Influence of NaCl Aerosols on the Functional Characteristics of Children

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Our paper presents the influence of the NaCl aerosol resulted in situ, in dynamic halochambers, by structural reformation of salt aerosols in the presence of pentahydrol, on the volume of exhaled air, arterial tension and pulse of children, as a result of systemic controlled practice of team and individual physical education games, with subjects of ages from 10 to 15. For reference we used children of the same age and with the same physical education program, but whose activities were performed in open spaces, or in gyms, without salt aerosols. Our study emphasized the fact that the NaCl aerosols formed in situ, in the atmosphere of the halochamber, at a rate of over 0.600mg/m^3 of salt aerosols influences the lung capacity, which was sensible increased in both male and female subjects when exercises were performed in halochamber, compared to outdoor and the body started to recover easier after physical efforts, especially after exercises that involved moderate efforts

Keywords: salt aerosols; halotherapy; functional characteristics; harmonious physical development

The aerosols of NaCl from natural sources (marine aerosols and salt aerosols), or from artificial sources (halochambers, saline devices, or inhalers) are polydisperse systems whose particles cover a wide range of sizes, between simple aquated ions to gigantic-sedimentable particles (>1000nm). Among these, in gaseous atmospheres, under the influence of water oligomers (in environments with an air humidity between 85 and 100%UR), starting from the Aitken particles (<50nm) to the sedimentable ones (with a diameter of approximately 500nm), some transform into solions - shape-shifting glomerule particles in a continuous structural reformation, with negative charged mono-molecular water dipole surface layer and a composition consisting of a single type of salt [1-15].

Those particles, who reformed structurally from salt aerosols under the influence of the pentahydrol in damp environments, are structures with the formula $[x(NaCl)_{2n} \times y(H_2O)_5]_{(aq)}{}^{q-}$, where n>2 and x and y correspond to glomerules with diameters ranging between 50 nm and 100nm, whose surface charge is subunitary q, which makes the solions behave as a negative spherical air ion with a neat internal structure consisting of NaCl nano-polyhedrons and of water pentahydrols, shaped as a crystalline cluster [2, 8-10, 12].

Moreover, in aqueous saline solutions, right below the hypersaturation limit, under the microscope one may note the presence of spherical solions, as glomerules, resulted by structural reformation from nanocrystalites subject to the balances of dissolution-recrystalisation processes, with an electrostatic halo around them, due to their negative charge, which keeps them apart [11]. By increasing the concentration to the over-saturation limit of NaCl, after processes of solvolysis, the nonopolyhedrons in the clusters reunite by recrystallization, forming octahedric microcrystallites.

The polygonal aerosol nanocrystalites absorbed into the tissue (teguments, or pulmonary pleura) may cause damage by dehydrating the contact area, while solions, due to processes of delicvescence and solvolysis, enhance the bioactive processes within the areas they interact with [2, 11, 12].

Thus, for therapeutic environments, they use submicronic, gaseous microdispersions, both as solions (hygro-, or aquo-aerosols) and as partially dry aerosols. For ambiental environments, to generate the "clean air effect", they primarily use partially dry aerosols with a negative superficial charge. They destabilize, by electro-neutralization, the positive charged aerosols, such as those resulted from burning/pyrolysis (for example cigarette smoke), as well as the nanodispesions resulted from the metabolism of certain fungi, or moulds [8-12, 16-20].

Saline/salt aerosols resulted from natural or artificial sources, depending on their practical application, should have well monitored specific lifespan and activity, that is, a minimum concentration value, a specific grain size variation range and a specific negative surface charge which are thoroughly controlled in time [2, 8-12].

There are several studies on the impact of negative salt air ions and of solions on human performance and especially on that impact on children, elderly persons and on sportsmen [8-13, 16-22].

In that regard, the present paper presents the results of experiments on the influence of semi-hydrated solions on pupils who perform their physical education classes in an environment with an optimal level of aerosols (0.6…1.2mg/m^3), which should induce a harmonious development of their functional anthropometric characteristics, by improving their dynamic characteristics and their resistance to physical efforts.

