strength, and quality of life<sup>28</sup>.

A meta-analysis of 12 randomized trials by Song et al. further validated HILT efficacy, showing clear reductions in pain intensity and functional limitations, particularly in neck and back disorders<sup>29</sup>.

## 4.2 MAGNETOTHERAPY

Magnetotherapy has demonstrated benefits in musculoskeletal disorders, with proven anti-inflammatory and analgesic effects in osteoarthritis, back pain, and degenerative spinal changes<sup>30</sup>. Its mechanism involves acceleration of cell regeneration through improved energy metabolism and microcirculation. This optimizes cell function and speeds up tissue recovery<sup>31</sup>.

Recent advances focus on high-induction magnetotherapy, or high-induction electromagnetic stimulation, which appears to enhance soft tissue elasticity and regeneration<sup>32</sup>. Sert et al. demonstrated that this method significantly improves upper extremity function and reduces pain in patients with subacromial impingement syndrome compared to conservative treatment alone<sup>33</sup>.

Magnetotherapy has also shown efficacy in autoimmune diseases such as rheumatoid arthritis<sup>34</sup>, and in oncology-related rehabilitation. Pulsed magnetotherapy improved circulation, pain, and sensitivity in chemotherapy-induced peripheral neuropathy compared to pharmacotherapy alone<sup>35</sup>. In urology, functional magnetic stimulation is an established treatment for urinary incontinence, improving quality of life without side effects<sup>36,37</sup>.

## 4.3 MECHANOTHERAPY

Recent innovation in mechanotherapy includes therapeutic massage robots. Devices such as the ADAMO robot combine mechanical precision with therapeutic massage principles. Marín-Méndez et al. found robot-assisted therapy equally effective as manual therapy for nonspecific low back pain, with overweight patients deriving particularly high benefit<sup>38</sup>.

A systematic review of robotic massage interventions (published until March 2023) confirmed positive effects on both physical and mental health, covering orofacial rehabilitation, scalp, shoulder, back, and whole-body applications<sup>39</sup>. This supports mechanotherapy as a valuable adjunct to traditional rehabilitation.

## 4.4 VIRTUAL REALITY (VR)

Virtual reality provides immersive, computer-generated environments that engage patients in interactive rehabilitation. Its healthcare applications include psychotherapy, pain management, and functional rehabilitation<sup>40-42</sup>.

An umbrella review synthesizing 14 meta-analyses (13,184 patients) confirmed VR's benefits in musculoskeletal rehabilitation, with improvements in pain, balance, and functional capacity, along with reduced anxiety, depression, and fatigue<sup>21</sup>.

In neurological rehabilitation, VR has shown superior results in Parkinson's disease therapy, particularly for balance, compared to conventional physiotherapy<sup>43</sup>. Additionally, VR reduces pain and distress during invasive procedures<sup>43-45</sup>, increases patient motivation, and improves range of motion<sup>46-48</sup>.

VR is also a valuable educational tool, enhancing patient understanding of diseases and treatment, and supporting behavioral change<sup>49</sup>. Beyond medical contexts, VR has proven effective in relaxation therapy, reducing stress and anxiety, including in psychiatric patients with insomnia<sup>50,51</sup>.

## 4.5 TELEMEDICINE, TELEMONITORING, AND WEARABLE TECHNOLOGIES

Telemedicine delivers healthcare remotely, enhancing accessibility, reducing costs, and improving continuity of care<sup>52,53</sup>. Telemonitoring allows real-time evaluation of physiological parameters, enabling timely interventions<sup>54,55</sup>.

Telerehabilitation, a subfield of telemedicine, supports remote delivery of physical, occupational, cognitive, and speech therapy<sup>56</sup>. Studies confirm that synchronous telerehabilitation (real-time therapist guidance) produces better adherence and outcomes than asynchronous models<sup>57,58</sup>. For example, several studies have

been conducted in patients with multiple sclerosis, confirming that telerehabilitation could be a suitable alternative for making long-term rehabilitation care more accessible and improving its quality.<sup>59</sup>

Wearable technologies—including smartwatches, fitness bands, electronic textiles, and integrated biosensors—expand the possibilities of continuous health monitoring. They track heart rate, blood pressure, temperature, oxygen saturation, sleep, and physical activity<sup>60–62</sup>. These devices provide biofeedback, optimize rehabilitation, and increasingly reach medical-grade accuracy<sup>54–56</sup>.

Beyond healthcare, wearables are widely applied in sports for training optimization and in ergonomics to monitor posture and prevent occupational injuries.<sup>63,64</sup>

#### 4.6 INNOVATIONS IN BALNEOTHERAPY

Balneotherapy remains a central feature of Czech spa medicine. Current innovations include the use of therapeutic microbubbles in hydrotherapy, which improve skin barrier permeability and circulation. Studies suggest benefits in atopic eczema and psoriasis—conditions included in the Czech Indication List for spa care<sup>7,65,66</sup>.

