Profile Forming of Infrared Cabin User's Biomedical Indicators

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Abstract

The construction and methodology of a infrared cabin developed by the authors for activation of human body functional reserves are described in the article. A device is equipped with a system of human physiological parameter monitoring. The results of thermal load level produced by the infrared cabin on the human cardiovascular system are presented.

Keywords

Infrared radiation • Infrared cabin • Monitoring of biomedical parameters

1 Introduction

In modern medicine, infrared (IR) therapy is widely used for the treatment of skin diseases (acne, eczema, atopic dermatitis, allergic skin rash), surgical diseases (trophic ulcers, bedsores, burns), diseases of the locomotor apparatus (sprain, calcaneal spur, bruises and injuries of joints, dislocations, arthroses and arthritises, miozita, sports injuries), pathologies of ENT organs (rhinitis, plays the dandy, tonsillitis, otitis, laryngitis). The modern level of technologies development allows to improve medical equipment. Therefore, the development of medical and diagnostic complexes with a management function of exposure parameters proceeding from physiological characteristics of a bioobject is perspective.

An Infrared (IR) therapy can be performed either by means of warming up of a human in the infrared cabin (sauna) or by local radiation of parts of human body by infrared radiators. The first direction is especially essential in treatment and rehabilitation: by means of the exposure on the whole human body an activation of metabolic processes, an acceleration of the metabolism in tissue, removal of toxins at the expense of the strengthened sweating are reached.

The majority of modern IR cabins implements a long-wave exposure on human body, thus causing a temperature increase of the upper skin layers, while for a deep tissue warming up they recommend to use short-wave sources of IR radiation. It is also necessary to note that the existing IR cabins have no control system of physiological parameters of a human, not allowing to coordinate a heat strain with an individual functional user state. Overheating of an organism can cause a sudden increase of temperature indicators, pressure, pulse thus imposing restrictions for use of the infrared saunas in case of heart failure, stenocardia, increased arterial blood pressure.

For the purpose of elimination of the above described shortcomings authors have developed an energy efficient mobile infrared cabin for the low-intensive exposure of IR radiation, mainly by a short-wave infrared range, on human body [1]. The device is equipped with a monitoring system of biomedical parameter and parameters of a thermal mode inside the cabin. This monitoring system is a capacious and convenient form to provide information in the course of a IR-therapy.

In order to control the safety and assessment of efficiency of the physico-therapeutic procedure a profile forming of user's biomedical indicators are being carried out during a IR-therapy session.

2 Device Description

The infrared cabin design (Fig. 1) and an automatic control algorithm of operational modes are presented [1–3].

The IR cabin represents a rectangular camera with an entrance door and can be located both in horizontal, and in vertical positions. The most convenient option is the horizontal location. A flap lid is designed for entrance in the

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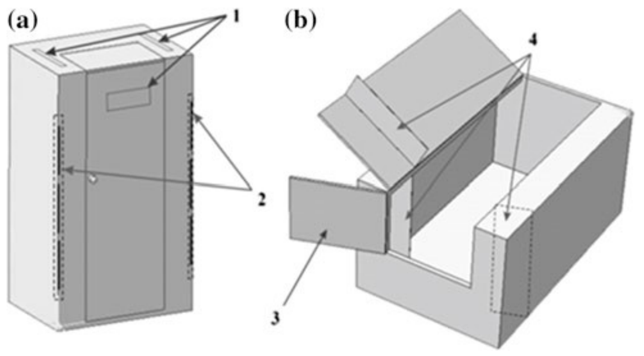

Fig. 1 IR cabin design: vertical location (**a**), horizontal location (**b**): 1—ventilating windows, 2—IR radiators, 3—a flap cover, 4—protective reflectors, reflecting IR radiation

horizontally located cabin. Additional air flow is provided by the ventilating windows. Protection against undesirable user's head overheating is realized through the protective reflectors, reflecting IR radiation.

As IR radiators halogen quartz lamps with a maximum emission spectrum in the near infrared range were used (to warm up deep-lying human body tissues) [4, 5].

The device skeleton diagram is provided in Fig. 2 [2].

The IR cabin consists of sensors for registration of user's physiological indicators, thermal mode sensors, an analog-to-digital converter, a transmission data unit, a data reception block, a control panel, an input data device, an information display device, IR radiators, a power supply block of IR radiators..

