THE EFFECT OF SIMULATED HIGH ALTITUDE (LOW PRESSURE) ON THE TEMPERATURE AND PASSABILITY OF THE NOSE *

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I. Purpose of study

In previous years the effect of simulated high altitude of 2000—2500 m, in a low pressure climatic chamber, on asthmatic and bronchitic patients has been studied (Tromp, 1963 b, 1964 b, 1965, 1966). It was found that apart from the lungfunction (Vital Capacity, Forced Expiratory and Inspiratory Volume and Indirect Maximum Breathing Capacity) also the thermo-regulation efficiency (determined with a water bath test, Tromp, 1964 a) improved and the production of 17-ketosteroids increased after a series of low pressure climatic chamber treatments.

During August and September 1965 three additional studies were made:

1. The change in temperature of the palm of the left hand, both in normal healthy students and in asthmatics during a rise in simulated altitude from 0—2000 m.
2. The change in temperature of the expiratory and inspiratory air of the nose during a similar rise in altitude.
3. The possible change in passability of the nose during a rise in altitude up to 2500 m.

These studies were carried out with four male students and eight asthmatics in a low pressure climatic chamber of the Biometeorological Research Centre, located at the Department of Internal Diseases of the University Medical Centre at Leiden.

II. Methods of study

A. Subjects used:

Four healthy male students were studied, a medical student (V) of 18 (weight 70 kg, height 1.75 cm, thoracic circumference 97 cm); a law student (J) of 22 (weight 65 kg, height 181 cm, thoracic circumference 90 cm); a second law student (D) of abt 21 (weight 73 kg, height 189 cm, thoracic circumference 95 cm) and a third law student (M) of 20 (weight 66 kg, height 178 cm, thoracic circumference 93 cm).

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With a Peak Flow Meter of Wright the maximum rate of lung expiration in l/min was measured. Subject V had an expiration rate of abt 570, subject J: 550, subject D: 600 and subject M: 580 l/min.
Apart from these students eight subjects suffering from asthmatic bronchitis have been studied.

B. Period of study

All experiments with the students were carried out in the period 30 August — 30 September 1965 between 9 and 11.30 am. This reduced the possible difference in physiological reactions of the subjects due to their biological rhythm. During the same period and during October 1965 the eight asthmatic patients were studied.

C. Description of the experiment

The students arrived at the hospital at 8.45. Usually two subjects were studied at the same time. First a thermoregulation test (water bath test of lef hand) was made in order to study general high altitude effects (Tromp, 1963b, 1964a). With the Peak Flow Meter of Wright the max. rate of lung expiration was recorded in order to check their physical fitness (Mr V had only a few hours sleep each night during the period of study). The two subjects were placed in the low pressure climatic chamber, which was kept at a temperature of abt 15 °C and a relative humidity of 40—50 %. Technical details of this chamber were previously described (Tromp, 1964b). One of the two subjects was used for passability measurements of both nostrils. A simple passability meter (the normal manometer type, without automatic recording, constructed by the Oto, Rhino, Laryngology Department at Leiden) was used during this pilot project. The second subject was used for temperature measurements in the mouth and nose. In the front part of the right nostril an Ellab Standard Thermocouple Applicator (type E 5) was placed without touching the nasal membranes. This type of electrode is usually used for temperature measurements of the ear membrane. In the later experiments the applicator type H 3 was used for the nostril. In the mouth, und the tongue, the Ellab Applicator type OR 5 was placed. With the skin applicator type H 1 the temperature of the middle of the palm of the right hand was recorded.
As soon as the subjects entered the climatic chamber the passability of both nostrils of one of the subjects was recorded, the hand palm temperature and the temperature of the right nostril (both during inspiration and expiration) of the other subject.
After the subjects were more or less adapted to the room temperature of the climatic chamber (an arbitrary period of half an hour was chosen, which proved to be sufficient for our experiments) a second recording was made of these different parameters. The vacuum pump was started and a simulated altitude was created. At an altitude of 2000 m (equal to abt 594 mm atmospheric pressure) a third recording was made. The recordings were repeated two or three times during 15 minutes. After 15 minutes the altitude was increased to 2500 m (equal to 560 mm pressure). At this altitude every 5 minutes during a period of 25 minutes, the same recordings were repeated. The altitude