Traditional balneological therapies (hydrotherapy, peloid therapy) continue to demonstrate effectiveness in musculoskeletal disorders, including osteoarthritis and post-traumatic recovery<sup>4,67,68</sup>. These treatments reduce stiffness, improve mobility, and relieve pain, thereby reducing NSAID consumption<sup>69</sup>.

## 5 DISCUSSION

### 5.1 INNOVATION IMPERATIVES IN CZECH SPA CARE

The challenges currently faced by the Czech spa sector underscore the urgent need to implement innovations that transform traditional spa practices through modern technologies, particularly in therapeutic procedures, to enhance the overall quality and sustainability of services. The World Health Organization defines health innovation as *“new or improved solutions with the transformative ability to accelerate positive impact on health, enhancing efficiency, effectiveness, quality, sustainability, safety, or affordability of health services, including policies, practices, systems, products, technologies, services, and delivery methods”*<sup>70</sup>. In addition, the WHO Health Innovation Group emphasizes that such innovation specifically seeks to improve health outcomes with a focus on the needs of vulnerable populations<sup>71</sup>. In the spa context, innovation serves not only to modernize services and improve clinical outcomes, but also to increase attractiveness for clients, acquire new customer groups, and strengthen competitive positioning. Political and financial decisions regarding reimbursement and accessibility will play a critical role in ensuring equitable access to innovations and their integration into health policy and practice<sup>1,3</sup>.

### 5.2 REHABILITATION AND PHYSICAL MEDICINE: KEY INNOVATION DOMAINS

Based on the literature review, the greatest innovation potential in spa care lies in rehabilitation and physical medicine, particularly through modern technologies such as high-intensity laser therapy (HILT), high-induction magnetotherapy, robotic mechanotherapy, virtual reality, telemonitoring, and wearable devices. These technologies can increase treatment efficiency, improve patient experience, and provide personalized care while addressing workforce shortages in spa facilities<sup>16,30,39</sup>. Their aim is not to replace balneotherapy and natural healing resources, but to act synergistically to enhance their effectiveness.

Legislative restrictions under Czech law No. 164/2001 Coll. require natural healing resources to be used in their original form, which limits certain types of innovations in balneotherapy. Nonetheless, innovation remains possible in the delivery methods of these resources, in process automation, and in improving the patient experience during therapy. Synergies between balneotherapy and physical modalities have been shown to reduce pain and fatigue, improve range of motion, and enhance quality of life more effectively than physical therapy alone<sup>15,72,73</sup>. This approach is particularly beneficial in chronic low back pain<sup>74</sup>, one of the most common spa indications in the Czech Republic.

Laser therapy, especially HILT, and various forms of magnetotherapy are strongly supported by clinical evidence for musculoskeletal disorders, including arthritis, degenerative back pain, and post-traumatic conditions<sup>16,19,25,30,31</sup>. Both methods provide analgesic, anti-inflammatory, and regenerative effects, and are accepted medical indications across all Czech spas. Their wide range of applications, non-invasive character, and relatively low staffing requirements make them highly promising for routine integration into spa rehabilitation. Robotic mechanotherapy further enhances these advantages by automating procedures, ensuring repeatability, and reducing the burden on limited human resources<sup>38,39</sup>.

### 5.3 PSYCHOLOGICAL AND PSYCHOSOMATIC INNOVATION: VIRTUAL REALITY AND BALNEOPSYCHOTHERAPY

Virtual reality represents another modern technology with high relevance for spa care. Studies confirm its effectiveness in treating musculoskeletal disorders<sup>21,48</sup>, as well as neurological diseases, which constitute the second most frequent spa indication in the Czech Republic<sup>17,48</sup>. VR provides flexible and individualized rehabilitation solutions, with strong evidence supporting its role in managing chronic pain<sup>74</sup>, improving balance and mobility<sup>43</sup>, and reducing anxiety and depression<sup>51</sup>. Integrated feedback systems allow for real-time monitoring of patient progress and optimization of therapy<sup>75,76</sup>, which not only improves outcomes but also alleviates the workload of healthcare staff.

The psychological dimension of spa therapy is equally important. Balneopsychotherapy, which combines natural-resource-based procedures with psychotherapeutic interventions, has been highlighted as a promising area of innovation. Spa stays naturally encourage relaxation, detachment from everyday stress, and psychosomatic balance<sup>77</sup>. Research shows that balneotherapy can modulate stress-related biomarkers such as cortisol<sup>78</sup>, influence neurotransmitter activity (dopamine and serotonin)<sup>79</sup>, and reduce fatigue and stress within a relatively short period<sup>6</sup>. Integrating VR with spa-based psychosomatic interventions could therefore amplify both physical and mental health benefits.

