Transcutaneus Photophoresis of Metal Ions Using Emitters of Band Spectrum of Chemical Elements

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Local exposure to light with hollow cathode lamp radiating band spectrum typical of manganese, copper, potassium, sodium, calcium, and magnesium enhances migration of these elements from the solution applied to the skin to the blood in rats. This effect is most pronounced at low initial blood level of manganese. Its serum concentration increased 17-fold after application of manganese salts and exposure to hollow cathode lamp radiating manganese spectrum.

Key Words: *band emission spectrum; macro- and microelements; manganese; serum; rats*

Trace elements are essential for regulation of all metabolic processes, and therefore all autonomic systems of the body. Disturbances in trace element homeostasis are important etiopathogenetic factors for a wide range of diseases and pathological conditions [1,10,14]. Activation of enzyme system with various micro- and macroelements corrects impaired metabolic processes and maintains homeostasis in the organism [11,13]. Trace element insufficiency is traditionally corrected by their administration *per os* and sometimes by parenteral administration [2]. In this case, higher doses of agents are required for attaining the effective concentrations in the target organs, which is fraught with negative side effects. In light of this, recent investigations are focused on the search for alternative routes of administration, *e.g.* photophoresis. Complex of climatic factors of the Dead Sea health resorts, *i.e.* exposure to water with unique composition in combination with insolation, can be regarded as natural prototype of this approach. Combination of these two factors results in substantial elevation of trace element level in the blood, which provides pronounced therapeutic effects. These circumstances prompted us to investigate the possibility of using the above factors in a modified form for the development of physiotherapeutic procedures effectively increasing the level of critical trace elements.

Term "atomovites", *i.e.* atoms of life, and derivative term "atomovitoses" were introduced to emphasize biological activity of low and ultra-low doses of compounds in the organism [2]. In accordance with contemporary tendencies for preferential use of factors with low and ultralow intensity, All-Russian Research Institute of Optico-Physical Measurements developed hollow cathode lamps (HCL) radiating low-energy band spectra of various chemical elements [3]. The results of preliminary studies suggest that exposure to HCL with band spectrum of manganese and copper can facilitate their transport from the saline solutions applied on the skin [6]. This article represents results of evaluation of effects of three types of HCL on manganese, copper, potassium, sodium, calcium, and magnesium serum levels in rats.

MATERIALS AND METHODS

Experiments were carried out on male Wistar rats weighing 150-200 g (Stolbovaya nursery, Russian Academy of Sciences). The animals were kept under standard condition 4 animals per cage with controlled illumination and temperature regimens (24°C, 12:12 h light-

