
BALNEOLOGY RESEARCH IN HUNGARY

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Balneotherapy came into the focus of science in the late 19th century both at an international and a domestic level. That was when analyses of scientific quality first appeared in the fields of balneotherapy and physiotherapy. In 1882, the Royal Hungarian Medical Association established an independent balneological commission. In 1889, Vilmos Tauffer, professor of gynaecology, became the first chairman of the body who established a scientific association in order to develop spas, protect spa waters and improve medical work. In 1891 the Balneological Association of the Hungarian Sacred Crown was founded (with the participation of physicians, geologists and engineers), which continued its operation after World War I as the National Balneological Association and does so today as the Hungarian Balneological Association. As a result of the Treaty of Versailles, after World War I, Hungary lost over two thirds of its territory. The decisive majority of internationally known and renowned spas were beyond the new borders of the country. Therefore, the development of spas in Hungary focused on the capital (Szent Lukács Spa, Széchenyi Spa, Szent Gellért Spa) and, in other parts of the country, mainly on Hévíz and Balatonfüred. In 1925, Archduke Ferenc József, great-grandson of palatine József became the chairman of the Budapest Spa City Association established in 1922, who undertook his assignment with great energy due to his widespread legal, technical, political and scientific knowledge. In 1928 The Rheumatological Association of Hungarian Physicians (MORE) was established, led by baron Sándor Korányi (internal specialist) as chairman who contributed to the foundation of the Rheumatological and Spa Research Institute at the Medical Faculty of the University in 1938 led by Sándor Belák who had, up till then, been the director of the Physiology Institute of the Medical Faculty at Péter Pázmány University. The institute had a decisive role in the scientific development of the era.

During the international spa congress taking place in Budapest in 1937, the International Spa, Climatology and Marine Medical Association, the legal predecessor of today's FEMTEC (Federation Mondiale du Thermalisme et du Climatisme) was established. The organisation selected Budapest as its permanent headquarters. The continuous development was halted by World War II. In 1948 a Balneological Research Institute was

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established at the Szent Lukács Spa led by Ödön Schulhof, which later closed down in 1961. In Hévíz, his brother, Vilmos Schulhoff, and the inventor of the weight bath, Károly Moll, performed significant physiotherapeutic research. In 1951, the National Institute of Rheumatology and Balneotherapy was established in order to provide for the highest level of care, education and research in the field, from which the Polyclinic of the Hospitaller Brothers of the St. John of God in Budapest separated. The Foundation for Balneology Research was established in 1999 with the mission to organise, co-ordinate, and when necessary, sponsor scientific efforts. In 2005, the Foundation earned in excess of € 100,000 Euro by winning the prize of the 'Jedlik Ányos' Fund, to be applied towards the support of balneology research. The publication of studies sponsored from this resource is in progress.

Balneological science till 80-ies

The chairman of the Rheumatics and Spa Research Institute established in 1938 was Sándor Belák. The school founded by him became decisive from the aspect of further research. Belák analysed the impact of the environment on resistance and immunity, and thus the climatic and spa impact on the autonomic nervous system, and its reactivity. He focused on the role of prevention. During an examination performed with his colleagues at a vacation organised for 3000 children, he proved that a change in the climate has an impact on both sympathicotonia and vagotonia and the change was of opposite directions. His hypothesis stated that the change would finally stop at a middle level (normalisation) [1-2]. According to the works of I. Balogh, Zsiray and Strecker performed at Hévíz, a temporary instability occurs on the 7th or 8th day, followed by normalisation. Zoltán Rákosfalvy supplemented Belák's hypothesis with the theory that the process is accompanied by increased oscillation [3].