### 5.4 ROBOTIC TECHNOLOGIES AND WORKFORCE SUSTAINABILITY

The integration of robotic systems, particularly robotic massage, aligns with spa care traditions and addresses one of the sector's most pressing challenges: workforce shortages. Robotic massages have demonstrated physical and psychological benefits comparable to manual massage<sup>39</sup>, while also reducing musculoskeletal strain on therapists themselves<sup>38</sup>. This is significant given that spa professionals often face occupational health problems due to repetitive manual work. Robotic systems thus present a dual advantage—improving patient care while protecting staff health. In contexts of population aging, declining workforce numbers, and growing client demand, automation and robotics in rehabilitation and massage may ensure sustainability of spa services<sup>80</sup>.

### 5.5 DIGITALIZATION: TELEMEDICINE, TELEMONTORING, AND WEARABLES

Digital technologies have become indispensable for modern healthcare and hold particular promise for spa medicine. Telemedicine enhances accessibility, supports communication between patients and providers, and optimizes follow-up care<sup>52,53</sup>. During spa stays, telemonitoring systems provide real-time physiological feedback, enabling individualized treatment adjustments<sup>54,62</sup>. After discharge, these tools maintain continuity of care and help sustain therapeutic outcomes, reducing reliance on outpatient services<sup>56</sup>.

Wearable technologies such as smartwatches, fitness bands, and biosensors further extend these opportunities. They allow continuous monitoring of cardiovascular parameters, physical activity, sleep, or glucose levels<sup>54,60–62,81,82</sup>. Applications in chronic disease management, particularly in diabetes mellitus, demonstrate their potential for secondary prevention in the spa setting. Studies confirm their ability to shorten hospital stays, improve access to rehabilitation, and engage patients more actively in their own care<sup>57,83,84</sup>. These advantages also extend to ergonomics and sports, with wearables helping to prevent injuries, optimize training, and monitor occupational risk<sup>62,63,64</sup>.

### 5.6 BARRIERS, POLICY, AND FUTURE DIRECTIONS

Despite their promise, the integration of modern technologies into spa medicine faces several challenges. Legislative barriers, particularly concerning balneotherapy, remain significant. Broader use of telemedicine also requires regulatory clarity, infrastructural support, and patient acceptance. Furthermore, sustainable financing models—potentially through public subsidies or partnerships with research institutions—will be necessary to ensure widespread adoption<sup>1,3</sup>.

Nevertheless, the trajectory of innovation in spa care is clear: combining evidence-based modern technologies with natural therapeutic resources can strengthen competitiveness, improve outcomes, and enhance the attractiveness of Czech spa medicine both domestically and internationally. The balance between tradition and innovation will be decisive in positioning Czech spas as leaders in integrative, prevention-focused healthcare.

Based on the conducted literature review, it can be concluded that research in the field of spa medicine still lacks sufficient data grounded in Evidence-Based Medicine. Existing studies from spa settings tend to focus predominantly on individual therapeutic methods. However, the effectiveness of spa treatment lies primarily in its complexity. Therefore, it is essential that future research continues to investigate not only specific methods but also approaches spa care as an integrated whole.

**Simplified overview of modern technologies in spa care:** therapeutic effects, strength of evidence, and application potential.

Technology	Therapeutic effects	Evidence strength	Potential in spa care
<u>High-Intensity Laser Therapy (HILT)</u>	Analgesic, anti-inflammatory, functional improvement in musculoskeletal disorders	Supported by systematic reviews and RCTs <sup>16,23,29</sup>	Widely applicable, non-invasive, low staffing needs
<u>Magnetotherapy</u>	Pain relief, anti-inflammatory effects, regeneration, benefits in arthritis and neuropathy	Clinical trials and meta-analyses <sup>18–20,30–33,35–37</sup>	Suitable for musculoskeletal and autoimmune conditions, oncology rehab, urology
<u>Robotic mechanotherapy</u>	Automated massage and rehabilitation, reduced therapist workload	RCTs and reviews <sup>38,39</sup>	Addresses staff shortages, ensures repeatability, supports rehabilitation
<u>Virtual Reality (VR)</u>	Pain reduction, improved mobility, psychological benefits (stress, anxiety, depression)	Umbrella reviews, meta-analyses <sup>21,40–51</sup>	High potential in neurorehab, musculoskeletal rehab, balneopsychotherapy
<u>Telemedicine &amp; Telemonitoring</u>	Remote care, real-time monitoring, continuity post-stay	Growing evidence in rehabilitation <sup>52–58</sup>	Extends spa care beyond facilities, improves accessibility and follow-up
<u>Wearable devices</u>	Continuous monitoring of cardiovascular, metabolic, sleep and activity parameters	Strong and rapidly growing evidence <sup>60–64,85</sup>	Secondary prevention, personalized rehab, integration into lifestyle changes
<u>Balneotherapy innovations</u>	Microbubble therapy, improved skin barrier, traditional peloid/hydrotherapy	Evidence from dermatology & rheumatology <sup>65–69</sup>	Maintains spa identity, can be combined with modern devices

Legend: Evidence strength refers to the type and quality of available studies (systematic reviews, randomized controlled trials – RCTs, clinical trials). Only sources relevant to spa or rehabilitation contexts were included.