3 Profile Forming of User's Biomedical Indicators of Infrared Cabin

The infrared therapy methodics with the help of the developed device was resulted in user's location in in the horizontally located infrared cabin. A session time was 20 min. During the procedure directly inside the IR cabin the registration of body temperature in three points was being carried out (on forehead, in armpit, in an abdominal zone), upper and lower blood pressure, user's pulse. After the IR-therapy completion an examinee was left in the IR cabin within 20 min. At this time the registration of body temperature, pulse, upper and lower arterial blood pressure was being carried out (for assessment of the recovery nature of physiological indicators after the completion of a therapeutic session). In its turn before and after the IR-procedure the user's weight had been registered. The air registration inside the IR cabin had also been carried out in two points (in examinee's abdominal and head zone) in dependence on time.

In the software program Excel environment in real time the obtained data were processed and the graphics of the registration of body temperature, pulse, upper and lower pressure were formed—a profile of user's biomedical indicators of the infrared cabin.

8 examinees took part in the studies (7 men, 1 woman, age from 19 to 24 years).

Figures 3, 4, 5 and 6 an example of the resulting temperature indicators, pulse figures, upper and lower pressure of examinee No. 7 is shown.

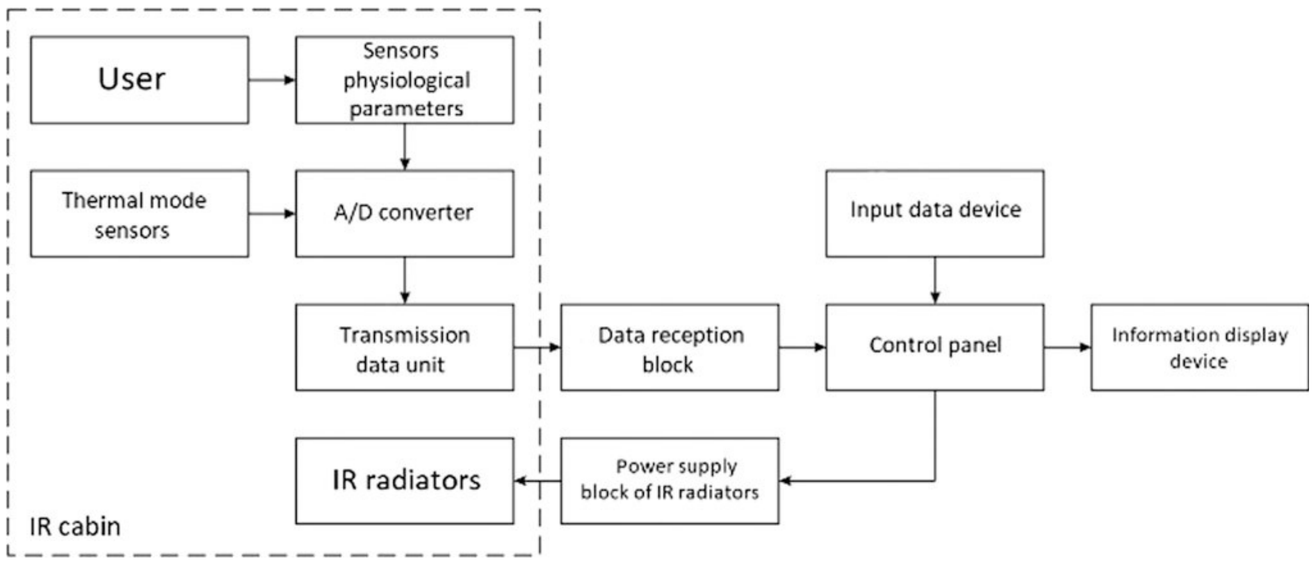

Fig. 2 Infrared cabin design skeleton diagram with automatic control of exposure parameters

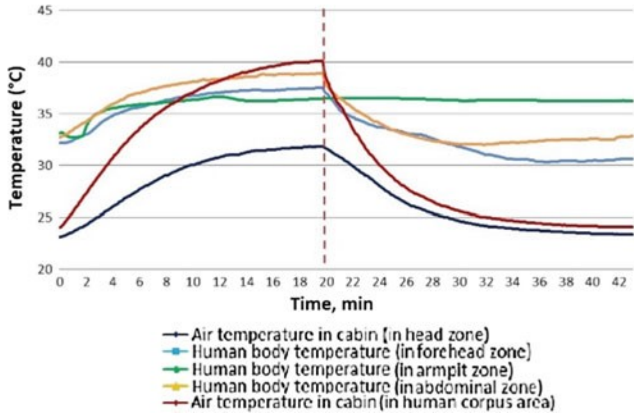

Fig. 3 Dependence of examinee's body temperature and also air temperature in IR cabin depending on time