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The system	Parameter	Oct 2008	Oct 2009	Oct 2010	Feb 2011	Oct 2011	Feb 2012
Outdoor or gym	Temperature, °C	20	20	20	21	20	21
	Presure, atm	750	740	740	750	750	740
	Relative Humidity, %	70	60	65	60	60	70
	Illumination, lx	120	116	112	118	120	118
The halochamber	Aerosol concentration, mg/m³	0.649	0.667	0.682	0.669	0.705	0.664
	Presure, atm	20	20	20	21	20	21
	Relative Humidity, %	750	740	740	750	750	740
	Illumination, lx	65	65	65	60	65	60
	Presure, atm	85	80	80	82	85	82

Table 1
CLIMATIC CHARACTERISTICS OF THE TWO SYSTEMS USED IN OUR EXPERIMENT (OUTDOOR AND HALOCHAMBER)

Experimental part

The Halochamber

The experimental halochamber was set in a sealed classroom, dry, with three thermally insulating windows made of ionized glass, with UV filters and oak frames, the room air capacity being 150m^3. The access to that room was through an antechamber (from which one could also access the other rooms needed to assist the activity of the halochamber). In the upper corners of the wall oposite of the entrance to the room (which had no windows) we fitted two devices of the SALIN Plus type (made by Tehnobionic Buzău Romania), which generated semi-dry air ions. Those devices consisted of a vent and a diaphragm containing porous granules extruded from halite recrystallized from over-saturated solutions. They continuously recirculated the air in the halochamber (which was kept at 75-85% UR and 20-22°C). The vents kept an airflow of 28 - 32 m^3/h, together reaching 56 – 64 m^3/h. To achieve the minimum level of saltaerosols and of solions one needed to turn the two devices on at lest 3-5 hours before using the room for physical education activities. By erosion, the airflo from the two devices collects the salt nanoparticles from the frail crystalites in the surface bloomings and disperses them into the atmosphere of the halochamber, where, under the influence of air humidity, due to the difference in hygroscopicity, they reform structurally as pentahydric olygomers and those nonocrystalites, differentiated according to salt types, when they form the spherical glomerules, coated by a layer of surface, negatively charged, water dipoles, known as solions [12].

In the halochamber we worked with specific series of pupils (grouped according to age/grades), for one hour, twice a week, Monday and Thursday with one category and Tuesday and Friday for the other, from 10:00 to 18:00, with breaks of at least one hour between the groups, so as to determine the parameters set for our experiment and to refresh the solion level [12].

The reference groups worked either indoors, or outdoor, depending on the weather.

Determining the solion level and the microclimatic parameters

The solion generating devices were turned on approximately 6 hours before starting classes in the halochamber. Half an hour before the pupils started their physical exercises, we determined the environment characteristics and those pertaining to the function of the halochamber and the same procedure was repeated after each class. To measure and monitor the composition of the atmosphere in the halochamber we used common methods to determine the climatic parameters in a room, as well as specific methods, such as: conductometric determination of the solion concentration, the quantity of particles and their lifespan, by using an optical particle counter with a laser beam and an air ion rationalizer [12, 14, 23].

Because the dynamics of solion emissions in the halochamber depended on the conditions in the environment, during measurements we kept a constant airflow and constantly monitored the microclamate formed in the halochamber, creating artificial temperature and humidity conditions, which were imposed by the working procedure. Our measurements were made in three zones of the halochamber: in the center of the room, in one upper corner opposite from the entrance, at approximately 400mm from the walls, the ceiling and the floor. Table 1 presents the climatic characteristics of the two systems used in our experiment (outside/inside the gym and in the halochamber). The temperature and relative humidity (UR) were measured with a digital electronic hygrothermometer, the pressure with a barometer, and the illumination with an electronic light meter [12].

Before and after each class we measured the concentration, the granulometry, the volume and the lifespan of the solions in the halochamber, with a differential conductometer and a particle counter (Sibata GT 321).