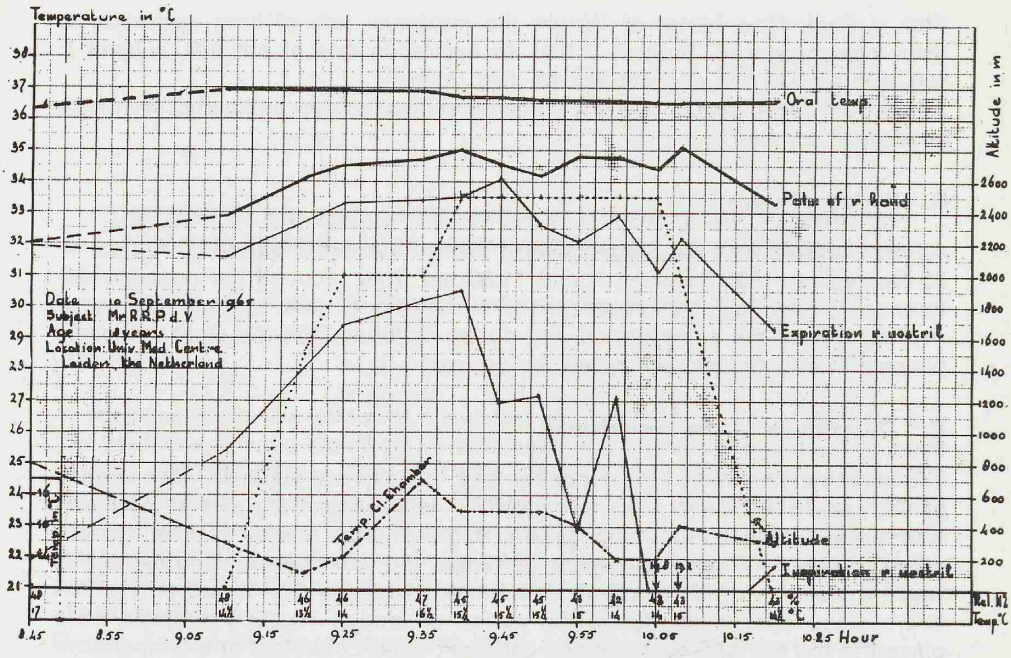

Figure 1.

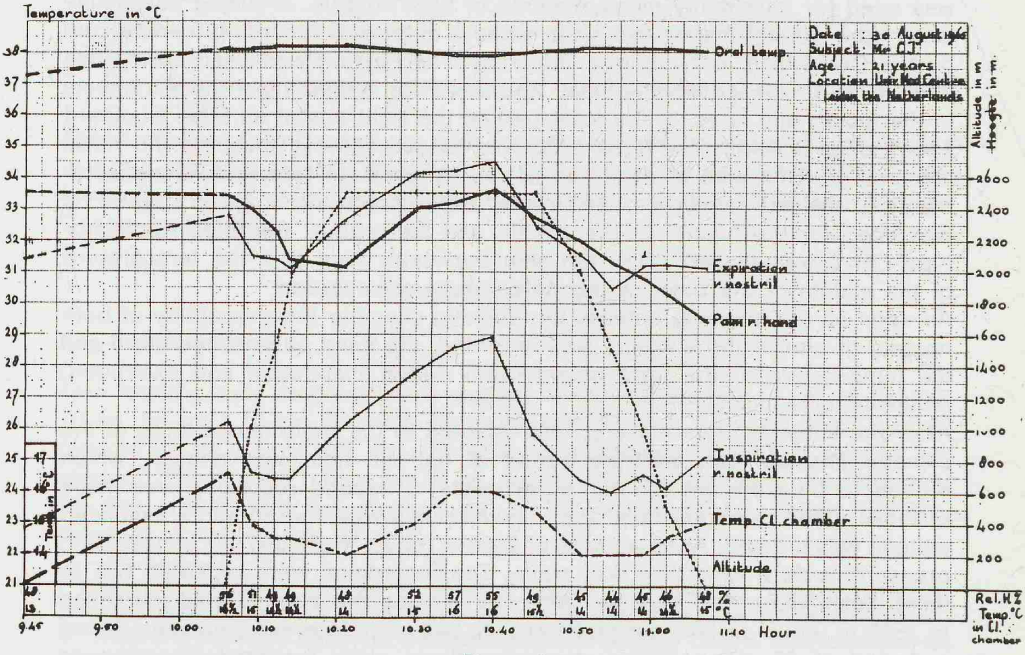

Figure 2.