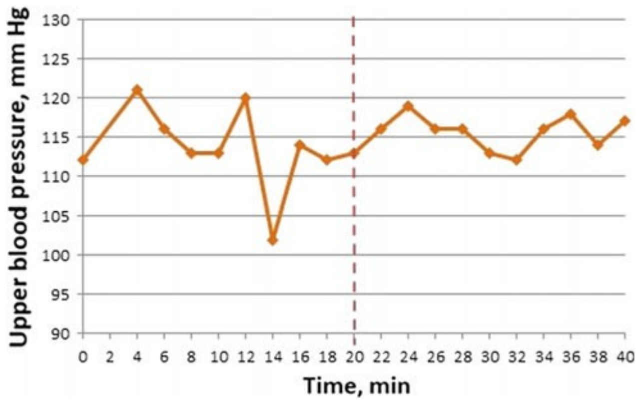

Fig. 4 Dependence of relative change of examinee's upper blood pressure oat different times

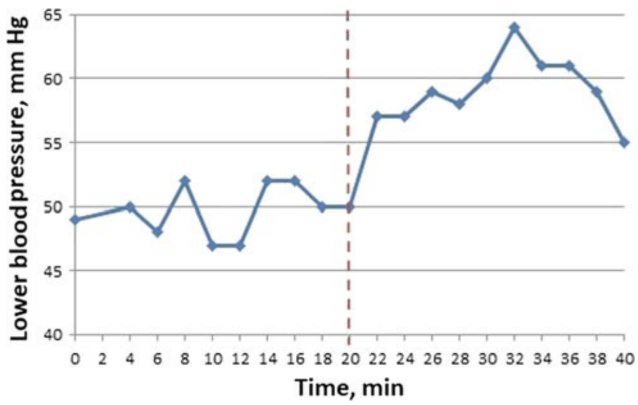

Fig. 5 Dependence of relative change of examinee's lower blood pressure at different times

In Fig. 3 a dependence graphic of examinee's body temperature and also the air temperature in the IR cabin is provided in dependence on time.

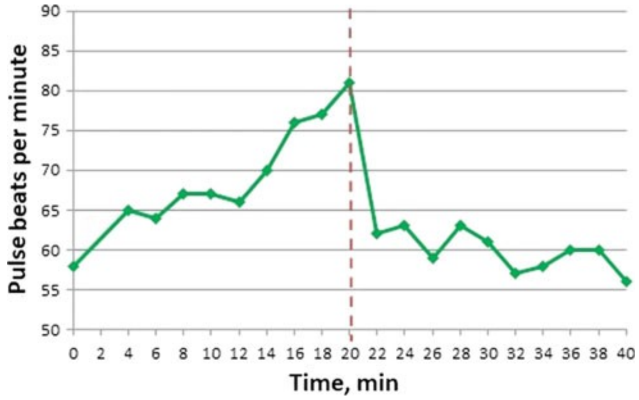

Fig. 6 Dependence of relative change of examinee's pulse at different times

The temperature numbers, which are located in three points of examinee's body, are graphically placed between the air temperature curves in the head and abdominal zones, have been increasing during the 20-min IR procedure, and have returned to the original numbers after turning off the IR emitters.

On average after 10 min since the turn on of the infrared cabin the air temperature inside the cabin (in the human corpus area) reaches 37–38 °C. The cabin is being heated; starting from this period the increased heating of examinee's body begins.

After 20 min since the turn on of the infrared cabin the air temperature inside the cabin in the human corpus area reaches 40–42 °C. During this period, the examinee's body temperature in the abdominal zone makes up 38.0–38.8 °C, in the armpit zone—36.4–37.3 °C. The body temperature increase to 38.5 °C imitates a natural organism reaction on infectious processes. At the same time the activation of defense mechanisms and the suppression of pathogenic bacteria and viruses development also happens. After 20 min since the turn on of the infrared cabin the air temperature inside the cabin in the head zone reaches 31–32 °C (due to the protective reflectors on the head level), thus providing head protection from undesirable overheating. During this period, examinee's body temperature in the forehead zone makes up 36.0–37.5 °C.

For dynamics assessment of physiological indicators in order to form the profile relative changes of the upper and lower pressure, pulse at different times were calculated (Figs. 4, 5 and 6). As initial level a number was taken into account that had been recorded before the procedure was started.

After the procedure completion was carried out an analysis of the obtained data that revealed the following regularities.

The upper blood pressure is reduced on average by 1.6 ± 5.19 mm Hg within the 20-min time interval spent in the infrared cabin. Furthermore, it is possible to highlight an examinees' group with a lowering tendency of the upper blood pressure, and an examinees' group with an increasing tendency of the upper blood pressure, finally saying of the allocation of the hypertensive and hypotensive among the population.