The pupil workgroups

We conducted experiments on pupils in the 5th-8th grade, grouped by age, according to their year of birth (1997, 1998, 1999) and by sex (male and female). The groups that performed outdoors or in the gym were named F_{0i}199X for girls and B_{0i}199X, for boys, i representing the number assigned to the pupil and 199X the year of birth. The groups that performed in the halochamber were F_{Hi}199X and B_{Hi}199X. Each group consisted of 8-10 pupils, with similar weight, height and thoracic circumferences, in order to ensure a successful randomization work. Each child was monitored during the experiments and weekly by a medicine specialist. All research have been carried out according to Helsinki Declaration on human subject testing and we have Declaration of the Ethics Commission of Alexandru Ioan Cuza University of Iasi. The maximum concentration of NaCl aerosols that could be achieved in halochamber is 1.5 mg/m^3 and there are no known side effect of these in literature, even for children with lung diseases such as asthma [17, 18, 20].

The physical performed activities

All groups performed during the classes scheduled by the school program, twice a week, for one hour. The exercises they performed complied with the national syllabus for schools. Thus, at the beginning and the end of each class, for 5-10 min, the pupils performed respiratory gymnastics exercises on music, with profound and slow inhaling and also with long, forced exhaling, aiming to increase their pulmonary capacity. The physical exercises program and the activities performed during class were aimed to [12].

- improve and enhance the health of the pupils, strengthen the body (its resistance to colds and its healing capacity, improving work capacity in general);
- increase their physical capacity (body strength and resistance);
- improve the functional capacity of the body by increasing the cardio-vascular potential, improving the respiratory system and enhancing the metabolism of the body;
- control breathing amplitude and rhythm by simple techniques and in combination with various games, so as to release anxiety and psychic tensions;
- balance their psyche and eliminate the emotional tensions in children.

In order to attain those goals, according to age, we selected from the syllabus those exercises that encouraged a better harmonization of specific structural and functional biometric characteristics, among which:

- walking (variants), running (variants), jumping (variants), exercises for all the segments of the body (with and without additional objects, or music) - for the first 20 minutes;
- games (football and basketball for boys and handball and volleyball for girls) - for the next 20 minutes.

For functional determinations in correlation with physical eforts, the girls performed sit-ups and the boys push-ups, which were counted and timed.

Those exercises were performed gradually, in correlation with the effort.

The pupils that worked in the halochamber interacted with the solion atmosphere both through their skin (they wore shorts and t-shirts) and by inhalation. All the groups of children experienced identical exercise regimes.

The biometric characteristics and their determination

We performed a series of morpho-structural biometric measurements, in order to determine the physical development level of the pupils [12]:

- pulmonary capacity, determined by a portable Peak Flow Meter PFM20, Peak A-I-R spirometer, the maximum volume of exhaled air being measured in L/min;
- arterial tension, determined by a HZ-8501 digital tensiometer;
- pulse and cardiac frequency, determined by a HZ-8501 digital tensiometer.

Experimental data processing

As the characteristics of the group we worked with depended on a wide variety of factors, both exogenous (environmental) and endogenous (genetic inheritance), in order to facilitate the interpretation of our results, we made a graphical representation of the growth percentage in time. Thus, the biometric data were recorded periodically, after 12, 24, 28, 36 and 40 months, so as to establish the evolution in weight and height of our subjects. For thorax development determination we made measurements after 12, 24 and 40 months. Based on the data we recorded we made a primary table. Then we calculated the arithmetic average value (m) for a specific period in each group of pupils, $F_{0m}199X$ for girls and $B_{0m}199X$ for boys. Afterwards we calculated the percent increase in each characteristic C, from their initial values (C_0), according to the subsequent measurements (C_j), where j represents the month of the year when the measurement was made, by using the formula (*12*).

$$C(\%)F_{0m}199X \text{ or } C(\%)B_{0m}199X = 100 \times (C_j - C_0)/C_0,$$
and
$$C(\%)F_{Hm}199X \text{ or } C(\%)B_{Hm}199X = 100 \times (C_j - C_0)/C_0;$$

In the end we drew the graphs for C(%) = f(t), the time representing months, for the average values in boys and girls and according to the conditions they performed in (indicated by O for outside and H for halochamber) Each biometric characteristic in our study was represented within the same system of coordinates, vertical C(%) and horizontal time in months. Based on those graphs, we evaluated the evolution in each group and established the influence of salt aerosols and of the solions reformed in situ on the characteristics we studied.