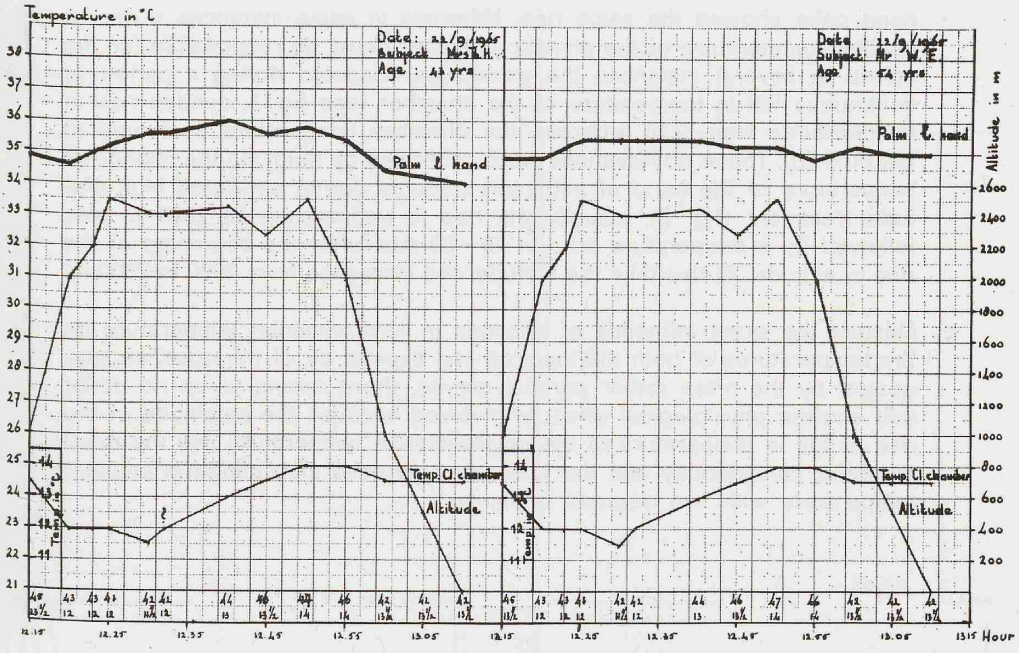

Figure 3.

was lowered again to 2000 m and again the same recordings were made. The last recordings were carried out after the altitude was reduced to sealevel. Examples of the curves, obtained as a result of these different recordings, are given in figures 1, 2 and 3.
The same experiments, except passability recordings, were carried out with eight asthmatic patients.

III. Results

1. Temperature studies

a. There was usually a close relationship between even the smallest changes in temperature of the climatic chamber and the changes in temperature of the hand, and both the inspired and expired air of the nose (see for example fig. 2). The oral temperature is almost unaffected. Whereas the close relationship of the temperature of inspiration and ambient temperature is understandable, it was rather surprising that it is also true for the expired air after being warmed up in the lungs.

b. Despite this strong effect of the environmental temperature, a clear high altitude effect could be observed. Practically without an exception both inspiratory and expiratory air temperature of the nose increase with increasing altitude up to 2000 m (see fig. 1). Also the temperature of the

hand palm showed the same rise. Whereas in some instances a rise in ambient temperature of the climatic chamber could be responsible for the effect, in several instances the same was observed during a period of continuous fall in temperature of the chamber (see fig. 1, sudden rise in temperatures from 9.10 whereas the chamber temperature continued to fall till 9.20). These observations were confirmed by studying the change of temperature of the hand of asthmatic patients during simulated high altitude treatment (fig. 3). Usually the rise in temperature at 2000 m was followed by a temperature fall abt 20—30 min. after the beginning of the rise in altitude. At this time the altitude was increased from 2000 to 2500 m.

c. Despite the great influence of changes in environmental temperature on the temperatures of both the inspired and expired air of the nose, as suggested by the often rather parallel curves, there seems to be no doubt that another physiological effect is involved because the amplitude of the rise or fall in temperature of the environmental temperature and the nasal air differ considerably and the latter may surpass the change in ambient temperature with two degrees or more.

