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Climatotherapy

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Abstract. For successful climatotherapeutic treatment the body has to be exposed daily over several weeks under an exact dosage regime, to the biometerological conditions. For doing this – to provide rest, or to apply stimuli – four different methods are described: climatic terrain treatment, fresh air rest-cures, air baths and heliotherapy. Climatotherapy is conducted in a marine climate, in upland and in alpine regions. These three zones differ in the intensity of their climatic stimuli. Today, climatotherapy has become more differentiated, and has been newly structured following objective parameters. It always refers to specific diseases.
Key words. Relief; adaptation; climatic conditions; exposure methods; indications; climate cure concepts.

Introduction

The traditional view of climatotherapy is that existing complaints could be reduced or an existing disease could be cured, simply by exposing the patient to a particular climate. This applies mainly to diseases of the skin and the respiratory system and their treatment by climatotherapy in high mountain areas or at the seaside. However, in most of our health resorts, which are situated at medium altitudes, the patient will indeed be relieved from stressful environmental conditions, but the intensity of the physiological stimulus resulting from the climatic conditions is not high enough to influence a clinical picture directly. In this situation, climatotherapy has to be carried out as indication-oriented health resort therapy, intentionally supported by a particular climate ('climate cure').

Therapeutic objective of climatotherapy: adaptation to natural environmental factors or relief from stressful climatic elements

The basic principle of all kinds of climatotherapy is based on two points: rest, or relief, and adaptation to natural environmental factors.
In climatotherapy atmospheric qualities in general are not considered as isolated phenomena, but in the perspective of their combined effects on men. Therefore the meteorological parameters are combined in so-called effect complexes (fig. 1): thermal, actinic and chemical (see Jendritzky in Part I of this review).
The thermal effect complex including air temperature, air humidity, wind speed and short- and long-wave radiation takes a primary place in climatotherapy. The

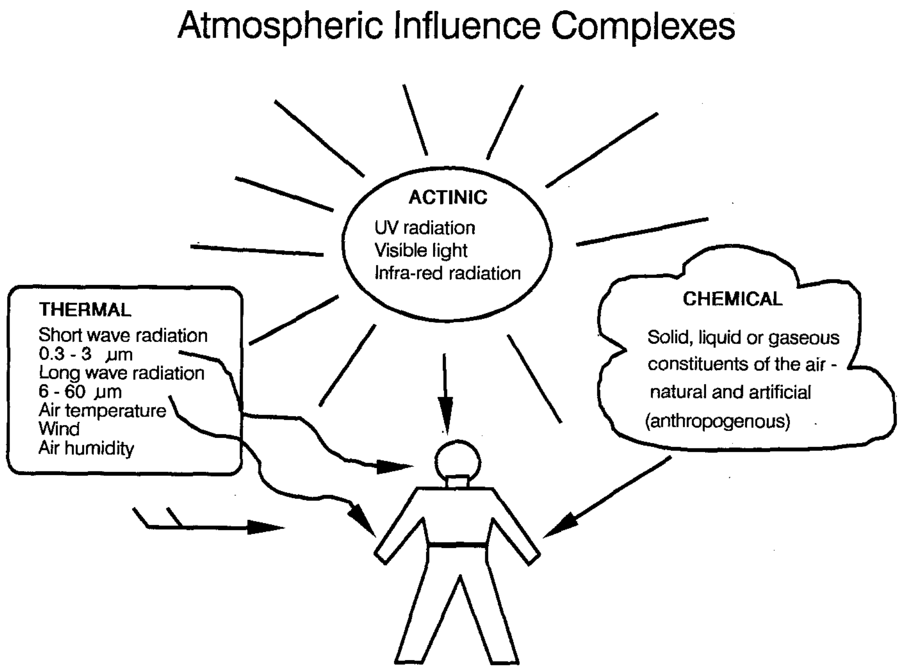

Figure 1. Meteorological effect complexes (adapted from Sönning[46] and Jendritzky[19]).

parameters of this complex have effects on man's thermoregulation: human heat exchange between the body and the environment is conducted by radiation, convection, conduction and evaporation (see Höppe in Part I of this review). The circulation is involved in all forms of heat exchange, as the blood leads the internal heat to the skin.