Results and discussions

After recording the initial data in a table and after processing them and drawing an evolution graph of specific functional characteristics (pulmonary capacity, arterial tension and pulse) of each group of pupils, according to their age and sex, we were able to emphasize their evolution during the three years of our study.

As regard the evolution of the maximum volume of exhaled air, in the case of the pupils born in 1997, the evolution graph also indicated a greater impact of aerosols/solions on boys (fig. 1a), the difference in growth between the outdoor and the halochamber groups being of 11.91% for boys and only 5.21% for girls. We should note that during the first 12 months the progress registered in both boys and girls was similar and then the boys that performed in the halochamber evolved more rapidly.

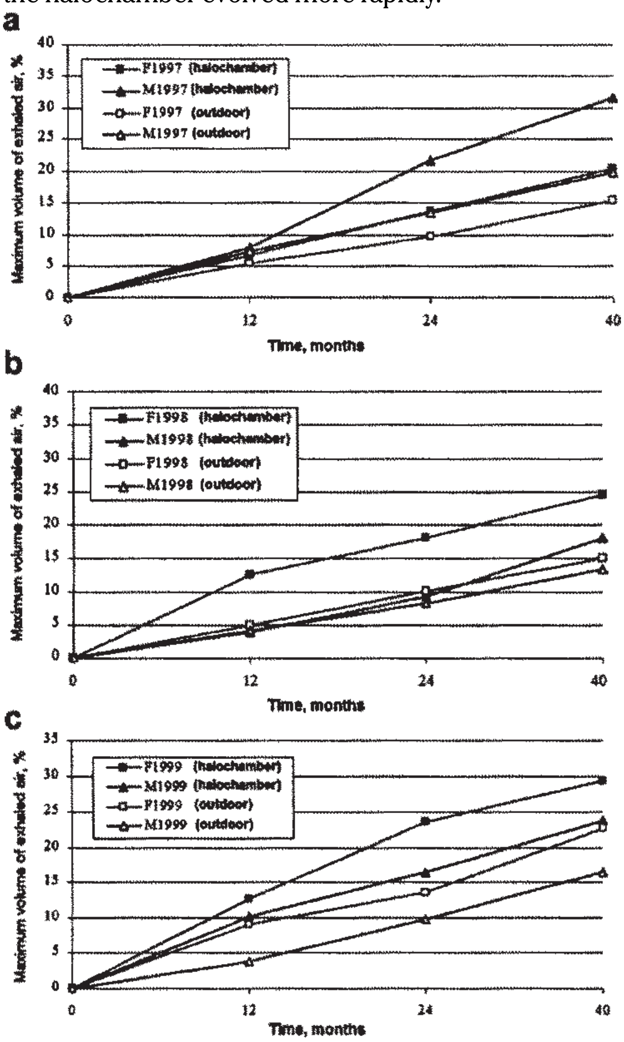

Fig. 1. Evolution of the maximum volume of exhaled air for the pupils: a - born in 1997, b - born in 1998 and c – born in 1999

