Does balneotherapy with low radon concentration in water influence the endocrine system? A controlled non-randomized pilot study

ARTICLE *in* BIOPHYSIK · APRIL 2009

Impact Factor: 1.58 · DOI: 10.1007/s00411-009-0222-3 · Source: PubMed

6 AUTHORS, INCLUDING:

Katalin Nagy
Markhot Ferenc Hospital
9 PUBLICATIONS **32** CITATIONS

Tibor Kovács
University of Pannonia, Veszprém
62 PUBLICATIONS **533** CITATIONS

Norbert Kavasi
National Institute of Radiological Sciences
43 PUBLICATIONS **269** CITATIONS

Tamas Bender
Budai Irgalmasrendi Kórház Kht.
53 PUBLICATIONS **500** CITATIONS

Radiat Environ Biophys (2009) 48:311–315
DOI 10.1007/s00411-009-0222-3

ORIGINAL PAPER

Does balneotherapy with low radon concentration in water influence the endocrine system? A controlled non-randomized pilot study

Katalin Nagy · István Berhés · Tibor Kovács · Norbert Kávási · János Somlai · Tamás Bender

Received: 4 July 2008 / Accepted: 5 March 2009 / Published online: 24 March 2009

Abstract Radon bath is a well-established modality of balneotherapy for the management of degenerative musculoskeletal disorders. The present study was conducted to ascertain whether baths of relatively low (80 Bq/l) radon concentration have any influence on the functioning of the endocrine system. In the study, a non-randomized pilot study, 27 patients with degenerative musculoskeletal disorders received 30-min radon baths (of 31–32°C temperature and 80 Bq/l average radon concentration) daily, for 15 days. Twenty-five patients with matching pathologies were subjected to balneotherapy according to the same protocol, using thermal water with negligible radon content (6 Bq/l). Serum thyroid stimulating hormone, prolactin, cortisol, adrenocorticotropic hormone, and dehydroepiandrosterone levels were measured before and after a balneotherapy course of 15 sessions. Comparison of the accumulated data using the Wilcoxon test did not reveal any significant difference between pre- and post-treatment values or between the two patient groups. It is noted that while the beneficial effects of balneotherapy with radon-containing water on degenerative disorders is widely known, only few data have been published in the literature on its effect on endocrine functions. The present study failed to demonstrate any substantial effect of thermal water with relatively low radon content on the functioning of the endocrine system.

K. Nagy
Department of Rheumatology,
Markhot Ferenc County Hospital, Eger, Hungary

I. Berhés
3rd Department of Internal Medicine,
Markhot Ferenc County Hospital, Eger, Hungary

T. Kovács · J. Somlai
Institute of Radiochemistry and Radioecology,
Pannon University, Veszprém, Hungary

N. Kávási
Social Organization for Radioecology Cleanliness,
Veszprém, Hungary

T. Bender (✉)
Polyclinic of the Hospitaller Brothers of St. John of God
in Budapest, Budai Irgalmasrendi Kórház, Árpád fejedelem u. 7.,
1023 Budapest, Hungary
e-mail: bender@mail.datanet.hu; bender.tamas@irgalmas.hu