The influence of weather on bathing in sulfurous medicinal water was studied by Örményi Imre and Konrád Katalin. From the value of blood pressure and pulse the vegetative index of Kérdő was obtained. Individual meteorosensitivity was assessed with 8 subtypes. The vegetative nervous system shifted in parasympathetic direction under the effect of bathing. Similar reactions were demonstrable in the individual types of warm front sensitivity. Paradoxical reactions of those sensitive to cold front became manifest if various cold fronts passed [4]. A separate chapter is dedicated to the activities of the Schulhoff brothers and Károly Moll. Ödön Schulhoff studied the processes occurring during bath reaction, noticed leucocytosis occurring on the 4-6th day, which normalised in the 3rd week leading to leucopenia in week 4. All that was not related to the intensity of an increase in pains. He noticed that the positive effect of the *streptococcus* cutan reaction seen at the beginning of the bath therapy turned to negative by the end. The afore mentioned reactions did not occur in the case of individuals bathing in tap water. With the help of the special tool for measuring the volume of the lower limb developed by Károly Moll, it could be shown that the volume of the lower limb significantly decreased in the spa, and the effect increased

with the depth at which the patient's leg was located under the surface of the water. That carried great significance at the therapy for lower limb peripheral circulatory disorders. The significance of the weight bath developed by Károly Moll is also featured in the same chapter [5-6].

András Richter worked beside Sándor Belák at the Rheumatological and Spa Research Institute at the beginning of his career. From 1954, as the head of the Research Department of the National Institute of Rheumatology and Physiotherapy, among others, he analysed the physiological impact of thermal-mineral water alongside a tap water control group. In his animal experiments he analysed the impact on skin, skeletal muscle and liver metabolism, kidney functions and stomata. In his studies in rat experiments the effect on dermal metabolism of bathing for 20 minutes in water of 37°C containing 0.357 % and 2 % sodium chloride, 10.2 mval calcium (Ca) and magnesium (Mg) and 61.7 mval Ca and Mg respectively was studied. Results were compared with the effect of bathing for 20 minutes in tap water of 37°C as well as with the values of untested controls. He found that sodium chlorid water reduces, Ca and Mg inhalt water increases the hydratation of skin as compared to the values of tap water controls. Na dependent ATPase activity is intensed slightly by tap water (+23.2 %) and vigorously by mineral waters. Water containing 31.7 mval Ca and Mg has the strongest (+153.5 %), on the other hand sodium chlorid water has more lasting effect. Protein phosphorylation of skin does not change significantly after tap water bath, but a significant acceleration of 25.7-55.9 % is noted under the effect of various mineral waters. The cAMP content of the skin following bathing in water containing 61.7 mval Ca and Mg a value of 360.6 ± 55.7 is obtained, which is expressively significant. The isotope sulfate uptake increases with 47.3 % in bathing in water containing 10.2 mval Ca and Mg. Anyone of the bathes increase glycolysis of the skin [7]. He found that glycolysis, the isotope sulfate and phosphate uptake in the skeletal muscle increased after bathing in mineral water above [8]. Lactate dehydrogenase and creatinin phosphokinase activity increased in cartilage [9]. The changes of renal function on the effect of hot mineral baths was examined. The creatinine clearance value, the chloride contents of the plasma and the urine has been established in the case of 27 osteoarthritis patients in the morning, directly after 30 minutes of bathing in 37°C water, after 1 hour rest. The creatinine clearance value increased at 69.7 % of the examined patients after the baths + 17.1 % ($p=0,01$), after the rest to 22.8 %. In the case of 37 % of the examined individuals a decrease was found, which is also significant. Based on the changes of the chloride values, their opinion is that the effect of the bath inreases the reabsorption in the tubular system. This is also proved by the fact that in case of animal experiments, the hot mineral baths significantly increase the activity of $(K+Na)Cl_2$ ATPase, an increased ATP production is also supposed because the key enzyme of the glycolysis the LDH also shows a significant increase in renal tissue [10].

Balneology papers nowadays (published or in press) are available from medical databases, Pubmed, Pedro, Cochrane, Web of Science, Scopus.