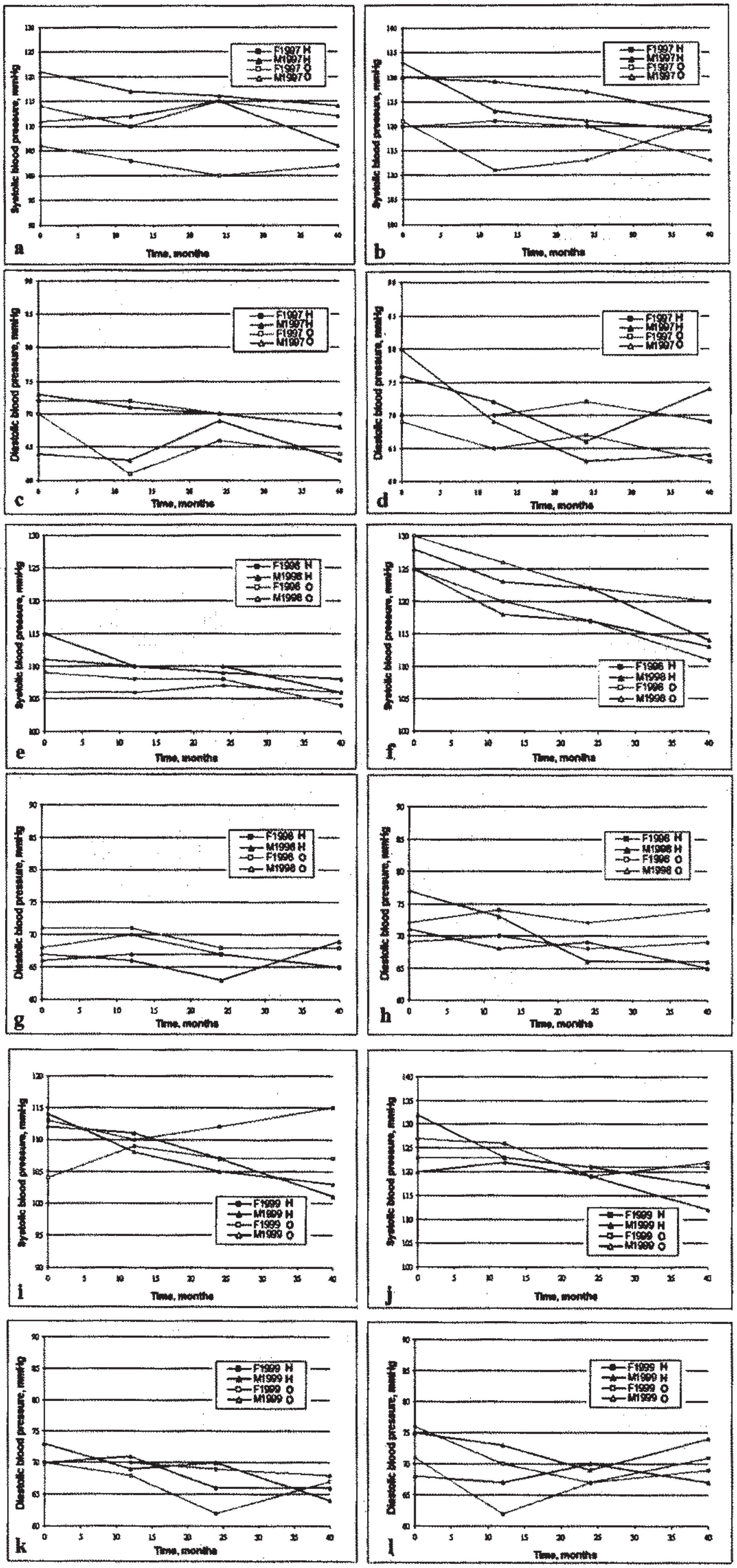

Fig. 2. Evolution of arterial tension for the pupils born in 1997: a - systolic tension before physical effort, b - systolic tension after physical effort, c - diastolic tension before physical effort, d - diastolic tension after physical effort; for the p upils born in 1998: e - systolic tension before physical effort, f - systolic tension after physical effort, g - diastolic tension before physical effort, h - diastolic tension after physical effort; and for the pupils born in 1999: i - systolic tension before physical effort, j - systolic tension after physical effort, k - diastolic tension before physical effort, l - diastolic tension after physical effort; H – halochamber, O – outdoor

For those born in 1998, the evolution of the maximum volume of exhaled air (fig. 1b) was quite different in regard to the increase registered by girls, as compared to boys, the increase reaching up to 24.48% in the case of girls and 18.30% for boys. The groups that performed outdoors only registered an increase of up to 15.00% (15.09 for boys and 13.33 for girls), those values remaining the same throughout the entire study period. During the first 24 months the evolution registered by the group of boys that performed in the halocamber was similar to that of the group that performed outdoors and afterwards it increased gradually.

The variation in time of the maximum volume of exhaled air for the subjects born in 1999 (fig. 1c), clearly indicates the differences between the reference and the halochamber groups, especially in girls. While the initial diference in percentage between the two groups of girls was 3.66%, after exposure to solions that difference increased to 6.68%. In the case of boys, the initial difference was 6.19% and it increased to 7.23%.