Introduction

Radon springs used for medical purposes exist in many countries of the world, including Italy (Ischia), Austria (Bad Gastein), Japan (Misasa), or Czech Rebublik (Jachimov). Recently, a number of papers have been published on the intensity of ionizing radiation inside and close to radon spas (Vogiannis et al. 2004; Radolić et al. 2005; Labidi et al. 2006). There are a couple of low-activity radon spas also in Hungary, e.g. in Budapest (Rudas Spa) and at Hévíz, although the best example is the health resort at Eger located in North East Hungary (Szerbin 1996; Somlai et al. 2007). Spa culture in this city reaches back to the Turkish occupation during the sixteenth century. Average radon content of the medicinal spring at Eger is 80 Bq/l, which is lower compared to the water of Bad Gastein or Jachimov. Radon is a noble gas that emanates during the radioactive decay of radium, a ubiquitous element occurring everywhere in the Earth's crust. The first in the decay series is ^{238}U, which decays by emitting three alpha and two beta particles to become ^{226}Ra. This nuclide emits also alpha particles and decays to become ^{222}Rn (called "radon" throughout this paper), which is also an alpha emitter (half-life, 3.8 days). In water, radon is present either dissolved or as an air–gas mixture. In medicine, radon is used for balneotherapy, dry bath, and inhalation. Radon is absorbed into the body through the skin and lungs. During balneotherapy, radon decay products remain in the water, only radon can be absorbed through the skin (note that radon can be inhaled as well). During the relatively short duration of the treatment sessions, radon is distributed in highly perfused body regions and largely eliminated through the lungs, with exhaled air. A fraction of the absorbed radon nuclei remains in fat tissue and other organs, and may also be eliminated by respiration. Only approximately 0.5% of the radon nuclei decay in tissue, and fat, gonads and the adrenal cortex are exposed by the alpha particles generated. Radon may be responsible for an enhancement of the activity of natural killer cells along with an activation of the monocyte–macrophage system, stimulation of uric acid excretion, and induction of epinephrine production; it also suppresses DNA synthesis while stimulating DNA repair, as well as gonadal function (Nagy and Bereczki 2000; Falkenbach 2000; Deetjen et al. 2005). Only meagre data are available in the literature on the potential influence of radon bath on the endocrine system, especially, if data obtained during recent decades with state-of-the-art measurement methods are considered.

Materials and methods

Location and radon measurements

This study was intended to ascertain whether bathing in thermal water of low radon content has any influence on endocrine parameters. Measurements were performed in Eger, in the Turkish basin of the 'Törökfürdő' Spa, and in the remedial basin of the nearby Hotel 'Flóra' (Baradacs et al. 2001). The water composition from these two medicinal springs is almost identical, in terms of mineral and radon content. However, in contrast to the 'Törökfürdő' Spa, the radon content is negligible in the water in the remedial basin of Hotel 'Flóra' as it is warmed and treated with a pool filtration system. In the 'Törökfürdő' Spa, radioactivity from radon was measured using a Lucas cell (PYLON WQ 1001 system) (Lucas 1957; Baradacs et al. 2001; Kovacs et al. 2003), whereas an etched track type radon detector ('Radamon' Institute of Nuclear Research, Debrecen, Hungary) was used in Hotel 'Flóra' (Csige and Csegzi 2001).

Investigated cohort

Included in the study were rheumatology patients with degenerative lesions of the spine and joints (i.e. osteoarthritis of the knee and hip, lumbar spondylosis). Twenty-seven patients (19 women and 8 men; mean age 49.8 years) received balneotherapy at the 'Törökfürdő' Spa, whereas 25 patients (19 women and 6 men; mean age 58.16 years) were treated at Hotel 'Flóra'. All subjects were informed on the purpose, conditions, and course of the study before inclusion. The study was approved by the local institutional review board. One of the 26 patients recruited from Hotel 'Flóra' did not attend the follow-up visit, as well as endocrine workup was incomplete in several others, owing to technical difficulties. In the 'Törökfürdő' Spa, all 27 patients attended the control visit. Explicitely excluded were patients with acute febrile conditions, disorders associated with loss of consciousness, psychoses, extensive inflammatory lesions of the skin, infectious disease, coronary heart disease with angina at rest, unstable angina pectoris, malignant hypertension, severe heart failure, respiratory abnormalities, faecal or urinary incontinence, or acute stages of musculoskeletal disorders (e.g. acute radiculitis or arthritis).

Study protocol

Fifteen balneotherapy sessions of 30 min duration were administered. Water temperature was 31°C at the 'Törökfürdő' Spa, and 32°C at Hotel 'Flóra'. All study subjects were outpatients not receiving any concomitant treatment. Balneotherapy was administered always at the same time of the day.

Blood sampling was done immediately before the first and after the last treatment session, always at the same time of the day, in order to eliminate the influence of any diurnal variation on the hormone levels of the patients. Baseline endocrine screens included measurement of the serum levels of the following hormones: TSH (thyroid stimulating hormone), prolactin, cortisol and ACTH (adrenocorticotropic hormone), and DHEAS (dehydroepiandrosterone). Cortisol (nmol/l) and ACTH levels (pmol/l) were determined by radioimmunoassay (RIA using ^{125}I labelling), whereas TSH, prolactin (mU/l) and DHEAS (μmol/l) were measured with ultrasensitive immunoradiometric assay (IRMA) and monoclonal antibodies (Laszlo and Janaky 1986). As regards the measurements undertaken at the 'Törökfürdő' Spa, T3 and T4 levels were measured only subsequently in subjects with an abnormal TSH level.