## 6 CONCLUSIONS

Czech spa care represents a unique and complex healthcare system that integrates natural healing resources, rehabilitation, lifestyle interventions, and health education. While its foundations lie in long-standing traditions, the sector is currently facing both challenges and opportunities that highlight the importance of innovation. Modern technologies, particularly those in rehabilitation and physical medicine such as high-intensity laser therapy, high-induction magnetotherapy, robotic mechanotherapy, virtual reality, telemedicine, telemonitoring, and wearable devices—offer significant potential to complement and enhance the effectiveness of spa treatment. Their integration does not replace the natural therapeutic core of spa medicine, but rather acts synergistically to increase therapeutic outcomes, improve patient experience, and address systemic issues such as workforce shortages and long-term sustainability of care.

Evidence shows that combining balneotherapy with physical therapy modalities can reduce pain and fatigue, improve functional capacity, and enhance quality of life, particularly in musculoskeletal and neurological conditions, which remain the most common spa indications. Modern therapeutic technologies also respond to the growing importance of self-paying clients, who often demand higher efficiency within shorter treatment stays. At the same time, digital technologies, including telemedicine and wearable devices, extend spa care beyond the facility itself, enabling continuity of rehabilitation and prevention in everyday life.

Despite clear benefits, innovation in spa care is not without barriers. Legislative restrictions, financing models, infrastructural limitations, and patient acceptance all influence the pace of adoption. However, with appropriate policy support and strategic investment, the integration of evidence-based modern technologies into spa care can strengthen its competitiveness, increase accessibility, and improve overall outcomes for patients. By maintaining a balance between tradition and innovation, Czech spas can position themselves as leaders in integrative, preventive, and patient-centered healthcare, contributing not only to individual well-being but also to broader public health objectives.

## 7 ZUSAMMENFASSUNG

**Ausgangssituation:** Die tschechische Kurmedizin ist tief in der Geschichte verwurzelt und nimmt im europäischen Kontext eine herausragende Stellung ein. In den letzten Jahren sieht sie sich jedoch mit zunehmenden Herausforderungen konfrontiert, darunter eine alternde traditionelle Klientel, Personalmangel, begrenzte Finanzierungsmöglichkeiten sowie wachsende Konkurrenz durch Wellness Einrichtungen, die keine natürlichen Heilmittel nutzen. Diese Entwicklungen verdeutlichen die Bedeutung von Innovation und der Implementierung moderner Technologien, um Nachhaltigkeit zu gewährleisten, die Wettbewerbsfähigkeit zu steigern und den sich wandelnden Anforderungen des Gesundheitswesens und des Tourismus gerecht zu werden.

**Methoden:** Der vorliegende Beitrag ist als narrativer Review angelegt und untersucht die Potenziale der Integration moderner Technologien in den Bereich der Kurmedizin in der Tschechischen Republik. Es wurden Datenbankrecherchen in PubMed, Scopus, Web of Science, ScienceDirect und SpringerLink durchgeführt, wobei der Fokus auf peer-reviewten Fachartikeln und Übersichtsarbeiten lag, die zwischen 2015 und 2025 veröffentlicht wurden.

**Ergebnisse:** Die Analyse identifizierte Technologien mit dem höchsten therapeutischen und anwendungsbezogenen Potenzial für die Kurmedizin: Hochintensitätslasertherapie, Magnetotherapie, robotische Mechanotherapie, virtuelle Realität, Telemedizin und tragbare Geräte (Wearables). Diese Verfahren zeigen

positive Effekte bei der Behandlung muskuloskelettaler und neurologischer Erkrankungen, bei der Schmerzreduktion, in der Rehabilitation sowie in der Unterstützung der psychischen Gesundheit.

**Schlussfolgerungen:** Ein vielversprechender Weg für die Zukunft liegt in der synergetischen Verbindung traditioneller balneotherapeutischer Verfahren mit modernen Technologien, wodurch die Wirksamkeit, Individualisierung und Attraktivität der Kurmedizin gesteigert werden können. Dieser integrierte Ansatz kann zur langfristigen Nachhaltigkeit beitragen, Personalengpässen entgegenwirken und die Wettbewerbsfähigkeit sowohl auf dem nationalen als auch auf dem internationalen Gesundheits- und Wellnessmarkt verbessern. Zukünftige Forschung sollte sich auf die Generierung evidenzbasierter Ergebnisse aus kurortspezifischen klinischen Studien, die Validierung synergistischer therapeutischer Effekte sowie die Förderung strategischer Innovationsinvestitionen durch interdisziplinäre Zusammenarbeit konzentrieren.