Clinical studies

Balneotherapy for osteoarthritis of the knee

- The first double blind study (using tap water as control treatment) of patients with osteoarthritis of the knee was published by Hungarian authors, Szücs et al. [11]. Comparisons were made before and after the balneotherapy course. One of the groups bathed in medicinal water containing sodium chloride and hydrocarbonate along with iodine and bromide, whereas the other was treated with tap water. Kovács and Bender [12] published a double blind, follow-up study of 3 months duration, which investigated the effects of medicinal water from Cserkeszölő, containing sodium hydrogencarbonate, silicic acid, and fluoride. The study population comprised 70 ambulatory patients with clinical and radiological evidence of osteoarthritis of the knee. Patients completed 15 sessions of 30 minutes baths in water cooled to 36°C. Placebo treatment was undertaken with tap water mixed with a negligible amount of salt-containing thermal water, in order to make its colour and odour matching to that of the medicinal water used. Medical evaluations were done at baseline, immediately after the balneotherapy course, as well as 3 months later. Fifty-eight patients were evaluated ; 12 dropped out from the study for family reasons (n=6), intercurrent disease (n=4) and failure to attend the final visit (n=2). Thirty-one patients underwent balneotherapy with thermal water, and 24 with tap water. In the former group, improvement of initial pain was statistically significant throughout the study, whereas in the control group, improvement ensued only 3 months after balneotherapy. Compared to baseline, the difference in range of motion was significant both after treatment and 3 months later in the thermal water group, but not in the control group. Climbing/descending the stairs was not different between groups, as 3 months after balneotherapy, the improvement of these parameters was alternating between the two groups. Although joint tenderness decreased significantly after balneotherapy in the group treated with thermal water, no difference was seen between the groups 3 months later and the same was observed for ambulation skills. According to the physicians' rating, improvement was significant in the thermal water group immediately after balneotherapy ; however, there was no difference between the groups 3 months later.

- Another balneotherapy study evaluated treatment with thermal water from Nagybaracska – a medicinal water of sodium-calcium-hydrogencarbonate character, as regards its composition [13]. This study explored the short- and long-term effect of thermal-mineral water from Nagybaracska on the pain and articular movements of patients with mild-to-moderate primary osteoarthritis of the knee. The subjects of this randomised, controlled, double-blind study underwent balneotherapy on 20 occasions (five sessions per week for 4 weeks) altogether. According to the convincing evidence from this study, treatment with thermal-mineral water from Nagybaracska accomplished very substantial improvement of the total score and sub-domain scores of the WOMAC index (with the exception of the stiffness score), along with walking distance – this improvement could be demonstrated even 3 months later. In the group that had bathed in warmed tap water, WOMAC activity score and total score improved significantly by

the end of treatment. This is by no means surprising, as hydrotherapy is not placebo treatment ; it is widely used for the management of musculoskeletal disorders in countries short of thermal-mineral water. Notwithstanding this, the improvement achieved by the end of treatment was no longer detectable at the follow-up visit 3 months later.

- The third study conducted on patients with osteoarthritis of the knee (and lumbar pain) used medicinal water from Bánk, a settlement in Eastern Hungary [14]. This water containing sodium hydrocarbonate, fluoride, and metaboric acid was used for balneotherapy of the subjects of this follow-up study. Treatment improved the functional status of subjects significantly, both as reflected by the WOMAC scale for osteoarthritis of the knee and by the Oswestry questionnaire for chronic lumbar pain. Secondary endpoints demonstrated that balneotherapy over 15 days achieved a statistically significant improvement that persisted even after 3 months, in both patient groups. Moreover, treatment significantly enhanced the subjects' quality of life, as shown by the total scores and subscales of the SF-36 questionnaire. The reduction of analgesic requirements was also significant in both patient groups.

Balneotherapy for lumbar pain

Konrád et al. reported the results of three patient groups undergoing outpatient therapy with thermal water, underwater jet massage, and weight bath for lumbar pain, as well as of untreated controls. All three groups on active treatment improved and the comparison of analgesic requirements demonstrated these to be lower than in control subjects, even a year later [15].