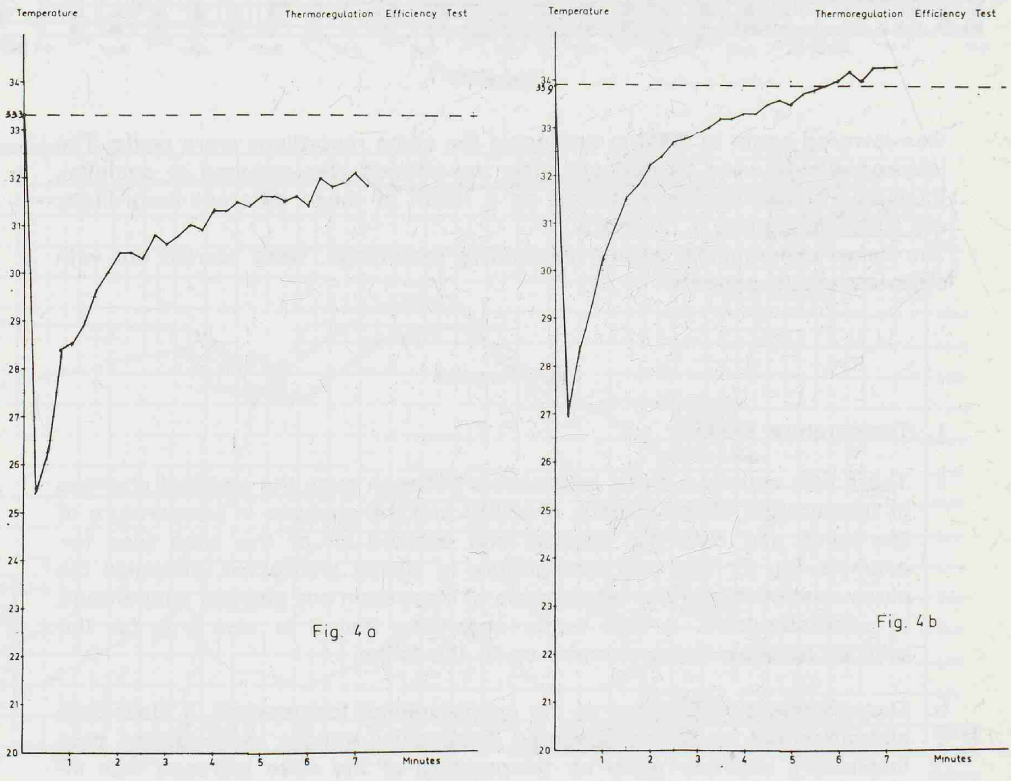

Figure 4.