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## REFERENCES

1. Becková, H. & Kantorová, K. Wellness as a cure for the problems of Czech spas? *International Journal of Spa and Wellness* **4**, 36–52 (2021).
2. Vystoupil, J., Šauer, M. & Bobková, M. Spa, Spa Tourism and Wellness Tourism in the Czech Republic. *Czech Journal of Tourism* **6**, 5–26 (2017).
3. Senkova, A., Kolesarova, S. & Kosikova, M. Innovative Activity of Spa Companies in the Slovak and Czech Republic in the Context of the COVID-19 Pandemic. *Marketing and Management of Innovations* **15**, 80–89 (2024).
4. Špišák, Ladislav. *Klinická Balneologie*. (Nakladatelství Karolinum, 2010).
5. Parliament of the Czech Republic. Act No. 164/2001 Coll. Act on Natural Healing Resources, Sources of Natural Mineral Waters, Natural Healing Spas and Spa Areas and on Amendments to Certain Related Acts (Spa Act. *Collection of Laws of the Czech Republic* (2024).
6. Huseynli, A., Marková, V. & Špišák, L. Preliminary study: the potential role of a one-week comprehensive spa treatment on mental health prevention of adult patients in Konstantinovy Lázně Spa, Czech Republic. *International Journal of Spa and Wellness* **8**, 317–332 (2025).
7. Ministry of Health of the Czech Republic. Annex No. 5 to Act No. 48/1997 Coll. Material for the Application of Legal Regulations in the Field of Providing Spa Medical Rehabilitation Care. <https://mzd.gov.cz/platny-indikacni-seznam-pro-lazenskou-peci/> Preprint at (2024).
8. Parliament of the Czech Republic. Act No. 48/1997 Coll. Act on Public Health Insurance and on Amendments to Certain Related Acts. *Collection of Laws of the Czech Republic*. <https://esbirka.gov.cz> Preprint at (1997).
9. Czech Statistical Office. *Spa Resorts by Region 2023. "Statistical Yearbook of the Karlovy Vary Region 2024*. (2024).
10. Jakubíková, D., Vildová, E., Janeček, P. & Tluchoř, J. *Spa Industry: Management and Marketing*. (Grada Publishing, 2019).
11. Vrablikov, M., Hrnčiarova Turciakova, A. & Baranova, M. Tourism as a Factor of Local and Regional Development. *Marketing and Management of Innovations* **14**, 199–212 (2023).
12. Janeček, P. & Jakubíková, D. ATTITUDES OF CZECHS TOWARDS SPAS DURING THE COVID-19 PANDEMIC. *Acta academica karviniensia* **21**, 25–35 (2021).
13. Vildová, E., Martinčík, D., Tluchoř, J. & Jakubíková, D. Measuring customer satisfaction and loyalty in spa companies. *E+M Ekonomie a Management* **18**, 151–168 (2015).
14. Wong, B. K. M. & Sa'aid Hazley, S. A. The future of health tourism in the industrial revolution 4.0 era. *Journal of Tourism Futures* **7**, 267–272 (2021).