The valued recorded for this age group presents an intermediary case between the ones born in 1997 and those born in 1998, which might be explained by the young age of the subjects and by the more childish manner in which the younger group performed with the measuring device. That evolution may also have been due to the genetic diversity and to differences in the quality of life for the children in the area under study (a rural mountain area with oil and forest industry)

In the case of the subjects born in 1997, the values of arterial tension, before and after physical effort, evolved differently for systolic tension (fig. 2a,b) as compared to diastolic tension (fig. 2c,d), those values being higher in boys than in girls. The differences in the values of systolic tension recorded for the group that performed in the halochamber, as compared to that that performed outdoors, are lower in the case of boys than in the case of girls. The differences were greater in the first 24 months and then decreased, the variations became smaller between the values registered during pauses and after exercises, because the body started to recover easier after physical efforts, especially after exercises that involved moderate efforts.

The values recorded for diastolic tension decreased slightly during the first 12 months and then remained constant for both boys and girls, with more constant values in girls than in boys. We should note that the values recorded for girls did not vary much before and after exercises, whereas in the case of boys we registered fluctuations that were hard to interpret.

In the case of the subjects born in 1998, the values of arterial tension, before and after physical effort, also evolved differently for systolic tension as compared to diastolic tension (fig. 2e-h). The values of systolic tension were