Statistical analyses

Statistical analysis was performed using the Wilcoxon test. Any significant deviation of variables from the normal distribution was ruled out by performing the Kolmogoroff–Smirnoff test beforehand.

Results

Water measurements

As for the spring water supplying the Turkish bath of 'Törökfürdő' Spa, dissolved radon concentration was 90 (75–100) Bq/l at the springhead and 80 Bq/l in the Turkish basin, respectively. The calcium concentration was 98.8 mg/l, magnesium concentration 16.7 mg/l, and bicarbonate concentration 342 mg/l.

In the water of the 'József' spring, supplying the remedial basin of Hotel Flóra, the dissolved radon concentration was 67 Bq/l at the springhead and 7.5 Bq/l in the basin, based on our own data (Baradacs et al. 2001). The calcium concentration was 90.4 mg/l, magnesium concentration 19.24 mg/l, and bicarbonate concentration 341.65 mg/l.

Patient measurements

The results obtained in terms of pre- and post-treatment values as well as in terms of the two patient groups (treated at the 'Törökfürdő' Spa or at Hotel 'Flóra') are given in Tables 1 and 2.

Discussion

The performed statistical analysis did not reveal any significant changes in monitored hormone levels before and after

Table 1 Comparison of results from the 'Törökfürdő' Spa and from Hotel 'Flóra'

Hormones	Place	*N*	Median	Minimum	Maximum	**Wilcoxon Z** Sign.Level
TSH	Törökfürdő Spa	28	0.115	−1.34	1.03	$Z = -1.597$
	Hotel 'Flóra'	21	−0.050	−2.80	0.60	NS $P = 0.110$
Prol	Törökfürdő Spa	25	−25.000	−181.00	348.00	$Z = -1.063$
	Hotel 'Flóra'	23	25.000	−139.00	192.00	NS = 0.288
Cort	Törökfürdő Spa	28	0.000	−560.00	350.00	$Z = -0.464$
	Hotel 'Flóra'	23	30.000	−510.00	412.00	NS $P = 0.643$
DHEAS	Törökfürdő Spa	28	−0.200	−2.80	2.40	$Z = -0.726$
	Hotel 'Flóra'	24	0.150	−3.60	1.60	NS $P = 0.468$
ACTH	Törökfürdő Spa	27	−0.450	−8.83	6.89	$Z = -0.113$
	Hotel 'Flóra'	24	−0.100	−15.17	7.15	NS $P = 0.910$

The significance of the median differences was calculated by the Wilcoxon test

TSH thyroid stimulating hormone (mU/l), *Prol* prolactin (mU/l), *Cort* cortisol (nmol/l), *DHEAS* dehydroepiandrosterone (μmol/l), *ACTH* adrenocorticotropic hormone (pmol/l), *NS* not significant

Table 2 Changes of hormone levels compared to baseline

Hormones levels	Paired differences mean	Wilcoxon test		
		N	*Z*	Significance (2-tailed)
"Törökfürdő" Spa				
TSH(b) − TSH(a)	0.086	28	−1.070	NS $P = 0.285$
Prol(b) − Prol(a)	−8.240	25	−0.901	NS $P = 0.367$
Kort(b)) − Kort(a)	−21.036	28	−0.318	NS $P = 0.751$
Dheas(b)) − Dheas(a)	−0.232	28	−0.775	NS $P = 0.438$
ACTH(b)) − ACTH(a)	−0.009	27	−0.120	NS $P = 0.904$
Hotel 'Flóra'				
TSH(b) − TSH(a)	−0.240	21	−1.165	NS $P = 0.244$
Prol(b) − Prol(a)	11.435	23	−0.608	NS $P = 0.543$
Kort(b) − Kort(a)	3.174	23	−0.152	NS $P = 0.879$
Dheas(b) − Dheas(a)	−0.042	24	−0.365	NS $P = 0.715$
ACTH(b) − ACTH(a)	−0.290	24	−0.371	NS $P = 0.710$

