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THERMAL WATER AND RADON EXPOSURE THROUGH THE SKIN

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ABSTRACT. Low doses - non cancer effect involve also, exposure to RADON alpha particle, through the skin, during radioactive thermal baths. Alpha radiation is considered to have a high impact on the immune-suppressive cytokine and to a certain degree it can influence the temporary regeneration of impaired health function in autoimmune patients, due to their analgesic and anti-inflammatory properties. Considering the benefits of thermal water with 30 Bq/l Radon, from Felix-Oradea, Spa Resort, Bihor county, Romania, we analysed the variation of skin biophysical parameters like hydratation (HYDR), trans epidermal water loss (TEWL), sebum quantity (S), and skin surface temperature (T), for different water 'temperatures, looking comparatively between the left hand submerged in radioactive water and the right hand, submerged in normal water.

Key words: *skin anti-inflamatory exposure; radioactive thermal water.*

INTRODUCTION

Thermal waters have a certain degree of radioactivity attributed to elements of the uranium and thorium natural decay series. One of the isotopes contained in elevated concentrations is ^{226}Ra. It decays into Radon, noted ^{222}Rn. After that, through ^{222}Rn decays alpha-particles are emitted. These alpha-particles can enter into our body by inhalation, ingestion or through the skin, during dermal contact with thermal water. Radon arrived in our body are delivered via blood to other tissues, respectively other human' cells. Retention' time into the body is short, 50% disappearing within 15–30 min, mainly through exhalation and also through excretion and diffusion through the skin after the bath. Although the effect of Radon, other than causing lung cancer, has received little attention, epidemiological studies and the results of treatment of patients in radioactive spa waters suggest that the gas has an effect on the immune system, (Bituh et al., 2009; Hofmann et al., 1999). This study belongs to the field of radioprotection which considers the health effects of low-dose radiation, ^{222}Rn being a natural radionuclide. Not all dosimetry issues regarding Radon entrance into the skin are yet solved. The quantitative nuclide-specific information about the deposition, adsorption, absorption and penetration of radon progeny from the skin surfaces in our body is still missing. In this context, for a good dosimetric quantification, the mechanism of its transport from the surface to basal skin layer and its' arrival into the blood ought to be very well understood. Thus, the uncertainty of dose effect relationship can be significantly decreased. The therapeutic use of Radon involves the intake of Radon gas either through inhalation or by transcutaneous absorption of Radon dissolved in the bath water. The importance of entrance routes of Radon into the body should be changed according with environmental conditions: concentrations, humidity and temperature. Although inhalation is a very important route, particularly in conditions such as thermal spas, the absorption route should be more important. It has been observed, in 2002, that speleo therapeutic Radon exposure causes a considerable increase in Radon progeny activity on skin, due to high adhesive properties of Radon. Later, in 2010, it was pointed out that among Radon's progeny, ^{218}Po has the biggest contribution to the cellular doses measured on the skin due to its highest deposited activity and the emission of two alpha particles (Soto, 1997; HLEG, 2009; Falkenbach et al., 2002; Tempfer et al., 2010).

Considering the importance of skin structure for the modelling of dermal exposure, our purpose was to follow the biophysical properties of skin in contact with thermal water having a Radon activity of 30 Bq/l. We analysed the variation of the following biophysical parameters: HYDR, TEWL, S and T for the same thermal water at two different temperatures, looking comparative to the left hand submerged in radioactive water against the right hand, submerged into the Radon-free tap water.

MATERIALS AND METHODS

The study took place during May-July 2014, and thermal water was taken from a natural spring Felix-Oradea, Bihor county Romania where is a very well known Spa resort.

Non-invasive instruments were used to analyse: dermal hydration - (HYDR), trans epidermal water loss - (TEWL), sebum quantity - (S), and the increase of temperature at the skin surface (T). The measurements were initially performed without water contact (22±2^{0}C and 30-45% relative humidity, in the room) and were later compared with the ones performed after the skin contact with water at 36.5°C and 40°C respectively. Both hands were submerged simultaneously in water: left hand in thermal water and right hand in normal water; the exposure lasted - 6 minute. Before the analysis the water surplus was removed with a towel. The exposures were successively performed and detection was made on hand surface, in the same site.