The analgesic property of sulphur is confirmed by abundant experimental evidence, but in clinical studies, this agent has been used only in combination with other therapies. The objective of a double blind, follow-up study was to compare the therapeutic effect of the sulphur-containing thermal water with that of tap water, in patients with chronic lumbar pain [16]. The properties of this medicinal water from Kehidakustyaán, a small settlement near Hévíz, are similar to those of the water of Lake Hévíz. All subjects took daily 30 minutes baths in water of 36°C temperature for 15 consecutive days (except Saturday and Sunday). Assessments were made at baseline, immediately after balneotherapy, and 3 months later. Fifty-six patients completed the study. The following subjective parameters were evaluated : pain intensity expressed on a visual analogue scale (in centimeters), modified Oswestry index, and patients' as well as physicians' rating of therapeutic efficacy. Semi-objective parameters included muscle spasm and tenderness of paravertebral muscles, whereas spinal range of motion was assessed (using a goniometer) along with analgesic consumption as objective measures. In the group treated with sulphuric baths, significant relief of pain (VAS), local tenderness, antalgic posture, and paravertebral spasm was observed. The modified Oswestry index and drug consumption remained unchanged. Where ascertained, the significant improvement of parameters persisted as late as 3 months later with no change compared to post-treatment values and thus, these proved lasting improvements. In the group treated with tap water, the only significant improvement was seen in VAS scores ; however, this was no longer detectable 3 months later.

Clinical evaluation of weight-bath therapy

In 1953 (*see the detailed description in the section on Hévíz*), Hungarian authors (Kurutz et al.) conducted biomechanical tests to substantiate the changes occurring during weight-bath. Therefore, the objective of our study was to demonstrate the effectiveness of weight-bath by scientific methods. Data from 71 of the 72 subjects were evaluated (one patient underwent hernia surgery) during the period between lumbar weight-bath and the control visit 3 months later. The study population was split into two groups of 36-36 patients with either cervical or lumbar degenerative disc disease. Within these two groups, 18-18 patients were treated with weight-baths, whereas the other 18-18 served as controls. All four groups received McKenzie exercises (for 20 minutes per occasion) with electrotherapy (dionine ionophoresis), but the two control groups were not treated with weight-baths. In lumbar discopathy, study parameters comprised lumbar pain intensity (expressed on a VAS), finger-floor distance, shifting of the hand on the thigh during lateral flexion of the spine, SF-36 score, Oswestry index, MRI changes of disc protrusion, as well as rating of therapeutic efficacy by patients and investigators. Indices monitored in the groups with cervical discopathy included cervical pain intensity (expressed on a VAS), maximum lateral flexion of the cervical spine (expressed in degrees), whereas the remainder were the same as those assessed in the lumbar discopathy groups. In the treatment group with degenerative disc disease of the cervical spine, weight bath improved clinical parameters and quality of life significantly and also on the long term – no decline of improved parameters was ascertained 3 months later, but rather, some of the parameters continued to improve further. In the control group, improvement of three parameters was significant, but transient only. In the group treated with weight-bath for lumbar disc disease, all parameters improved significantly after treatment. This improvement proved lasting 3 months later and two of the parameters improved further. In the control group, however, significant improvement was seen in a single parameter after the weight-baths and in two parameters 3 months later ; however, only one of the latter proved lasting. Weight-baths were rated effective both by the patients and by their physicians. MR images did not reveal any significant change in the degree of protrusion or of disc properties. It was concluded that underwater traction is a relatively simple, non-invasive, low-cost treatment modality, which can be implemented everywhere [17].

Balneotherapy and basic science

Data on the interactions between balneotherapy and the antioxidant system are relatively scarce in the literature. The majority of published papers assert the favourable influence of balneotherapy on antioxidation processes. This study was intended to explore the effects of balneotherapy on the antioxidant system, as well as to ascertain whether bathing in mineral water makes any difference compared to using tap water. Three groups of 10-10 patients underwent 10 sessions of 30 minutes balneotherapy either with medicinal water (from Cserkeszölő) containing alkalis and hydrogen carbonate, or thermal water (from Mórahalom) containing alkalis and chlorine, or tap water. Catalase, superoxide dismutase, malonic dialdehyde protein and glutathion peroxydase levels

were determined at baseline, as well as after the first and the tenth balneotherapy sessions. In patients treated with thermal water, the activity of monitored enzymes decreased as early as after the first session ; however, this change became more substantial after 10 sessions. Some reduction was observed also after treatment with tap water – and this emphasizes the favourable effects of hot water – but the magnitude of this change was smaller, than in groups treated with thermal water. Our study demonstrated the potential, beneficial influence of mineral waters on the antioxidant system. Enzyme activity was different after treatment with mineral or tap water, and this change can occur as early as after the first treatment session. Regardless of its composition, thermal water can mitigate deleterious enzyme activity [18].