15. Kulaoglu, O., Elden, H. & Doğan, A. G. The effect of balneotherapy and physical therapy applied to patients with chronic lack pain on pain intensity, quality of life, disability and mental symptoms. *Journal of Orthopedics Research and Rehabilitation* **1**, 5–10 (2023).
16. Arroyo-Fernández, R., Aceituno-Gómez, J., Serrano-Muñoz, D. & Avendaño-Coy, J. High-Intensity Laser Therapy for Musculoskeletal Disorders: A Systematic Review and Meta-Analysis of Randomized Clinical Trials. *J Clin Med* **12**, 1479 (2023).
17. Institute of Health Information and Statistics of the Czech Republic. *Spa Care* 2022. (2023).
18. Chen, L. *et al.* Effects of pulsed electromagnetic field therapy on pain, stiffness and physical function in patients with knee osteoarthritis: a systematic review and meta-analysis of randomized controlled trials. *J Rehabil Med* **0** (2019) doi:10.2340/16501977-2613.
19. Paolucci, T. *et al.* <p>Electromagnetic Field Therapy: A Rehabilitative Perspective in the Management of Musculoskeletal Pain – A Systematic Review</p>. *J Pain Res* **Volume 13**, 1385–1400 (2020).
20. Ahmad, M. A., A. Hamid, M. S. & Yusof, A. Effects of low-level and high-intensity laser therapy as adjunctive to rehabilitation exercise on pain, stiffness and function in knee osteoarthritis: a systematic review and meta-analysis. *Physiotherapy* **114**, 85–95 (2022).
21. Tang, P. *et al.* The Efficacy of Virtual Reality on the Rehabilitation of Musculoskeletal Diseases: Umbrella Review. *J Med Internet Res* **27**, e64576 (2025).
22. Downes, M. J., Mervin, M. C., Byrnes, J. M. & Scuffham, P. A. Telemedicine for general practice: a systematic review protocol. *Syst Rev* **4**, 134 (2015).
23. Abdildin, Y., Tapinova, K., Jyeniskhan, N. & Viderman, D. High-intensity laser therapy in low back pain management: a systematic review with meta-analysis. *Lasers Med Sci* **38**, 166 (2023).
24. Xie, Y.-H. *et al.* The effectiveness of high-intensity laser therapy in individuals with neck pain: a systematic review and meta-analysis. *Physiotherapy* **121**, 23–36 (2023).
25. Wyszynska, J. & Bal-Bocheńska, M. Efficacy of High-Intensity Laser Therapy in Treating Knee Osteoarthritis: A First Systematic Review. *Photomed Laser Surg* **36**, 343–353 (2018).
26. Abdel-Aal, N. M., Ali, K. M. & Eladl, H. M. Efficacy of high-intensity laser therapy on arthropathy of the hands in patients with systemic lupus erythematosus: a double-blinded, randomized controlled trial. *Clin Rehabil* **34**, 1303–1312 (2020).
27. Choi, H.-W. *et al.* Effects of high intensity laser therapy on pain and function of patients with chronic back pain. *J Phys Ther Sci* **29**, 1079–1081 (2017).
28. Akkurt, E. *et al.* Long term effects of high intensity laser therapy in lateral epicondylitis patients. *Lasers Med Sci* **31**, 249–253 (2016).
29. Song, H. J., Seo, H.-J., Lee, Y. & Kim, S. K. Effectiveness of high-intensity laser therapy in the treatment of musculoskeletal disorders. *Medicine* **97**, e13126 (2018).
30. Fortina, M. *et al.* Short time effects of a low-frequency, high intensity magnetic field in the treatment of chronic neck and low back pain. *AIMS Public Health* **9**, 307–315 (2022).
31. Leroch, M., Łaszcz, J., Bajer, W., Laber, W. T. & Ptaszkowski, K. High-induction electromagnetic field – biophysical basis and review of scientific reports. *Physiotherapy Review* **27**, 30–37 (2023).
32. Prucha, J., Socha, V., Sochova, V., Hanakova, L. & Stojic, S. Effect of High-Induction Magnetic Stimulation on Elasticity of the Patellar Tendon. *J Healthc Eng* **2018**, 1–8 (2018).
33. Sert, Ö. A. & Alkan, B. Clinical effectiveness of high induction electromagnetic stimulation in patients with subacromial impingement syndrome: A single-blinded randomized controlled trial. *J Back Musculoskelet Rehabil* **38**, 1303–1310 (2025).
34. Zwolińska, J., Kasprzak, M., Kielar, A. & Prokop, M. Positive and Negative Effects of Administering a Magnetic Field to Patients with Rheumatoid Arthritis (RA). *J Clin Med* **13**, 1619 (2024).
35. Kulchitskaya, D. B. *et al.* High-Intensity Pulsed Magnetotherapy in the Rehabilitation Programme of Patients with Chemotherapy-Induced Peripheral Polyneuropathy: a Prospective Randomized Clinical Study. *Bulletin of Rehabilitation Medicine* **22**, 72–82 (2023).
36. VADALÀ, M., PALMIERI, B., MALAGOLI, A. & LAURINO, C. High-power Magnetotherapy: <sc>A</sc> New Weapon in Urinary Incontinence? *LUTS: Lower Urinary Tract Symptoms* **10**, 266–270 (2018).
37. Gözlersüzer, Ö., Yalvaç, B. & Çakıroğlu, B. Investigation of the effectiveness of magnetic field therapy in women with urinary incontinence: Literature review. *Urologia Journal* **90**, 51–57 (2023).