HYDR was measured with Corneometer CM 825. The method involves the measuring of skin dielectric capacitance at surface. The method is very sensitive and the hydration can be assessed on the skin surface at depth of 10-20 µm in the stratum corneum. The results are expressed in arbitrary units from 0 to 100.

Tewameter TM 300 was used for the assessment of TEWL at the skin surface and the results are expressed in g/m^2/h.

Sebumeter SM 815 (Courage-Khazaka Electronics, Germany) was used for quantification of sebum secretion at the skin surface and the results were expressed in mg sebum/cm^2 skin. The software was also, from Courage-Khazaka Electronics, Germany. These methods are used frequently in skin research studies (Moldovan and Nanu, 2010).

The dermal infrared radiation was appreciated with Thermometer IR 900-30S, K-Type (Voltcraft Instruments, Germany), suitable for contactless temperature measurement when the surface emissivity is unknown. The radiation measurements were performed at 30 cm distance from the hand surface, in the same point, an area of 20 mm in diameter and were converted in ^{o}C. The analysis was performed in accordance with Lahiri et al. (2012).

Exposure group

Nine healthy volunteers aged between 18 and 75 years (seven females and two male), without dermatological diseases, history of allergies or other skin disease have been monitored, before and after the contact with normal and thermal water. They were asked not to use any cosmetic products before and during the study and not to wash the studied skin areas for about 24 h before the measurements. They were informed about the nature of the test and about the possible adverse reactions. All participants gave their written consent before starting the study.

All data were evaluated for normal distribution prior to statistical analysis. Data were expressed as Mean ± SEM. *P*-values <0.05 were considered significant. Statistical analysis was performed using one way Anova. All tests were interpreted using OriginPro 7.5.

RESULTS

Figure 1 presents a dermal hydration increase in thermal water at 40 ^{0}C with 47.79%, compared with background. This would suggest a changing of skin capacitance at depth of 10-20 µm as a consequence of water entering through dermal pores. A slight difference between left and right hand was observed at beginning, which is preserved at 36.5 ^{0}C (the left being less than the right). After the submerged in radioactive water at 40 ^{0}C, HYDR of the left hand became higher than the right hand (submerged in Radon-free tap water) with 19.56%. The results are statistically significant for both water temperatures, even if the trend reversed.

Figure 2 presents a greater skin barrier disruption, as the TEWL is increases. The increase of TEWL was observed for all volunteers, in both water types, being significant in comparison with the start value. The growth of TEWL was 266.9% higher in thermal water and 271.7% higher in Radon-free tap water, compared with the start. Although HYDR was 19.56% higher in thermal water at 40 ^{0}C, TEWL was 12.56% lower, most likely due to activation of homeostatic mechanisms, increase of local vasodilatation and blood flow.

Figure 3 shows that how the Sebum amount (S) from the skin surface decreases significantly with the increase of water temperature. At the beginning, S was higher for the right hand, due to local pattern of sebaceous gland (Figure 4). After 6 minute in thermal water at 36.5 ^{o}C the S value decreased with approximately 47% while in Radon-free water 85.9%. However, in water at 40^{0}C, the sebum amount dropped close to zero, with no differences observed between left and right hand.

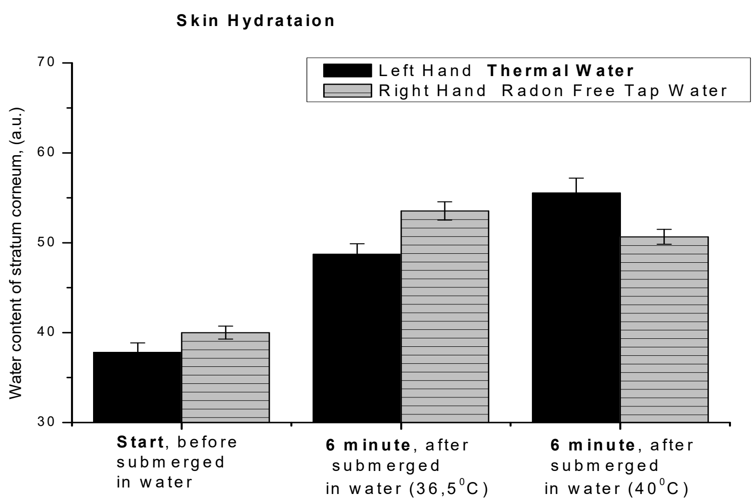

Fig.1. *Skin hydratation (HYDR) after the submersion of left hand in thermal water and right hand in the Radon-free tap water, (Mean ± SEM, are indicated)*