At high temperatures the most important mechanism of heat exchange is the evaporation of sweat. However, it is limited by the water vapour pressure, the absolute water concentration in the air. In a warm environment the body therefore has to increase the activity of the circulation to dispose of heat, and on the other hand, evaporation is automatically limited by high air humidity. A warm and humid environment is an additional strain and has to be avoided. Therefore relief from warm and humid air is one of the basic principles of climatotherapy.

A cool environment, however, forces adaptation and is an ideal basis for all forms of climatotherapy. 'Hardening' is one of the most important goals of climatotherapy in terms of prevention. Hardening is supposed to increase the ability to compensate for external stresses like cold stimuli.

Each cold stimulus causes an immediate effect; the therapeutic goal of hardening is achieved by adaptation to recurring stimuli (fig. 2). The physiological mechanisms by which resistance against infection is improved by hardening are not yet sufficiently understood. The optimizing of local blood circulation has been discussed, as well as an increase of an unspecified immunological response.

Although many questions concerning the physiology and the health-improving effects of hardening have not yet been answered, hardening is a basis of many climatotherapeutic applications.

To summarize: rest and relief are promoted by staying in a climate free of air pollution, allergens or stressing atmospheric conditions, like a high heat load. Stimuli which trigger adaptation are UV-radiation, visible light, the lowered oxygen partial pressure at high altitudes (more than 1600 m), high wind speed and low temperatures.

The terms 'stimulus' and 'relief' have to be used with caution, because what may be a stimulus under some conditions may, under other conditions, provide rest and relief. For instance, wind in exposed locations in mountain areas with a high cool-off rate is a strong stimulus. However, on hot days the wind's cooling effect makes a longer stay outside possible without strain on the body's thermal regulatory system. Then it has a relieving effect. Stimulus and rest – both are elements of climatotherapy (fig. 3).

The bioclimatic zones and their therapeutic effects

Climatotherapy is conducted in three bioclimatic zones: near the sea, in upland areas, and in alpine regions. These three zones differ in the intensity of their climatic stimuli.

Marine climate

This climate provides strong stimuli, which forces adaptation.

The stressors are:
- low temperature,
- high wind speed,
- UV-radiation, and
- maritime aerosol.

The adaptation to these factors leads especially to hardening, to an increase of endurance capacity and to a loosening of bronchial mucus.