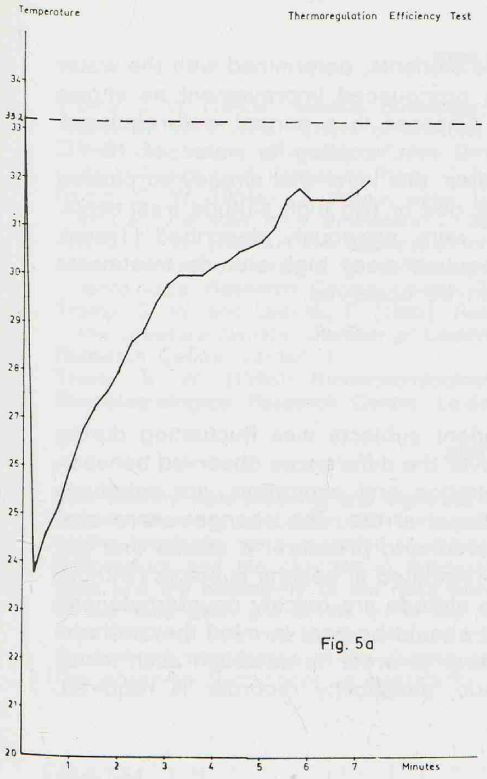

Fig. 5a

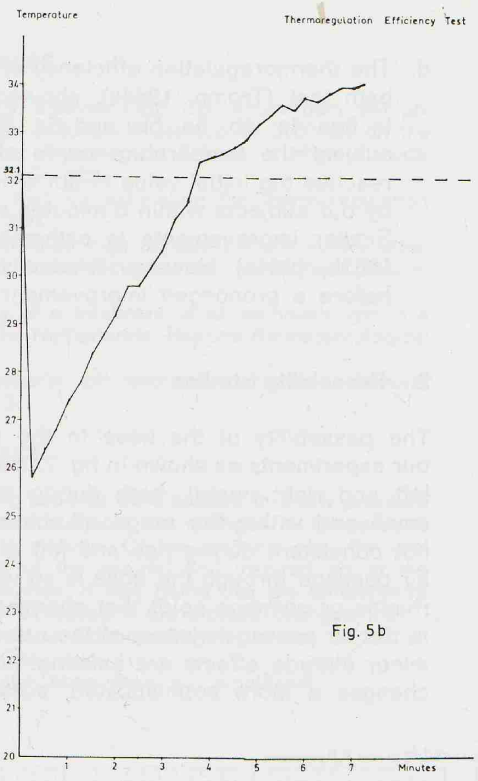

Fig. 5b

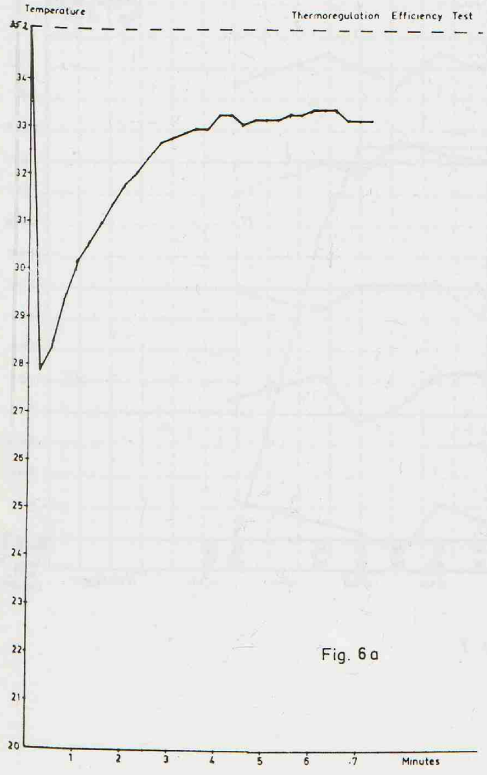

Fig. 6a

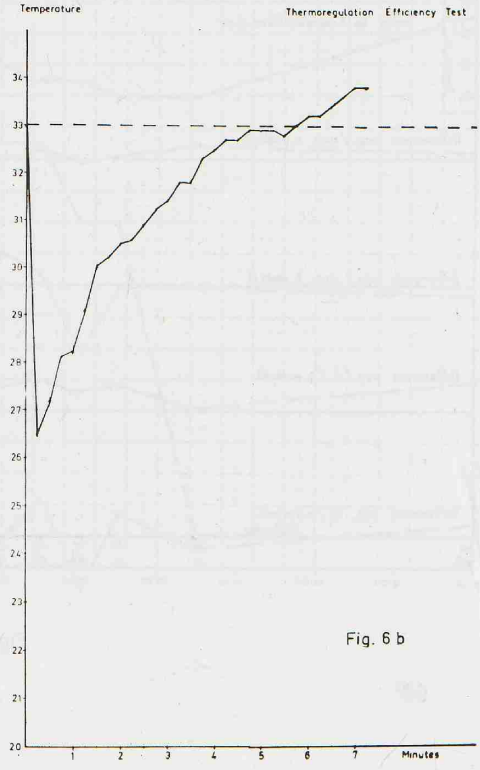

Fig. 6b

d. The thermoregulation efficiency of the students, determined with the water bath test (Tromp, 1964a), showed a pronounced improvement as shown in figs 4a, 4b, 5a, 5b, and 6a, 6b. Whereas in a normal well-regulated subject the temperature curve after 2 min. cooling in water of 10 °C reaches the initial value in abt 6 minutes, this level was already surpassed by our subjects within 6 minutes after one or two high altitude treatments. Similar improvements in asthmatics were previously described (Tromp, 1963b, 1964a). However it usually requires many high altitude treatments before a prononced improvement can be observed.

2. Passability studies

The passability of the nose in the student subjects was fluctuating during our experiments as shown in fig. 7. However the differences observed between left and right nostril, both during inspiration and expiration, are relatively small and within the range of observational errors. The changes were also not consistent during rise and fall of barometric pressure. It