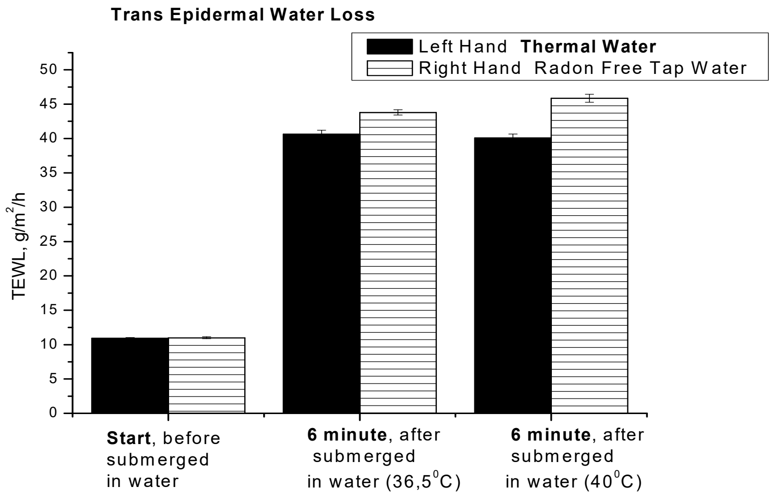

Fig. 2. *Trans Epidermal Water Loss (TEWL) after the submersion of left hand in thermal water and right hand in the Radon-free tap water, (Mean ± SEM, are indicated)*

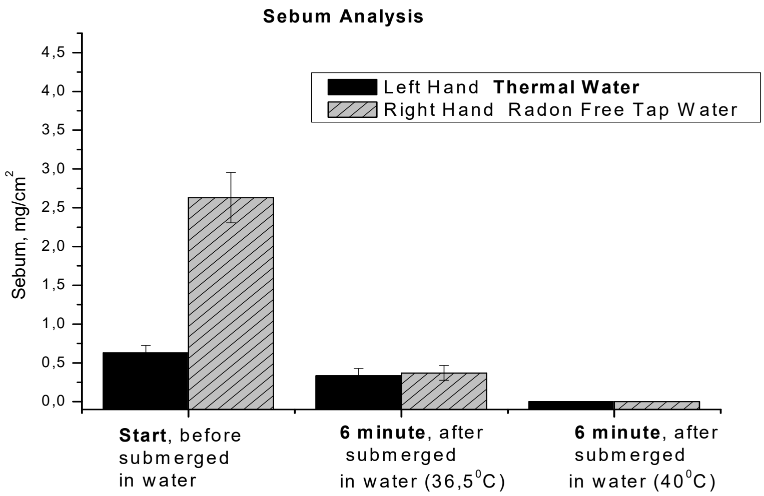

Fig. 3. *Sebum quantity (S) after the submersion of left hand in thermal water and right hand in the Radon-free tap water, (Mean ± SEM, are indicated)*

Figure 4 presents the surface temperature (T), measured at 30 cm from the skin to where were emitted expression of infrared dermal radiation. Due to the difference in blood flow, significantly higher average temperature was observed for the right hand.