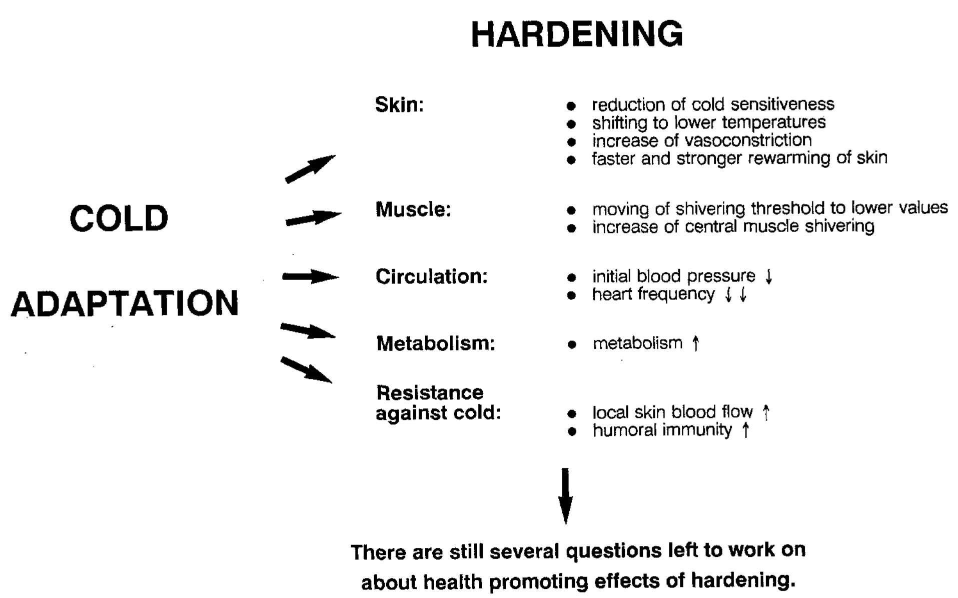

Figure 2. Physiological changes because of cold adaptation, i.e. hardening. Thin arrows signify increase or decrease.

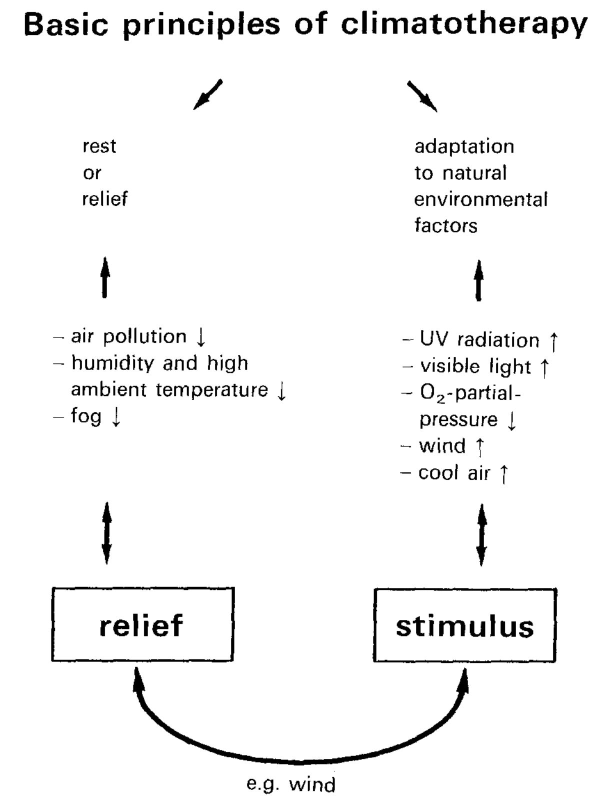

Figure 3. Basic principles of climatotherapy. Thick arrows indicate relationships, thin arrows signify increase or decrease.

The relieving elements of sea climate are:

- air purity,
- absence of allergens, and
- absence of heat load.

These provide for an increase of the respiratory function and for a reduction of allergic reactions of the respiratory system and the skin. The absence of heat load relieves the cardiovascular system. An experimental proof of a physiological response to iodine in sea-air is still lacking.

In comparison to the marine climate on islands, a coastal climate shows a slight moderation in almost all parameters, since it is influenced by the continent. The climatic conditions on islands, and the climate immediately by the sea, are most suitable for climatotherapy (thalassotherapy).

The most important indications for therapy in a seaside climate are respiratory diseases, allergies, diseases of the skin, and atopias[7]. In addition, there are detailed studies available about therapeutic effects on patients with cardiovascular disorders[23] or exhaustion syndrome, and with complaints of the locomotor system. A careful dosage of thermal stimuli is, however, necessary – the sensitivity of patients with diseases of the locomotor system to cool and humid stimuli is well known[42]. The so-called 'regimen refrigerans', the application of slight cold stimuli, has been used systematically for a long time[21]. The cures are still very popular at the present day for children with infections who are suffering from immuno deficiencies[32].

High mountain climate

The high mountain climate exists, by definition, at locations more than 1000 m above sea level (ASL) including valleys[1]. Increased UV-radiation and wind speed, and reduced oxygen partial pressure, air temperature, air humidity and air pollution are the most important factors.