The lower blood pressure is reduced on average by 0.7 ÷ 1.95 mm Hg within the 20-min time interval spent in the infrared cabin. Furthermore, in the highlighted by the upper pressure (see above) examinees' groups a similar lowering and increasing tendency of blood pressure is observed.

The pulse increases on average by 11.1 ÷ 6.97 beats per minute within the 20-min time interval spent in the infrared cabin. The weight was decreased by 160 grams during the procedure.

Figures 7, 8, 9 and 10 the resulting temperature numbers, the pulse, upper and lower pressure numbers, of all the examinees are also listed. Figure 7 shows a graph of dependence of examinees' body temperature as well as the air temperature in the infrared cabin, in dependence on time.

The temperature numbers, which are located at three points of examinee's body, have been increasing during the 20-min IR procedure, and have returned to the original numbers after turning off the IR emitters.

On average after 10 min since the turn on of the infrared cabin the air temperature inside the cabin (in the human corpus zone) reaches 37.5–38.5 °C.

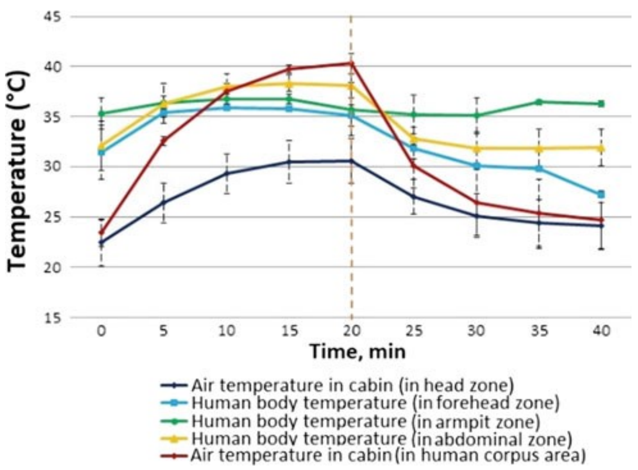

Fig. 7 Dependence of examinees' body temperature as well as air temperature in infrared cabin at different times

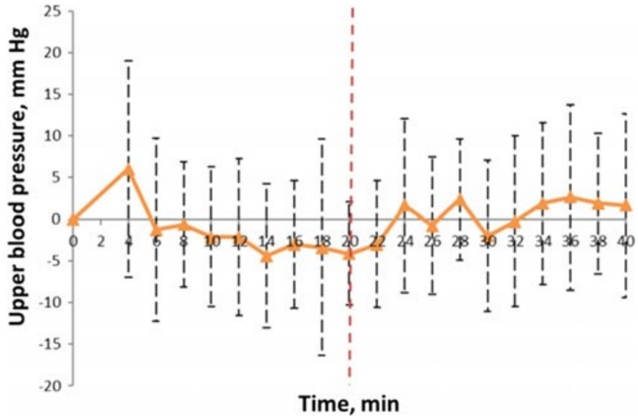

Fig. 8 Dependence of relative change of examinees' upper blood pressure at different times

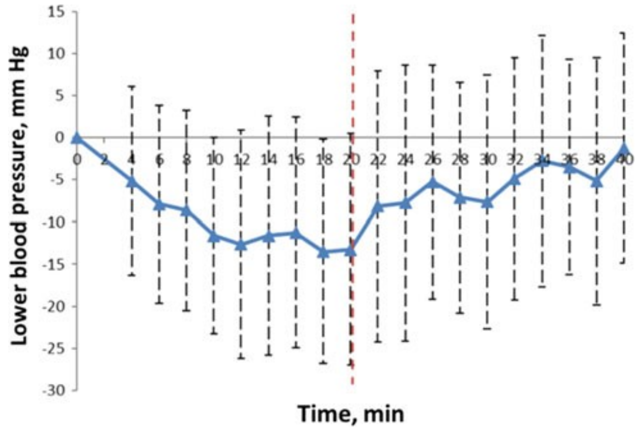

Fig. 9 Dependence of relative change of examinees' lower blood pressure at different times