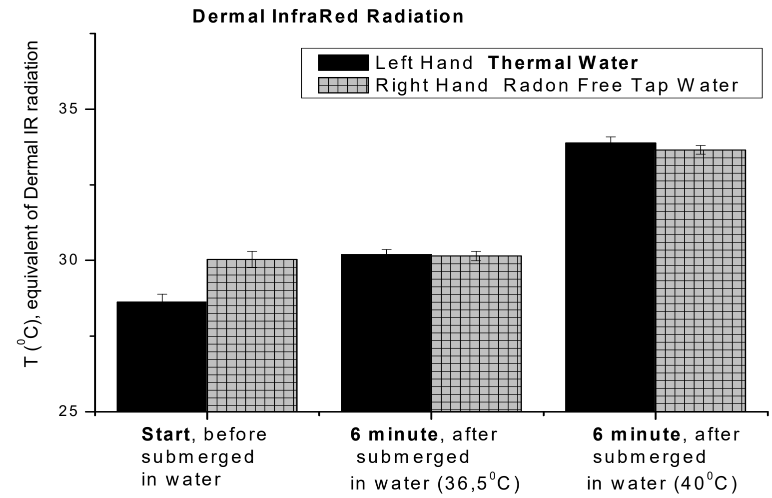

Fig. 4. *Dermal Infrared Radiation converted in ⁰C after the submersion of left hand in thermal water and right hand in the Radon-free tap water, (Mean ± SEM, are indicated)*

The average temperature of the left hand increased with 5.4% following the submersion into thermal water, at 36.5 ^{0}C.

Similar reaction was observed for the right hand. In thermal water of 40^{0}C the increase was around 18.37% for the left hand, while in Radon - free tap water was only 12.04% compared to the start values. A local vasodilatation explains this local heat of temperature, in accordance with our observation regarding the activation of homeostatic mechanisms with imbalance between inflow and outflow of water from dermis.

DISCUSSIONS

The skin is a highly organized structure consisting of three main layers. The layer thickness of human forearm skin assessed by various imaging methods is stratum corneum 0.010−0.020 mm, living epidermis 0.030−0.130 mm, dermis 1.1 mm and subcutaneous fat 1.2 mm. The sebaceous gland can be found at 1-4 mm (Falke, 2005).

According to our results, the contact with thermal water during the bath had a significant influence. With measurements of TEWL and S we assess the skin surface changes and with HYDR, the changes on depth of 10-20 μm, corneum stratum which is the superficial layer of epidermis. Increased in skin hydration observed in thermal water means the alteration of electrical properties in stratum corneum layer, which is constituted by several plans of dead cells intimately linked by an extracellular array composed of lipid bilayer, formed by ceramides, cholesterol and fat acids. An increase of water content at this level changes the ions content and distribution (particularly calcium), which may cause perturbation of signalling pathways, the balance of epidermal cell proliferation / differentiation by influencing the calcium homeostasis and cytokine expression (Pinnagoda et al., 1990; Proksch et al., 1993).

The barrier to water permeation is not absolute and the normal movement of water through the stratum corneum into the atmosphere is known as TEWL and constitutes part of insensible water loss. An increase in TEWL, often results in significant changes of hydration at epidermis level. Generally, increasing of TELW means disruption of dermal barrier and increasing of skin vulnerability, due to disorganization in bilipid layer of the stratum corneum. This correlation cannot be made during the submersion in thermal water due to activation of homeostatic mechanism with increasing of blood flow and emitted infrared radiation from the skin surface. Loss of sebum quantity at skin surface was observed after both submersions in thermal water and in the Radon-free tap water. A lot of functions attributed to sebum in humans may be thus affected, such as photo protection, antimicrobial activity and delivery of fat-soluble anti-oxidants to the skin surface and pro- and anti-inflammatory activity exerted by specific lipids, (Zouboulis et al., 2008; WHO, 2009). Radon is lipophilic;

therefore, its absorption is enhanced in fat-containing tissues. The entrance through disrupted skin barrier will be higher, according to the increase of hydratation. Once entered and attached to the lipid bilayer, it cannot get any easier. This observation is in accordance with the results of Tempfer et al., (2010), who calculate a decreasing of Radon progeny activity at the depth of 20 μm, using a skin thickness model of 55 μm.

During measurement of dermal emitted infrared radiation, the influence of thermal water was observed at a depth of milimeters, greater than the thickness of corneum stratum. Increasing of dermal temperature, after exposure in thermal water, based on our results could have many more consequences on physiological processes via the micro-dermal circulatory beds, which justify its application in therapeutic treatment in radioactive spas, (Falkenbach et al.,2005; Shehata et al., 2006; Moder et al., 2011).

CONCLUSIONS

Radon exposure through the skin is possible due to contact with thermal water. A radioactivity of 30 Bq/l in the thermal water can induce several changes at skin surface and deeper into the dermal layer, meaning a barrier disruption. At the same time activation of homeostatic process can be possible.

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