In Swiss high mountain areas climatotherapy was already practised at the turn of the century. Particularly the climate treatment of tuberculosis gained importance. Today 'high-altitude climate therapy' is used for dermatological diseases, like psoriasis or neurodermatitis, taking advantage of the strong UV-radiation, and also for patients with allergic reactions of the respiratory system, making use of the complete absence of allergens, like pollen and house dust mites.

Owing to the low air temperature in combination with the decreased air humidity, physical exertion is possible with relatively little thermoregulatory strain; the high mountain climate therefore additionally provides particularly good conditions for endurance training of patients with cardiovascular diseases. Research[18] has confirmed the harmlessness of stays at high altitudes for patients recovering from coronary diseases, or for hypertensive patients: in hypertensive patients pulse frequency, systolic and diastolic blood pressure are even lowered during a four-week stay in a high altitude area (fig. 4). Caution has to be taken with exposing older people to too large an altitude difference in too short a space of time, as already-existing cardiac irregularities might be enhanced. Stays at high altitude have a positive influence on performance and training effects. After a drop in performance at the beginning, training at high altitudes causes an intensification of cardio-circulatory adaptation.

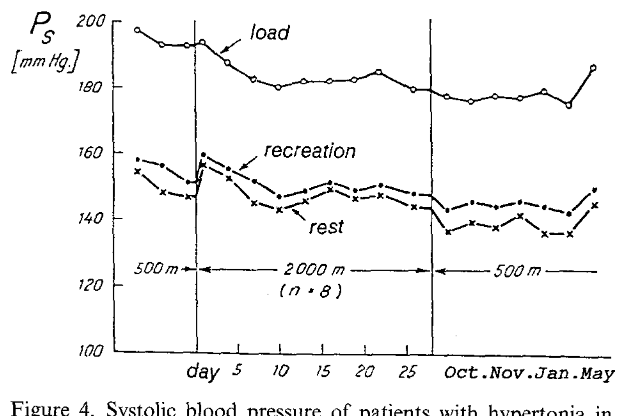

Figure 4. Systolic blood pressure of patients with hypertonia in quiet state, at defined ergometer load and in rest phase, during a stay at an altitude of 2000 m and after their return home (cf. Inama and Halhuber et al.[18]).

Several studies have dealt with the application of cold stimuli of various intensities during climatotherapy in alpine areas (particularly reference 39). Slight thermo-physiological changes were found; the skin temperature which was the most comfortable for the patients was highly significantly changed towards lower temperatures after the therapy. This is a clear indication of a reduced cold-sensitivity, and is regarded as a sign of a completed hardening process.

Upland climate

In these regions the altitudes used therapeutically range from 300 m ASL to 1000 m ASL. The topography influences the course of the weather significantly. The medium altitude climate shows mostly the same parameters as high mountain areas, nevertheless with reduced intensity. On the windward side of a range of hills, clouds and rain are more predominant compared to those areas in the lee, which are characterized by few clouds and longer hours of sunshine. During autumn and winter, in high-pressure weather situations, the valleys are cold and foggy, which leads to a reduction in air purity. Above the inversion layer, mild thermal conditions with high air purity and high radiation intensity can be found. In the summer, mountain and valley wind circulation, which is strongest on the slopes, provides good conditions for climate cure. The winds stimulate a constant exchange of air and therefore ensure lower temperatures during the night in valleys.

The mild medium-altitude upland climate offers good conditions not only for rest, but also for sport-medicine oriented endurance training. Almost all conditions can be treated in this climatic situation[37]. The only contra-indications are allergenic asthma and hay fever, as allergens in the form of pollen, moulds and house dust mites do always exist (see Puls, Bock and Leuschner in this issue).

According to the geographical situation of the particular resort, the climate of medium-altitude upland areas can offer either resting effects or increased stimuli. As the stressors at medium altitudes are weaker than those in high mountain resorts, these resorts offer the more relieving components of climatotherapy. Therapy requiring adaptation can usually only be achieved in this climate when exposure is combined with physiotherapy. Adaptation cannot be achieved by the climate alone. In this case, the term 'climate cure' should be used instead of 'climatotherapy' (see 'Practice of climatotherapy' below).