seems that the air passage through the nose is so well-regulated in healthy subjects (without rhinitis or common cold) that changes in altitude are quickly counterbalanced in the air passage system of the nose. It should be kept in mind that perhaps minor altitude effects are existing, however in order to establish such minor changes a more sophisticated, automatic, passability recorder is required.

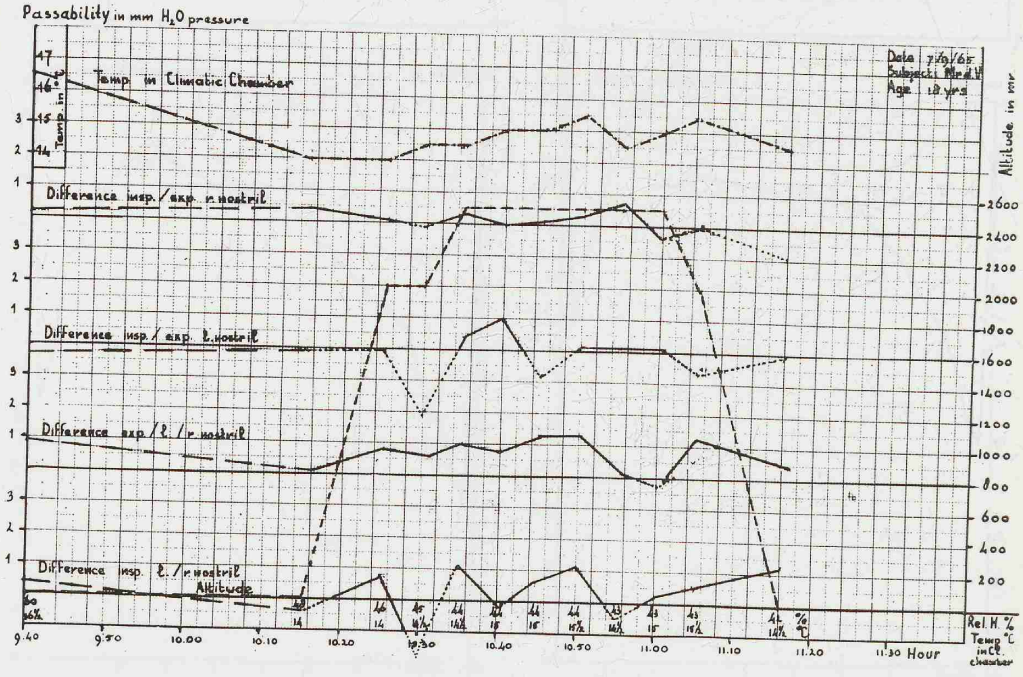

Figure 7.

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ABSTRACT

Four healthy male students and eight asthmatic patients were studied in a low pressure climatic chamber at Leiden. Of both groups of subjects the changes in temperature of the handpalm were recorded in relation to altitude. Of the students also the oral temperature and the changes in temperature of the expired and inspired air of the nose and the passability of the nose were studied. It was found that the temperature of the hand palm and of the air in the nose increases if the altitude changes from 0 to 2000 m. This rise in temperature took place independent of the rise or fall of the ambient temperature in the climatic chamber.
The observed fluctuations in passability of the nose were not significant.