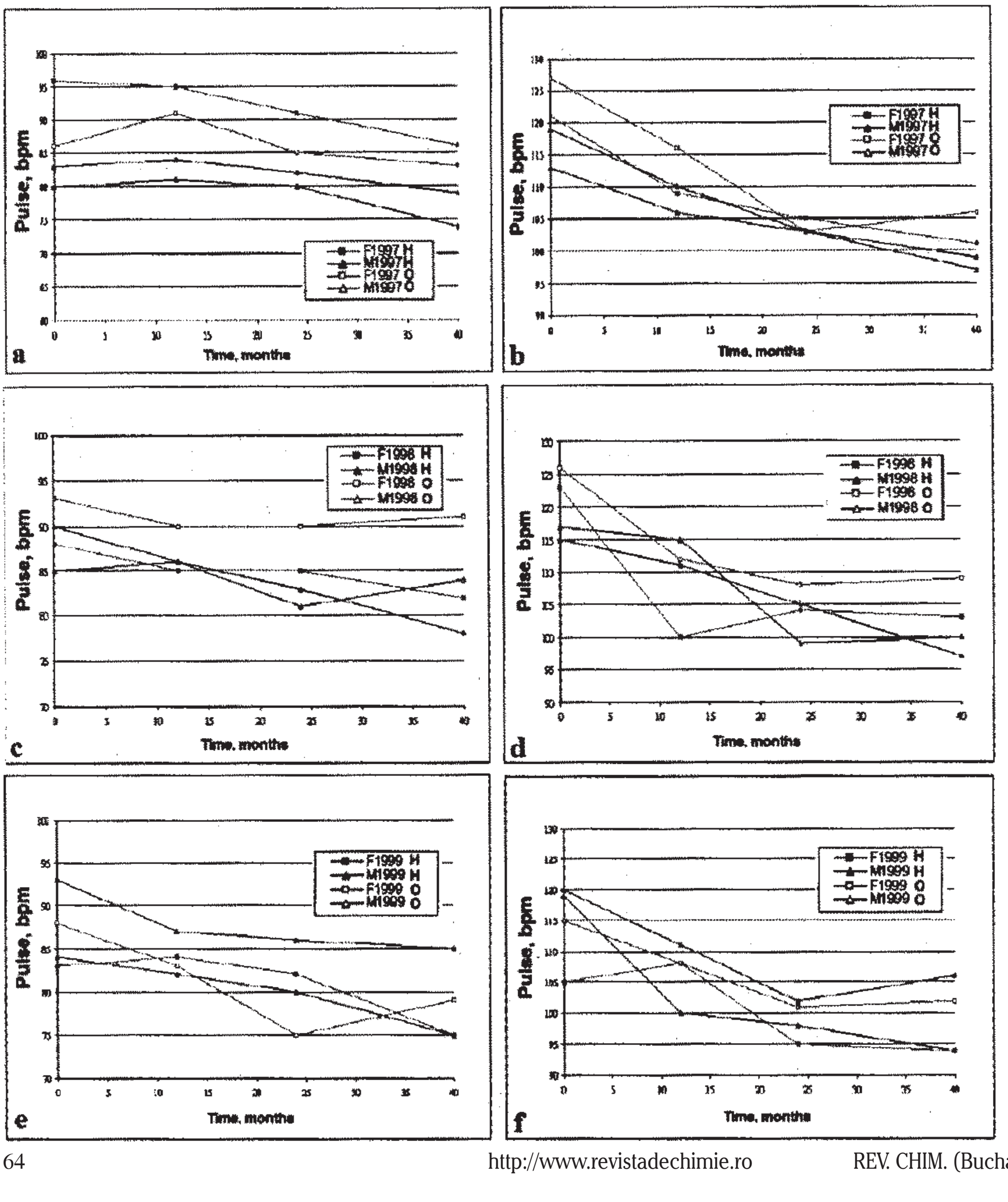

Fig. 3. Evolution of the pulse for subjects: a - born in 1997 before physical effort, b - born in 1997 after physical effort, c - born in 1998 before physical effort, d - born in 1998 after physical effort, e - born in 1999 before physical effort, f - born in 1999 after physical effort; H – halochamber, O – outdoor

similar during pauses for both the reference and the halochamber group. Those values increased after exercises in the case of the reference group. After 40 months, the group that performed in the halochamber registered a decrease in the values recorded during pauses and after exercises for both sexes.

The values of diastolic tension were lower for the subjects born in 1998 that performed in the halochamber, in both boys and girls. The girls registered similar values during pauses and after exercises, while the values for boys fluctuated as in the case of the subjects born in 1997.

In the case of the subjects born in 1999, the values of systolic tension were close in the pauses during the first 12 months and then evolved differently, the girls registering a higher arterial tension than boys (fig. 2i-l). After exercises, the values recorded after 12 months were close in both the reference and the halochamber group, for both sexes (122-123 mmHg). Towards the end of our study, the groups of girls registered a higher tension. The values of diastolic tension decreased during the first 24 months, for both boys and girls, and then started rising again. In both sexes we registered stronger fluctuations (inversions of values) that in the other two age groups, but there were clear differences between the reference and the halochamber group.

As regards the evolution of the cardiac frequency or of the pulse, in the case of the subjects born in 1997 (fig. 3a,b), we noted a decrease in the number of heartbeats/ minute recorded after exercises, with lower values in boys. At the beginning of our study, the difference between the average pulse value recorded in the boys that performed in the halochamber before and after exercises was 39 beats/ min and at the end it decreased to 25 beats/min. After 24 months the values recorded during pauses and after exercises decrease even more. The common peak value recorded after 24 months may have been caused by certain health issues.

For the group of subjects born in 1998 the pulse recorded during the first 12 months (fig. 3c,d) indicates approximately the same values after exercises for both boys and girls. Afterwards there was a decrease in the number of heartbeats/minute, the decrease after exercises being more evident in girls (F_{hm1998} = 123-103beats/min, F_{0m1998} = 126-109beats/min) than in boys (M_{hm1998} = 115-97beats/min, M_{0m1998} = 117-100beats/min).

For the subjects born in 1999, though, the decreasing pulse rate (fig. 3e,f) was quite obvious after the first 12 months, especially in boys.

Thus, the values of the pulse in the girls that performed in the halochamber and those that performed outdoors were quite different (F_{hm1999} = 105-94beats/min compared to F_{0m1999} = 115-102 beats/min), and they were not that different in boys (M_{hm1999} = 119-94 beats/min, compared to M_{0m1999} = 120-106 beats/min).

Conclusions

Based on the data we collected from the two main groups of subjects we came to the following conclusions:

-the lung capacity was sensible increased in both male and female subjects when exercises were performed in halochamber, compared to outdoor;

-differences in the values of systolic tension recorded for the group that performed in the halochamber, as compared to that that performed outdoors, are lower in the case of boys than in the case of girls;

-the differences were greater in the first 24 months and then decreased, the variations became smaller between the values registered during pauses and after exercises, because the body started to recover easier after physical efforts, especially after exercises that involved moderate efforts.

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