Methods of climate-exposure and their therapeutic effects

For a successful climatotherapeutic treatment the body has to be exposed daily over several weeks, with an exact dosage, to the biometeorological conditions like temperature, wind and UV-radiation. In traditional climatotherapy, four different methods to provide rest or to apply stimuli are described: climatic terrain treatment, fresh air rest-cures, air baths, and heliotherapy.

Table. Terrain treatment: general requirements for the footpath system

- different lengths of paths
- various ascending gradients (increasing requirements)
- geographical situation with excellent air purity
- different altitudes (different radiation, wind and temperature conditions)
- paths in the sun and in the shade (limitation of sun exposure)
- soft ground, varied, but by no means asphalt
- benches
- it has to be known whether the path is passable during the whole year and under bad weather conditions
- starting points easy to reach without a car (public transport, cable cars, etc)
- for emergencies: drive-back service, medical first aid
- dosage of endurance training after calculation of the physical load

Terrain treatment

What is called 'terrain treatment' means walking on sloping footpaths at a given walking speed with due consideration of the incline. In many clinics which specialize in recuperation and rehabilitation, and also in the form of an actual cure, this therapy is gaining ground.

During a terrain treatment the patients are confronted with the geomorphological structure and the specific climatic conditions of the health resort. To carry out the terrain treatment effectively, it is necessary that there should be a suitable range of terrain-treatment paths (table), the dosage must be correct, and the climate has to be suitable for therapeutical use.

Dosage. The idea of training during terrain treatment is fundamental. The cardiovascular training could consist of exercises leading to a systematic increase in physical endurance capacity. The main element of terrain treatment has to be endurance training, which consists of the improvement of heart capacity, blood circulation, lung function and muscular metabolism. The physiological parameter for the dosage of the physical load is pulse rate: a heart-rate of 180 beats minus age should be maintained during the training period. This cardiovascular training must be carried out three to four times every week for a period of 20 to 40 minutes for at least three weeks in order to obtain an improved state of health[15].

The training adaptation of the cardio-circulatory system can be differentiated into a central and a peripheral part (fig. 5). This adaptation to endurance training reduces the danger of strain caused by a disproportion between the oxygen available and the oxygen need in the myocardium by increasing the oxygen offered.

Influence of the climatic conditions during terrain treatment. The effects of a cool body temperature on some

Adaptation to endurance training	
central	O_2-uptake ↑ Hf ↓ RRs ↓ catecholamine ↓ peripheral resistance of cardiac vessels ↓
peripheral	muscle metabolism ↑ blood flow ↑
→ increase of oxygen uptake	

Figure 5. Physiological consequences of endurance training (following Hollmann and Hettinger[15]). Hf = heart frequency; RRs = systolic blood pressure.

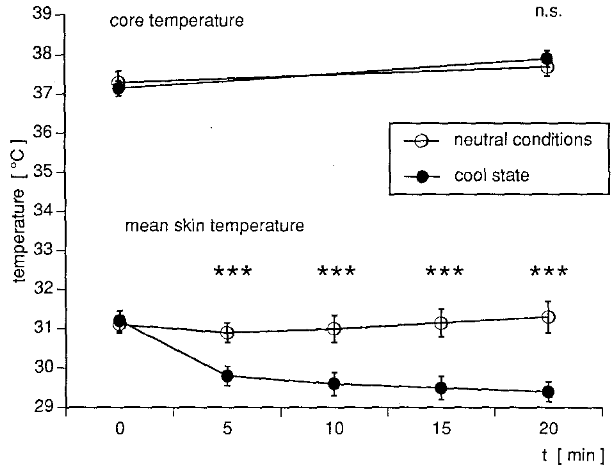

Figure 6. Course of mean skin temperature and rectal (core) temperature during terrain treatment under neutral and cool thermal conditions. Given walking speed and clothing (n = 32). Acute measurement; beginning, three measuring points and end of the cure exercise path.