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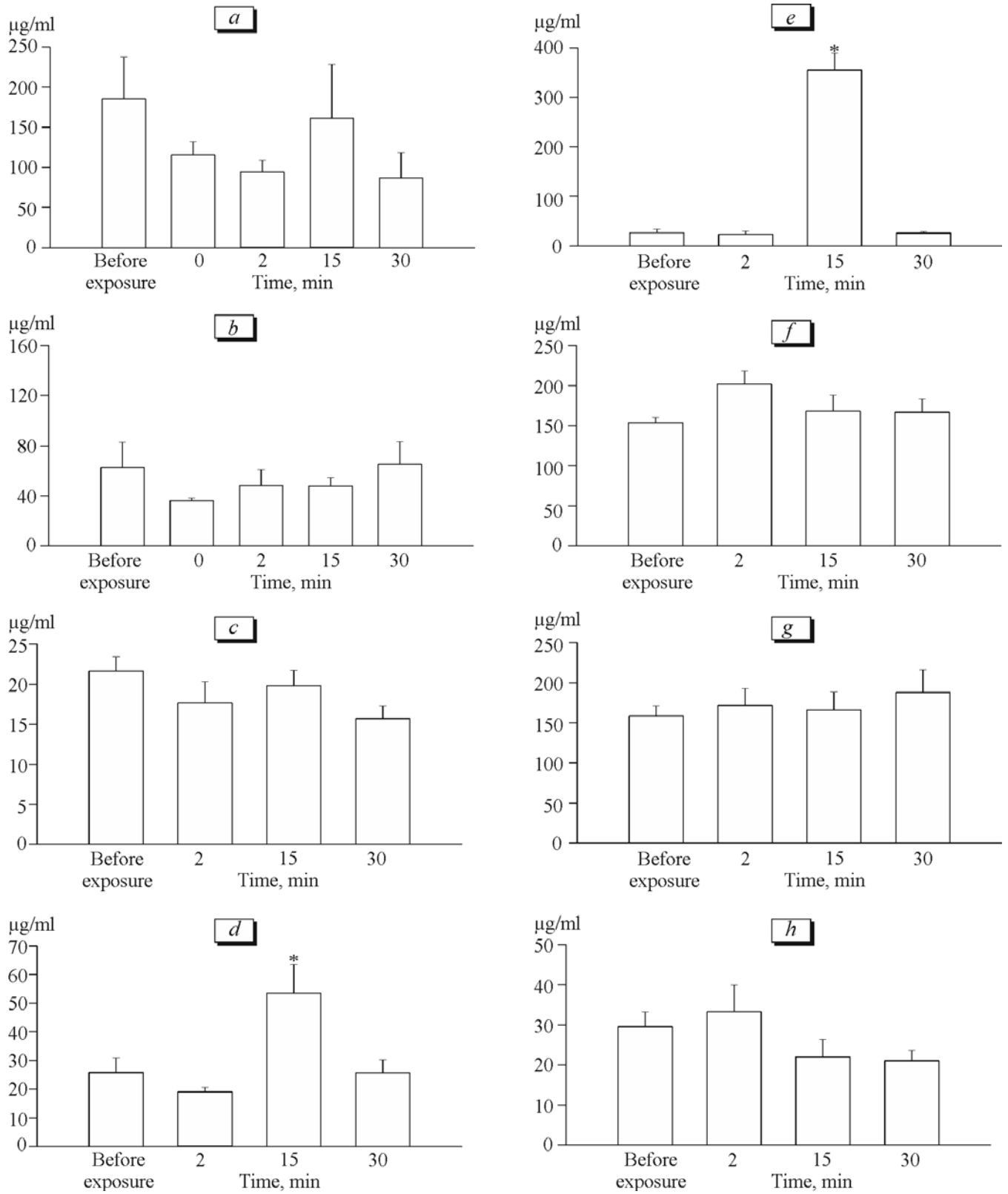

Fig. 1. Mn serum level in rats before and after exposure to HCL. Ordinate: Mn concentration. *a*) solution of Mn and Cu salts (n=4); *b*) solution of Mn and Cu salts+Dead Sea water (n=3); *c*) HCL-Mn, Cu (n=4); *d*) solution of Mn and Cu salts+HCL-Mn, Cu (n=4); *e*) solution of Mn and Cu salts+Dead Sea water+HCL-Mn, Cu+HCL-K, Na, Ca, Mg, experiment was carried out in December (n=4); *f*) solution of Mn and Cu salts+Dead Sea water+HCL-Mn, Cu+HCL-K, Na, Ca, Mg, experiment was carried out in March (n=6); *g*) solution of Mn and Cu salts+Dead Sea water+HCL-Al+HCL-K, Na, Ca, Mg (n=5); *h*) Dead Sea water+HCL-K, Na, Ca, Mg (n=5). *p<0.05 in comparison with baseline level.

