

Improvement of the Thermoregulation Efficiency of Man Above 1500 m Altitude

Our studies on the improvement of the thermoregulation efficiency of man above 1500 m altitude are primarily based on 15 years of observation of daily complaints of large groups of subjects, both children and adults suffering from bronchial asthma with no infectious components (TROMP^{1,2}). These subjects represent at least 1% of the population of Western Europe. A careful analysis of this very considerable material, based on 15 years of daily observation, has shown that the daily distribution of allergens (pollen, spores, house dust etc.) could not explain the curves of large groups of asthmatics indicating the daily frequency of asthma attacks in a constant group of asthmatics.

A statistical analysis of various meteorological parameters has shown that of all the known meteorological factors only the degree of atmospheric cooling shows a perfect correlation with the degree of asthmatic complaints per day, month or year. Both sudden increase in cooling or extreme heat stress, due to sudden changes in temperature, windspeed and humidity, cause an increase in complaints. It is also known to most clinicians and lung specialists that asthmatics are very sensitive to sudden changes in the thermal environment. It is therefore logical to assume that the total thermoregulation efficiency of asthmatics is not very great.

In order to test the degree of thermoregulation efficiency of asthmatics and other diseased subjects, we de-

veloped a simple water bath test (TROMP³). It could be demonstrated that the peripheral phenomena observed during this test in the left hand (see Figure 1) are not only locally controlled phenomena but they are controlled by higher brain centres (TROMP³). Low pressure climatic chamber studies in the Biometeorological Research Centre, Leiden, since 1960, have shown that a number of physiological changes occur both in asthmatics and healthy subjects above a simulated altitude of 1500 m. (but not below), which equals an atmospheric pressure of about 634 mm Hg. Neither patients nor healthy subjects knew the altitude to which they were exposed in the low pressure chamber.

Below the altitude of 1500 m long term effects have been reported from high altitude sanatoria, but we have not been able to demonstrate short term effects after one-hour treatments at an altitude below 1500 m. Some observations demonstrating the critical altitude boundary of 1500 m are as follows: 1. In asthmatics who are wheezy at sealevel the complaints decrease or disappear as soon as the 1500 m level is reached in the low pressure chamber, but not earlier. 2. Patients suffering from slight sinusitis experience serious pains in the sinus area as soon as the level exceeds 1500 m. 3. Subjects suffering from diaphragmatic hernia have serious stomach complaints as soon as they exceed the 1500 m level. 4. An increased peripheral blood flow is experienced by most subjects above 1500 m,

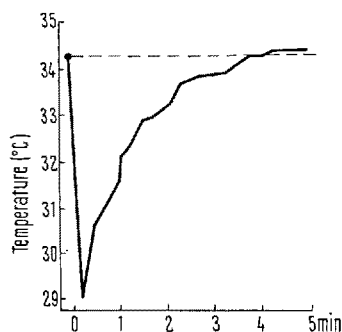


Fig. 1. Rewarming curve of the left hand of a normal healthy subject, with an efficient thermoregulation mechanism, after 2 min cooling of the left hand in water of 10 °C, followed by quick drying and measuring of the temperature of the handpalm every 15 sec with a thermocouple (for details see TROMP³).

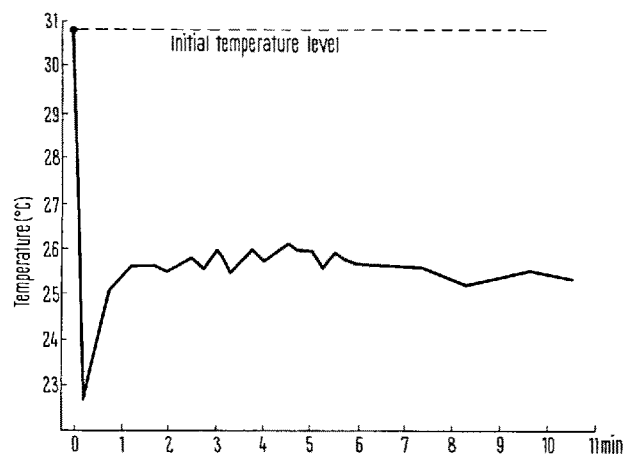


Fig. 2. Same as Figure 1. Rewarming curve of subject suffering from bronchial asthma.

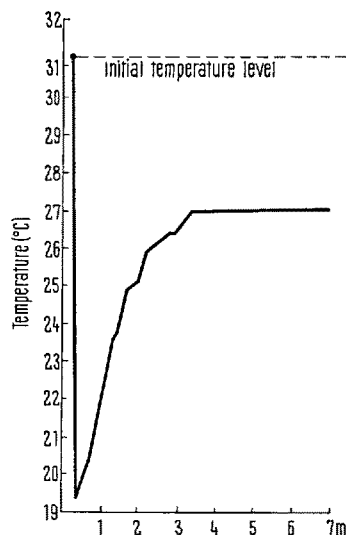


Fig. 3. Same as Figure 1. Rewarming curve of a subject suffering from asthmatic bronchitis.