physiological parameters is well known. During bicycle ergometer exercise under cool conditions – cold stimuli over the total body surface – heart rate decreased, compared to that during exercise at normal room temperature[50]. At the same time, oxygen uptake and cardiac output increase[33]. Even when only the face is exposed to cold air during exercise of a bicycle ergometer, a decrease in heart rate can be observed. An effect can also be found when both the skin temperature and also the core temperature are lowered simultaneously. During bicycle ergometer exercise after pre-cooling, the body temperature as a mean of core and mean skin temperatures was lowered 1 °C, and performance and O_2-pulse at a given heart rate were significantly higher[8,9].

Based on blood lactate concentration, our own studies[40] show an increase of the endurance effect brought about by a cool environment during training. The effect of cardio-pulmonal training can be induced under simultaneous cold adaptation during a terrain cure. Cold adaptation has an amplifying effect on the endurance training effect when the terrain treatment is conducted with a cool body shell.

This combination can be achieved by terrain treatment under cool conditions[40]. During terrain treatments lasting three weeks, which were conducted in the high-mountain climate of Garmisch-Partenkirchen, Germany (800–1800 m above sea level) and of Davos, Switzerland (1600–2000 m ASL), 153 cure patients without organic findings were randomly divided into three groups. Two groups carried out a therapy programme under different thermal conditions. The subjects in the 'zero group' did not join the therapy programme.

With patients in the 'cool group' the body shell was cooled down or kept cool, according to defined values, during the terrain walks. This was guaranteed by the clothing used, which was based on the known connection between body heat balance during physical work, subjective thermal sensation, and the insulation values of the clothes, depending on climatic environment conditions[13,20,38]. The 'cool group' showed, on average, a skin temperature about 2 °C lower than the group working under well balanced thermal conditions (control). The core temperature, however, was not influenced (fig. 6). The dosage of endurance performance was achieved with an increase in walking speed and training time.

Work under conditions of reduced skin temperature leads to an improvement in actual aerobic performance. During the acute test in the terrain, the blood lactate concentration under cool conditions was slightly, but significantly, lower for the same performance than under thermally neutral conditions.

After three weeks of training the patients of the 'cool group' showed a significantly lower increase in lactate than the patients in the control group under the same load (fig. 7). The blood lactate concentrations of cool and control groups differed at the end of the cure, under the same load, significantly.

The results show that under cool conditions, the same work is done in a more aerobic way. To achieve this immediate effect a reduction of mean skin temperature by 2 °C is enough. Endurance training with a cool body shell leads additionally to a cold-induced increase of the aerobic muscle metabolism. This increase is reflected in the level of blood lactate which results from easy endurance training: the training effect is almost doubled. Making use of low air temperatures and wind leads to clear therapeutic success.

For the treatment of various diseases an experimental basis in climatotherapy exists. Results of studies of terrain treatment provide a secure basis for the treatment of patients with functional cardio-circulatory disorders[40], arteriosclerosis[16] and coronary heart disease[31].