38. Marín-Méndez, H. *et al.* Using a Robot to Treat Non-specific Low Back Pain: Results From a Two-Arm, Single-Blinded, Randomized Controlled Trial. *Front Neurobot* **15**, (2021).
39. Yang, J. *et al.* Robotics in Massage: A Systematic Review. *Health Serv Res Manag Epidemiol* **11**, (2024).
40. Abbas, J. R. *et al.* What is Virtual Reality? A healthcare-focused systematic review of definitions. *Health Policy Technol* **12**, 100741 (2023).
41. Kouijzer, M. M. T. E., Kip, H., Bouman, Y. H. A. & Kelders, S. M. Implementation of virtual reality in healthcare: a scoping review on the implementation process of virtual reality in various healthcare settings. *Implement Sci Commun* **4**, 67 (2023).
42. Wang, C., Kong, J. & Qi, H. Areas of Research Focus and Trends in the Research on the Application of VR in Rehabilitation Medicine. *Healthcare* **11**, 2056 (2023).
43. Lheureux, A., Lejeune, T., Simons, A., Gillis, A. & Everard, G. Virtual reality effects on balance and mobility in people with Parkinson's disease: A systematic review with meta-analysis. *Ann Phys Rehabil Med* **68**, 101967 (2025).
44. Li, A., Montaña, Z., Chen, V. J. & Gold, J. I. Virtual Reality and Pain Management: Current Trends and Future Directions. *Pain Manag* **1**, 147-157 (2011).
45. Pourmand, A., Davis, S., Marchak, A., Whiteside, T. & Sikka, N. Virtual Reality as a Clinical Tool for Pain Management. *Curr Pain Headache Rep* **22**, 53 (2018).
46. Huang, Q., Lin, J., Han, R., Peng, C. & Huang, A. Using Virtual Reality Exposure Therapy in Pain Management: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Value in Health* **25**, 288-301 (2022).
47. Gumaa, M., Khaireldin, A. & Rehan Youssef, A. Validity and Reliability of Interactive Virtual Reality in Assessing the Musculoskeletal System: a Systematic Review. *Curr Rev Musculoskelet Med* **14**, 130-144 (2021).
48. Choy, C. S., Cloherty, S. L., Pirogova, E. & Fang, Q. Virtual Reality Assisted Motor Imagery for Early Post-Stroke Recovery: A Review. *IEEE Rev Biomed Eng* **16**, 487-498 (2023).
49. van der Kruk, S. R., Zielinski, R., MacDougall, H., Hughes-Barton, D. & Gunn, K. M. Virtual reality as a patient education tool in healthcare: A scoping review. *Patient Educ Couns* **105**, 1928-1942 (2022).
50. Riches, S., Azevedo, L., Bird, L., Pisani, S. & Valmaggia, L. Virtual reality relaxation for the general population: a systematic review. *Soc Psychiatry Psychiatr Epidemiol* **56**, 1707-1727 (2021).
51. Zhou, H., Chen, C., Liu, J. & Fan, C. Acute Augmented Effect of Virtual Reality (VR)-Integrated Relaxation and Mindfulness Exercising on Anxiety and Insomnia Symptoms: A Retrospective Analysis of 103 Anxiety Disorder Patients With Prominent Insomnia. *Brain Behav* **14**, (2024).
52. Haleem, A., Javaid, M., Singh, R. P. & Suman, R. Telemedicine for healthcare: Capabilities, features, barriers, and applications. *Sensors International* **2**, 100117 (2021).
53. Anawade, P. A., Sharma, D. & Gahane, S. A Comprehensive Review on Exploring the Impact of Telemedicine on Healthcare Accessibility. *Cureus* <https://doi.org/10.7759/cureus.55996> (2024) doi:10.7759/cureus.55996.
54. Smuck, M., Odonkor, C. A., Wilt, J. K., Schmidt, N. & Swiernik, M. A. The emerging clinical role of wearables: factors for successful implementation in healthcare. *NPJ Digit Med* **4**, 45 (2021).
55. Bowman, T. *et al.* Wearable Devices for Biofeedback Rehabilitation: A Systematic Review and Meta-Analysis to Design Application Rules and Estimate the Effectiveness on Balance and Gait Outcomes in Neurological Diseases. *Sensors* **21**, 3444 (2021).
56. Tenforde, A. S., Hefner, J. E., Kodish-Wachs, J. E., Iaccarino, M. A. & Paganoni, S. Telehealth in Physical Medicine and Rehabilitation: A Narrative Review. *PM&R* **9**, (2017).
57. Agostini, M., Moja, L., Banzi, R., Pistotti, V. & Tonin, P. Telerehabilitation and recovery of motor function: a systematic review and meta-analysis. *Journal of telemedicine and telecare*, 21(4), 202-213. *Journal of telemedicine and telecare*, 21(4), 202-213. **21(4)**, 202-213 (2015).
58. Cramer, S. C. *et al.* Efficacy of Home-Based Telerehabilitation vs In-Clinic Therapy for Adults After Stroke. *JAMA Neurol* **76**, 1079 (2019).
59. Grosserová, B. & Novotná, K. Telerehabilitace zaměřená na trénink rovnováhy Kazuistika pacientky s RS. *časopis REHABILITÁCIA* **61**, 174-183 (2024).
60. Deng, Z., Guo, L., Chen, X. & Wu, W. Smart Wearable Systems for Health Monitoring. *Sensors* **23**, 2479 (2023).