NS not significant, (a) before treatment (b) after treatment the treatment (Table 2); however, a detailed review of the latter indicated individual fluctuations. Except for one patient, baseline TSH levels of patients undergoing balneotherapy at the 'Törökfürdő' Spa were in the normal range (0.3–3.5 mU/l). Major changes of the TSH level during the treatment were observed in three patients; one of these had pre-existing subclinical hyperthyroidism (without clinical manifestations) at the beginning of treatment. Serum TSH level of this patient decreased from 0.14 mU/l (which is considered as the baseline, for this patient) to 0.02 mU/l (normal range, 0.3–3.5 mU/l). This patient developed full-blown hyperthyroidism manifested by clinical symptoms (including dyspnea and tachycardia) after balneotherapy and required pharmacotherapy with thiamazol. No other patient had clinical symptoms or underwent drug treatment, and none of the subjects discontinued balneotherapy. Thyroid function of the other two patients was normal before balneotherapy. One of them developed subclinical hyperthyroidism (0.53–0.23 mU/l), whereas the THS level of the other one decreased to the lower limit following balneotherapy (0.43–0.3 mU/l). Reduction of the TSH level by the end of the treatment was seen in the majority of subjects. Although this change was within the normal range of TSH values, it reflected an increase in thyroid function. In the majority of patients treated at Hotel 'Flóra', baseline and post-balneotherapy TSH levels were in the normal range (i.e. 0.3–3.5 mU/l), but minor elevation was ascertained by the end of the treatment.

Elevation of serum prolactin levels was detected in five subjects undergoing balneotherapy at the 'Törökfürdő' Spa, and significant hyperprolactinaemia was seen in two of these patients. After balneotherapy, serum prolactin concentration increased further in two patients (from 765 to 1,707 mU/l and from 2,175 to 2,500 mU/l, respectively), whereas in the others, elevated prolactin levels decreased (from 1,495 to 1,289 mU/l, and from 763 to 721 mU/l, respectively), and even returned to the normal range (80–500 mU/l) in one patient (from 565 to 217 mU/l). As regards patients with normal prolactin levels at the beginning of the treatment, post-treatment prolactin levels exceeded—although slightly—the upper level of the normal range in four subjects. In the group treated at Hotel 'Flóra', a marked elevation of the baseline prolactin level was observed in a single patient only (754–725 mU/l); however, this level decreased after balneotherapy. No other relevant changes were detected and, in contrast to patients treated with radon baths, abnormal elevation of prolactin level was not observed.

In the group treated at the 'Törökfürdő' Spa, monitoring of serum cortisol and ACTH levels revealed a reduction of elevated baseline values, and of lower-than-normal baseline levels towards the physiological range (2.2–13.2 pmol/l). No substantial changes of the ACTH level after treatment compared to that before were observed. The effect of the classical feedback mechanism (i.e. a decreasing cortisol level stimulates the ACTH production) was not observed when the changes of ACTH and cortisol levels were compared. In other words, a greater reduction of plasma cortisol was not followed by an increase in the ACTH level. Cortisol (160–620 nmol/l) and ACTH levels (2.2–13.2 pmol/l) of patients treated at Hotel 'Flóra' were in the normal range. Finally, DHEAS levels were unchanged and did not exhibit individual variations either, for both investigated locations.

Conclusion

Radon baths are increasingly popular among patients. As shown by some evidence, even the risk associated with radioactivity does not deter patients from preferring this modality of balneotherapy (Erickson 2007). However, data on the relationship between the use of radon baths and the incidence of lung cancer are controversial (Ye et al. 1998). Radon baths are administered for the treatment of musculoskeletal disorders, primarily ankylosing spondylitis and rheumatoid arthritis (Falkenbach 2001; Falkenbach et al. 2005; Franke et al. 2007), and the beneficial effect of radon on free radicals, for example, has also been demonstrated (Yamaoka et al. 2001). A modulating effect of radon bath on the plasma level of adrenocortical hormones was observed. Japanese authors found elevated ACTH and endorphin levels after balneotherapy with radon-containing water (Yamaoka et al. 2004). It is thus concluded that radon exposure may influence endocrine balance.