dark) with free access to food and water. Experimental animals were divided into 7 groups according to the regimen of exposure of the studied factors. Solutions of salts were applied on the skin in a volume of 0.5 ml (25 mm^2 exposure area) of the interscapular region in the projection of cervicothoracic spine. Group 1 animals were exposed to 1% $MnCl_2$ and 0.3% $CuCl_2$ solution mixed with glycerin (1:4 ratio). Group 2 animals were exposed to the same solution mixed in equal portions with Dead Sea water containing a wide spectrum of macro- and microelements, including Mn, K, Na, Ca and Mg [9]. Group 3 animals were exposed to HCL (Cortek) radiating the spectrum of Mn and Cu (HCL-Mn, Cu) for 30 sec. In group 4, animal skin was first exposed to Mn and Cu solution and then exposed to the same HCL with the same duration of exposure. Group 5 animals were treated with Mn and Cu solution mixed with Dead Sea water, then exposed to HCL-Mn, Cu, and then exposed to HCL radiating the spectrum of K, Na, Ca, Mg (30 sec each lamp). Group 6 animals were treated with the same solution and then exposed to HCL with spectrum of Al and K, Na, Ca, Mg. Group 7 animals were treated with Dead Sea water and HCL with spectrum of K, Na, Ca, Mg. Blood from the caudal vein was taken from all rats (1 μl blood was mixed with 1 ml distilled water) before and 2, 15, and 30 min after irradiation or saline application. The levels of Mn, Cu, K, Na, Ca, Mg were measured. Each group consisted of 3-6 rats. All manipulations were performed under Nembutal anesthesia (50 mg/kg of body weight). The concentration of the studied chemical elements was measured using atomic absorption spectrometer with electrothermal atomization Quant-Z.ETA [5,15]. The data were processed using nonparametric Wilcoxon test.

RESULTS

Local skin exposure to HCL-Mn, Cu or HCL-Mn, Cu together with HCL-K, Na, Ca, Mn resulted in significant increase in serum Mn level in the blood taken 15 min after the exposure from rats preliminary treated with saline solutions (Fig. 1, *d, e*). HCL-Mn, Cu irradiation of the skin after application of these elements resulted in a 2-fold increase in Mn level (Fig. 1, *d*). Successive irradiation with HCL-Mn, Cu and HCL-K, Na, Ca, Mg after treatment with Mn and Cu salts and Dead Sea water led to a 17.5-fold increase in Mn level (Fig. 1, *e*). Significant increase in Mn serum level in group 5 rats can be associated with its penetration through the skin during exposure to HCL not only from $MnCl_2$ solution, but also from Dead Sea water with very high Mn concentration (4000-7100 μg/liter). In addition, baseline Mn level in rat blood in winter (December; 30 μg/liter, Fig. 1, *c-e*, *h*) was 5-fold lower than in spring (March; 150 μg/liter; Fig. 1, *a*, *b*, *f*, *g*). This probably explains insignificant increase in its level (by 1.3 times) 2 min after irradiation with the same HCL and saline application (Fig. 1, *f*). According to published reports, normal Mn level in rat blood is 70-100 μg/liter [7,8]. Thus, the effect of HCL is more pronounced at low initial level of Mn ions in the blood, what indicates their possible corrective action.

Insignificant increase in Cu blood concentration (1.4-fold) was noted only after exposure to HCL-Mn, Cu and solutions of the corresponding salts (from 3800±250 μg/liter in the control to 5310±140 μg/liter after exposure). Baseline Cu level was high in these animals (4000 μg/liter in average), whereas data from other researches showed that concentration of this metal was 1500-2000 μg/liter and lower [8,12]. Exposure of rat skin only to HCL -Mn, Cu (Fig. 1, *c*) or to salts without irradiation (Fig. 1, *a*, *b*) did not increase serum levels of Mn and Cu at different time intervals. The increase in Mn level was also absent after local irradiation with HCL-Al and HCL-K, Na, Ca, Mg preceded by application of Mn and Cu salts and Dead Sea water to the skin (Fig. 1, *g*, *h*), what attests to selectivity of HCL action.

In some experiments, serum levels of K, Na, Ca, and Mg were assessed. An increase in K, Ca and Mg levels was observed only in groups 5 and 7 two minutes after local skin exposure to spectra of these elements and Dead Sea water with high concentration of these elements [9]. Maximum increase in serum level (2.4-fold) was observed for Mg (1.3 *vs*. 0.55 mg/liter in the control), Ca concentration increased 2-fold (from 0.5 to 1.0 mg/liter) and K concentration increased 1.5-fold (from 3.0 to 4.5 mg/liter). Na concentration in these groups remained virtually unchanged (11.5 mg/liter).

We conclude that local light exposure to band spectrum of certain chemical elements modulates migration of metal ions from solutions to the body through the skin. In addition, the effects of HCL on migration of macro- and microelements depend on baseline animal condition: metabolic processes, immune and neuroendocrine status, food composition, season *etc*. Our findings attest to the perspective for the development of physiotherapeutic methods based on HCL [6].

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