Beta-endorphin (BE), a neuropeptide consisting of 31 amino acids, is a derivative of pro-opiomelanocortin (POMC). The elevation of BE level is associated with a marked analgesic effect. According to data from the literature, stress is a potent inducer of BE release. During the stress reaction, corticotropin releasing hormone (CRH) cleaves POMC to release ACTH (which then mobilises glycocorticoids) and BE. Many modalities of physiotherapy induce elevation of BE level. Exercises involving prolonged exertion (e.g. running) are known to cause elevation of BE level and an abundance of data has been obtained on heat-induced changes of BE level. In our studies, the effect of balneo-phototherapy on BE production was studied first. This treatment modality involves bathing in hypertonic solution of salt from the Dead Sea (ToMeSa – Totes Meer Salz – therapy) while being exposed to narrow bandwidth (311 nm) UV-B light. According to data from the literature, BE levels are higher in psoriatic patients than in those without this disorder. Stress is known to have a strong influence on psoriasis. This population of patients was chosen, because the relevant information available is empirical, rather than evidence-based. Twelve psoriatic patients (3 females and 9 males with a mean age of 50.5 years) underwent concomitant balneotherapy with 10 % solution of Dead Sea salt and phototherapy with 311 nm UV-B for 35 consecutive sessions. Assessments were undertaken at baseline and on the day after the 35th treatment session (mean cumulative UV-B dose was 19.5 J/cm²). Clinically, improvement was reflected by the substantial (75-per-cent on average) reduction of the PASI index, from 22.9 (14.7-27.9) at baseline to 5.75 (1.2-8.2) after treatment. Although a decrease in BE level could be demonstrated, this was not statistically significant and accordingly, the mechanism of clinical improvement is probably not related to BE expression (at least at this dose level of UV-B irradiation) [19].

Balneotherapy and health care policy

Hungarian authors have exposed their views regarding balneology on many occasions, as reflected by the abundance of letters to the editor and ‘arisen matters’ published. Often, these criticised the omission of balneotherapy from the listing of treatment modalities for musculoskeletal disorders or the indistinction of balneology, hydrotherapy, and spa therapy – even by high-esteemed journals [20-24]. A joint statement of Hungarian and foreign authors has been published to clarify these entities [25].

Studies under publication

Turkish-Hungarian study

The 'hammam' is a special Turkish bath, which came into use when the Ottomans settled in Anatolia and had been extremely popular even earlier, in the Ottoman Empire. Its origin dates back to the thirteenth century, although it probably existed even earlier in Jordania, in the eighth century. The effects of a single session of hammam bath on pain, mental status, as well as on various clinical and laboratory parameters were studied in healthy volunteers [26].

Gynaecological balneology

This study evaluated alum-containing medicinal water at the Parádfürdő State Hospital [27]. The paper submitted for publication enlarges upon the following questions : Can the beneficial effect of alum-containing water be demonstrated in chronic gynaecological disorders ? Is there any difference between the clinical and laboratory parameters of patients undergoing balneotherapy with mineral or plain (tap) water ?

Balneotherapy for low back pain

A paper submitted for publication reports the results of a study evaluating the usefulness of the mineral water from Celldömölk (containing sodium hydrogen carbonate and chloride) in the management of patients with lumbar pain. Primary endpoints of this study included the effect of thermal water on lumbar pain, on the range of motion of the lumbar spine, and on the quality of life of patients, compared to treatment with tap water. Secondary endpoints were – among others – changes in the dose requirement of analgesics, and the safety profile of treatment [28].

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