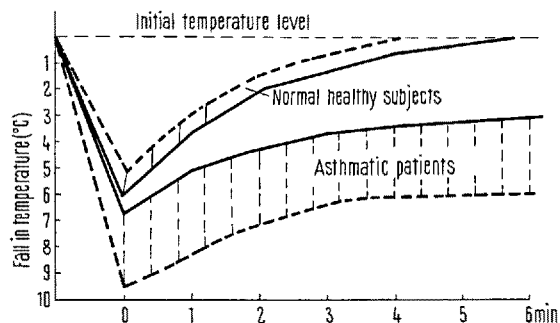


Fig. 4. Mean results of rewarming curves of 60 normal subjects and 190 asthmatic patients (total of 600 curves) recorded during water bath tests (TROMP³).

Changes in respiratory function of a girl of 14 years of age* after 48 low-pressure climatic chamber treatments

Date	No. of climatic chamber treatments	Vital capacity (ml)	Forced expiratory volume (ml)	Forced expiratory volume (% VC)	Forced inspiratory vol. as % VC	Maximal breathing capacity (l)
4. 2. 1964	0	3290	2350	71	91	70.5
23. 6. 1964	13	3900	3350	86	89	100.5
1. 9. 1964	24	4080	3380	83	89	101.4
17. 11. 1964	33	4170	3636	89	100	108.9
11. 1. 1965	38	4280	4180	98	99	125.4
21. 4. 1965	48	4470	4290	96	95	128.7
8. 9. 1965	Since 24. 4. no climatic chamber	4420	4230	96	89	126.9
Normal values				>70		108.3

* Height: 174 cm

particularly in patients suffering from vascular disorders. Above 1500 m altitude it is shown by a rise in temperature of the palm of the hands and feet. 5. A number of biochemical changes were observed in the urine of asthmatics above the 1500 m altitude level, but not below this level (TROMP et al.⁴): Increased excretion of 17-ketosteroids, rise in pH and decrease in hexosamine excretion (of 5 to 56 µg/100 ml); blood sugar studies showed contradictory results, although the experiments were carried out at the same hour of the day. In some instances the blood sugar increased slightly (about 12–32 mg/100 ml) in other subjects a similar decrease was observed. 6. However, the most important observation is the improvement of the thermoregulation efficiency determined with the waterbath test⁵. It is only observed above the 1500 m altitude level, both in asthmatic and healthy subjects (Figures 1–5).

The most interesting part of this observation is that after a series of low-pressure climatic chamber treatments, each lasting 1 h at simulated altitudes > 1500 m, temperature of 15°C and relative humidity of ± 50%, the asthmatic patient becomes so resistant to thermal changes in the environment that the asthma attacks are either reduced considerably or may disappear completely if the

number of one-hour treatments exceeds 80–100 high altitude treatments. It is even more surprising that after the thermoregulation efficiency becomes normal again it remains normal for very long periods, the longest follow up being 6 years (TROMP and BOUMA⁶).

Apart from these improvements, an improvement of the respiratory function (Table) can also be observed and an increase in the corticosteroid excretion, which is usually far below normal in asthmatics.

Summarizing, it can be stated that the method described can be successfully applied to other diseases characterized by a poor thermoregulation efficiency, such as rhinitis, rheumatic diseases, peripheral disorders, etc. (TROMP^{7,8}). The deeper physiological mechanisms involved in the long-term improvement of the thermoregulation efficiency are still unknown, but both the improved blood circulation in the hypothalamus at high altitude (as demonstrated in animals) and the physico-chemical effects of the respiratory centre in the brain on the composition of the blood passing the hypothalamic area, may be responsible for these long term changes.

Zusammenfassung. Nachweis, dass vor allem atmosphärische Abkühlungsfaktoren Asthmaanfälle auslösen können und dass der menschliche Organismus über einer kritischen Höhe von 1500 m gegen solche Temperaturreize weniger empfindlich ist. Permanente Besserung nach wiederholter Höhenbehandlung.

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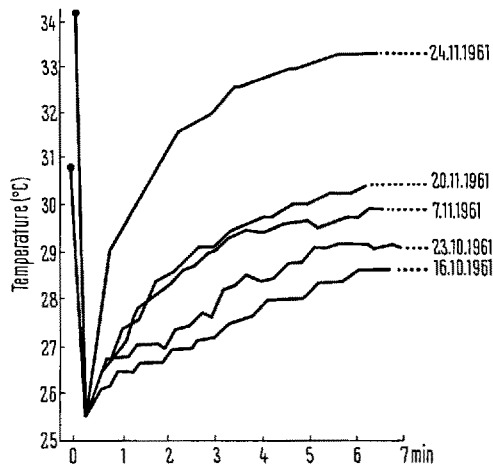


Fig. 5. Improvement of the thermoregulation curve of an asthmatic patient after a series of simulated high altitude (6000–7500 ft) treatments of 1 h each, in a low pressure climatic chamber, with temperatures of 10–15°C, relative humidity of 50%.

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5 As during long transatlantic flights the simulated altitude in the cabin of pressurized planes is often 1500 m, these observations have also practical importance.
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