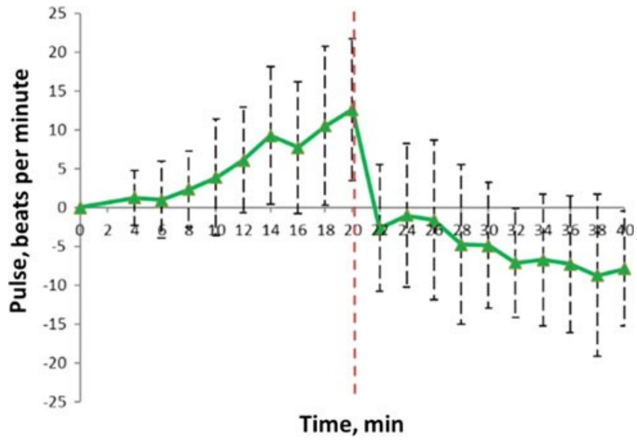

Fig. 10 Dependence of relative change of examinees' pulse at different times

After 20 min since the turn on of the infrared cabin the air temperature inside the cabin in the human corpus zone reaches 40–41.5 °C. Furthermore, the human body temperature in the abdominal zone makes up 38.0–38.5 °C, in the armpit zone—36 to 37 °C.

After 20 min since the turn on of the infrared cabin the air temperature inside the cabin in the head zone reaches 30.5–31.5 °C. Furthermore, the human body temperature in the forehead zone makes up 35.0–37.5 °C.

For profile formation and dynamics assessment of physiological indicators relative changes of the upper and lower pressure, pulse at different times were calculated (Figs. 8, 9 and 10).

After having analyzed the pulse, upper and lower arterial blood pressure data, were identified the following regularities.

The upper blood pressure is being reduced on average by 4.13 ± 6.15 mm Hg within the 20-min time interval of the IR procedure.

The lower blood pressure is being reduced on average by 13.25 ÷ 13.75 mm Hg. within the 20-min time interval of the IR procedure.

The pulse is being increased on average by 12.63 ÷ 9.16 beats per minute within the 20-min time interval of the IR procedure.

The weight is being decreased by 368 ÷ 342 g within the 20-min time interval of the IR procedure.

4 Conclusions

The results performed by the authors of the experiment allow to draw a conclusion about the heat load minimization on the user when conducting the IR therapy by means of the developed device, compared to the same IR cabins [1–3]: the air temperature inside the infrared cabin does not exceed 42 °C in the user's corpus zone and makes up 31–32 °C in the head zone; also at the same time the maximum human body surface tissues temperature makes up 38.8 °C (in the abdominal zone), for pressure numbers, there is the decreasing tendency not increasing.

A positive physiological effect is achieved through the use of sources of near infrared radiation as well as the cabin design features, allowing to reduce the air temperature upon safety of the heating efficiency. The presence of the protective reflectors and ventilation valves protects t user's head from undesirable overheating. In the end, all that allows to extend the scope of application of such devices by eliminating restrictions on its usage for people with cardiac insufficiency, stenocardia, increased blood pressure.

The profile forming of user's biomedical indicators provides the safety and efficacy of the infrared therapy procedure, as well as a possibility of an individual approach to a thermal load formation on the user during a session.

The authors plan to use the obtained information for matching heat load intensity with user's individual functional state throughout the whole session of the infrared therapy by means of automatic power control of the IR emitters on the basis of monitoring of user's physiological parameters. Also in the future the application of the developed by the authors IR cabin is planned for a multisession (10 sessions) 30-min therapy.

Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Osipov, A.N., Thostov, T.M.-H., Mezhennaya, M.M., Kulchitsky, V.A., Davydov, M.V., Kotov, D.A., Stetukevich, N.I., Shevtsov, V. F., Davydova, N.S., Drapeza, V.Y.: Infrared Cabin with a Biotechnical Feedback, vol. 1, No. 120., pp. S169–S170. Official Bulletin/National Center of Intellectual Property, IPC A61H33/06, Pat. 11587 Republic of Belarus
2. Mezhennaya, M.M., Osipov, A.N., Drapeza, V.Y., Thostov, M. M.-H., Davydova, N.S., Davydov, M.V.: Algorithm of automatic control of operation modes of the infrared cabin on the results of monitoring physiological parameters of the user. In: Collection of Scientific Papers of the XI International Scientific-Technical Conference "Medelektronika—2018. Means of Medical Electronics and New Medical Technologies", pp. S71–S74. Mn.: BSUIR (2018)
3. Drapeza, V.Y., Vorobey, A.V., Stasishina, A.M., Rozum, G.A., Davydov, M.V.: Study of the dynamics of physiological parameters of the user during therapy infrared cabin. In: In: Bogush, V.A., et al. (eds.) Scientific Journal "Reports BSUIR", vol. 7, No. 117, pp. S123–S127. Mn.: BSUIR (2018)
4. Издательство: J. Biomed. Opt. 12(4), SPIE—International Society for Optical Engineering (2007). ISSN 10833668
5. Ulashchik, V.S.: General Physical Therapy, p. S512. I.V. Book House, Lukomsky, Minsk (2008)