This study investigated the effects of thermal water with relatively low radon content on the human endocrine system, and no significant effects could be detected. The favourable changes reported in the literature occurred after balneotherapy in water of higher radon concentration than that observed in the present study. Theoretically, this suggests that thermal waters with higher radon content exert a greater influence on the endocrine system than those with lower radon concentration. As regards our study, the failure to demonstrate any beneficial effect might be due to the relatively small number of patients included, the lack of randomisation, and the large standard deviation of the measurements. It is therefore concluded that this investigation has to be extended to a larger patient population, if any differences in the effects of low radon and high radon balneotherapy is to be quantified.

References

Baradacs E, Hunyadi I, Dezso Z, Csige I, Szerbin P (2001) ^{226}Ra in geothermal and bottled mineral waters of Hungary. Radiat Meas 34:385–390

Csige I, Csegzi S (2001) The Radamon radon detector and an example of application. Radiat Meas 34:437–440
Deetjen P, Falkenbach A, Harder D, Jöckel H, Kaul A, Philipsborn H (2005) Radon als Heilmittel. Verlag Dr. Kovac, Hamburg
Erickson BE (2007) Radioactive pain relief: health care strategies and risk assessment among elderly persons with arthritis at radon health mines. J Altern Complement Med 13:375–379
Falkenbach A (2000) Therapeutische radonexposition (review). Phys Rehab Kur Med 10:199–205
Falkenbach A (2001) Radon therapy in Bechterew disease. Benefits and risk factors. Dtsch Med Wochenschr 126:1379–1380
Falkenbach A, Kovacs J, Franke A, Jorgens K, Ammer K (2005) Radon therapy for the treatment of rheumatic diseases—review and meta-analysis of controlled clinical trials. Rheumatol Int 25:205–210
Franke A, Reiner L, Resch KL (2007) Long-term benefit of radon spa therapy in the rehabilitation of rheumatoid arthritis: a randomised, double-blinded trial. Rheumatol Int 27:703–713
Kovacs T, Bodrogi E, Somlai J, Jobbagy V, Patak G, Cs Nemeth (2003) Ra^{226} and Rn^{222} concentrations of spring waters in Balaton Upland of Hungary and the assessment of resulting doses. J Radioanal Nuc Chem 258:191–194
Labidi S, Essafi F, Mahjoubi H (2006) Estimation of the radiological risk related to the presence of radon 222 in a hydrotherapy centre in Tunisia. J Radiol Prot 26:309–316
Laszlo F, Janaky T (1986) Radioimmunassay. Medicina, Budapest
Lucas HF (1957) Improved low-level alpha scintillation counter for radon. Rev Sci Instrum 28:680–683
Nagy K, Bereczki J (2000) A radonfürdõ hatásmechanizmusa. Balneológia Gyógyfürdõügy Gyógy-idegenforgalom 21:28–31
Radolić V, Vuković B, Smit G, Stanić D, Planinić J (2005) Radon in the spas of Croatia. J Environ Radioact 83:191–198
Somlai J, Torma A, Dombovári P, Kávási N, Nagy K, Kovács T (2007) Contribution of ^{222}Rn, ^{226}Ra, ^{234}U and ^{238}U radionuclides to the occupational and patient exposure in Heviz-spas in Hungary. J Radioanal Nuc Chem 272:101–106
Szerbin P (1996) Natural radioactivity of certain spas and caves in Hungary. Environ Int 22:389–398
Vogiannis E, Nikolopoulos D, Louizi A, Halvadakis CP (2004) Radon exposure in the thermal spas of Lesvos Island—Greece. Radiat Prot Dosim 111:121–127
Yamaoka K, Mifune T, Mitsunobu F, Kojima S, Mori S, Shibuya K, Tanizaki Y, Sugita K (2001) Basic study on radon effects and thermal effects on humans in radon therapy. Physiol Chem Phys Med 33:133–138
Yamaoka K, Mitsunobu F, Hanamoto K, Shibuya K, Mori S, Tanizaki Y, Sugita K (2004) Biochemical comparison between radon effects and thermal effects on humans in radon hot spring therapy. J Radiat Res (Tokyo) 45:83–88
Ye W, Sobue T, Lee VS, Tanooka H, Mifune M, Suyama A, Koga T, Morishima H, Kondo S (1998) Mortality and cancer incidence in Misasa, Japan, a spa area with elevated radon levels. Jpn J Cancer Res 89:789–796