61. de-la-Fuente-Robles, Y.-M., Ricoy-Cano, A.-J., Albín-Rodríguez, A.-P., López-Ruiz, J. L. & Espinilla-Estévez, M. Past, Present and Future of Research on Wearable Technologies for Healthcare: A Bibliometric Analysis Using Scopus. *Sensors* **22**, 8599 (2022).
62. DE ZAMBOTTI, M., CELLINI, N., GOLDSTONE, A., COLRAIN, I. M. & BAKER, F. C. Wearable Sleep Technology in Clinical and Research Settings. *Med Sci Sports Exerc* **51**, 1538–1557 (2019).
63. Donisi, L. *et al.* Wearable Sensors and Artificial Intelligence for Physical Ergonomics: A Systematic Review of Literature. *Diagnostics* **12**, 3048 (2022).
64. Stefana, E., Marciano, F., Rossi, D., Cocca, P. & Tomasoni, G. Wearable Devices for Ergonomics: A Systematic Literature Review. *Sensors* **21**, 777 (2021).
65. Liao, A.-H. *et al.* Mechanisms of ultrasound-microbubble cavitation for inducing the permeability of human skin. *Journal of Controlled Release* **349**, 388–400 (2022).
66. Och, F., Mankovecky, L., Saskova, D. & Kulaviak, L. Medicinal effects of microbubble bath on atopic eczema and psoriasis vulgaris. *Balneo and PRM Research Journal* **14**, 554 (2023).
67. Ozkuk, K. & Uysal, B. Effectiveness of balneotherapy in knee osteoarthritis. *Experimental Biomedical Research* **1**, 46–54 (2018).
68. Karagülle, M. & Karagülle, M. Z. Effectiveness of balneotherapy and spa therapy for the treatment of chronic low back pain: a review on latest evidence. *Clin Rheumatol* **34**, 207–214 (2015).
69. Bernetti, A. *et al.* Spa therapy and rehabilitation of musculoskeletal pathologies: a proposal for best practice in Italy. *Int J Biometeorol* **64**, 905–914 (2020).
70. World Health Organization. *WHO Global Report on Traditional and Complementary Medicine 2019*. (2019).
71. World Health Organization. *WHO Traditional Medicine Strategy 2014–2023*. (2013).
72. Dilekçi, E., Özkuk, K. & Kaki, B. The short-term effects of balneotherapy on pain, disability and fatigue in patients with chronic low back pain treated with physical therapy: A randomized controlled trial. *Complement Ther Med* **54**, 102550 (2020).
73. Koç, C., Kurt, E. E., Koçak, F. A., Erdem, H. R. & Konar, N. M. Does balneotherapy provide additive effects to physical therapy in patients with subacute supraspinatus tendinopathy? A randomized, controlled, single-blind study. *Int J Biometeorol* **65**, 301–310 (2021).
74. Özkuk, K. & Dilekçi, E. FİZİK TEDAVİ UYGULANAN KRONİK BEL AĞRILI YAŞLILARDA BALNEOTERAPİNİN TEDAVİYE ETKİSİ: PİLOT ÇALIŞMA. *İstanbul Tıp Fakültesi Dergisi* **82**, (2019).
75. Lüddecke, R. & Felnhöfer, A. Virtual Reality Biofeedback in Health: A Scoping Review. *Appl Psychophysiol Biofeedback* **47**, 1–15 (2022).
76. Rose, T., Nam, C. S. & Chen, K. B. Immersion of virtual reality for rehabilitation - Review. *Appl Ergon* **69**, 153–161 (2018).
77. Huseynli, A. & Špišák, L. The Role of Spa Care in Mental Health Prevention. *Florence* **2**, (2022).
78. Antonelli, M. & Donelli, D. Effects of balneotherapy and spa therapy on levels of cortisol as a stress biomarker: a systematic review. *Int J Biometeorol* **62**, 913–924 (2018).
79. Gálvez, I., Fioravanti, A. & Ortega, E. Spa therapy and peripheral serotonin and dopamine function: a systematic review. *Int J Biometeorol* **68**, 153–161 (2024).
80. Lai, M.-C., Tsay, W.-D. & Me-HuaKe. Research on Aromatherapy Relieving Anxiety of Menopausal Women and Introducing Artificial Intelligence and Robot Arms. in *2020 IEEE 2nd Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS)* 212–215 (IEEE, 2020). doi:10.1109/ECBIOS50299.2020.9203579.
81. Saha, T. *et al.* Wearable Electrochemical Glucose Sensors in Diabetes Management: A Comprehensive Review. *Chem Rev* **123**, 7854–7889 (2023).
82. Rodriguez-León, C., Villalonga, C., Muñoz-Torres, M., Ruiz, J. R. & Banos, O. Mobile and Wearable Technology for the Monitoring of Diabetes-Related Parameters: Systematic Review. *JMIR Mhealth Uhealth* **9**, e25138 (2021).
83. Bokolo Anthony Jnr. Use of Telemedicine and Virtual Care for Remote Treatment in Response to COVID-19 Pandemic. *J Med Syst* **44**, 132 (2020).
84. Lu, L. *et al.* Wearable Health Devices in Health Care: Narrative Systematic Review. *JMIR Mhealth Uhealth* **8**, e18907 (2020).

85. Seçkin, A. Ç., Ateş, B. & Seçkin, M. Review on Wearable Technology in Sports: Concepts, Challenges and Opportunities. *Applied Sciences* **13**, 10399 (2023).