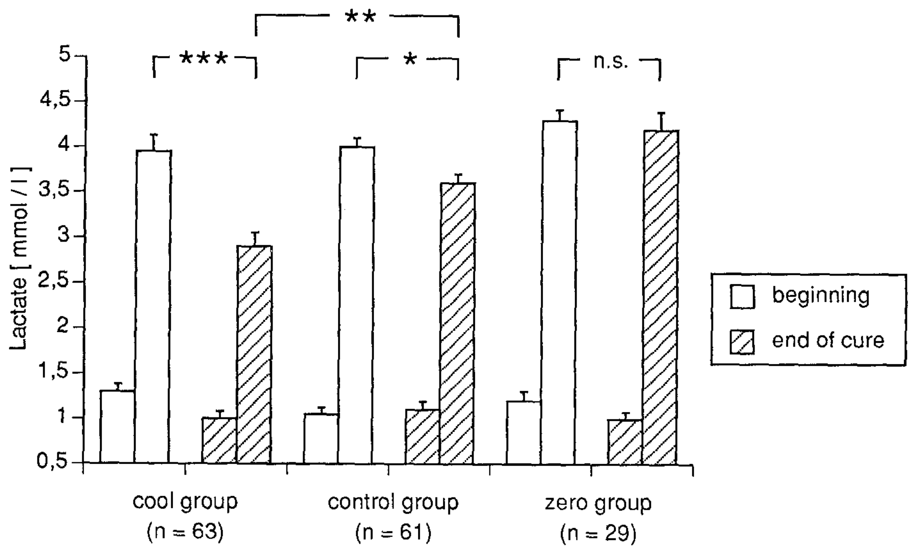

Figure 7. Blood lactate concentration before and after bicycle ergometer test (thermally neutral test conditions), at beginning and end of cure, for cool group (n = 63), control group (n = 61) and zero group (n = 29).

Fresh air rest-cure

The second climatotherapeutical treatment is the fresh air rest-cure. It is defined as 'slight exposure to cold during rest'. The goal of the fresh air rest-cure is cold adaptation, the stimulation of regeneration and a slight increase in physical endurance capability.

The ideal way of relaxation during rest therapy is sleeping during the day in the fresh air, under conditions where the body is cool. The physiological basis of fresh air rest-cure is that rest, combined with a slightly decreased skin temperature over a period of about 40 minutes per day, leads to definite physical relaxation.

The regeneration which occurs at the same time leads additionally to a slight increase in endurance capability ('training en repos'). Experimental work concerning 'training en repos' originates mostly from the former GDR and the Soviet Union. In recent years, the effects of fresh air rest-cures have been intensively studied. However, in one study[24], the fresh air rest-cure to which healthy persons and patients with disorders of the cardio-circulatory system without organic findings were exposed was very intensive. The subjects underwent a fresh air rest-cure for 6 days a week over 5 weeks in which they remained lying down until cold-induced shivering occurred. After these 5 weeks the exposed group had a significantly increased functional capacity.

These results could be confirmed by our own research, using mild cold exposure[44]. The cool group felt 'slightly cool' during the fresh air rest-cure, which was conducted 4 times a week over 4 weeks. At the end of the cure, heart frequency and lactic acid showed a significantly lower increase in ergometer tests than was found under the same load at the beginning of the cure. The values for the cool group at the end of a fresh air rest-cure were significantly lower than the values for the thermoneutral control group (fig. 8).

The astonishing result is that resting, in combination with a parallel cooling of the body's shell – as practised during fresh air rest-cures – leads to an increase in physical endurance capacity. Of course it has to be assumed that the increase in endurance capacity brought about by a fresh air rest-cure is not as big as that achieved by physical endurance training. However, the two methods, fresh air rest therapy and terrain treatment, could complement each other excellently in terms of their therapeutic effects. Therefore, today, fresh air rest therapy is conducted in addition to various other cures.

Although there is a lot of experience of the hardening effects of the fresh air rest-cure, measured values of the immunological reactions are still lacking.

To summarize: with the fresh air rest-cure a reduction in the predisposition to infection[47] can be achieved, and functional cardio-circulatory diseases[5,25] can be improved. Although the treatment of diseases of the respiratory systems and of tuberculosis[12] using fresh air rest-cures can look back on a long tradition, so far experimental proof of the effectiveness of such treatment is still lacking.

Air baths

An air bath is a stay in the fresh air with the body uncovered. It is a type of cold therapy, so if the radiation intensity of the sun is high it can only be carried out in the shade. The activity is kept low and will be adjusted to the thermal conditions according to the subjective feeling. Transpiration should be avoided. The therapeutic goal and the basic principles are the same as those of the fresh air rest-cure.

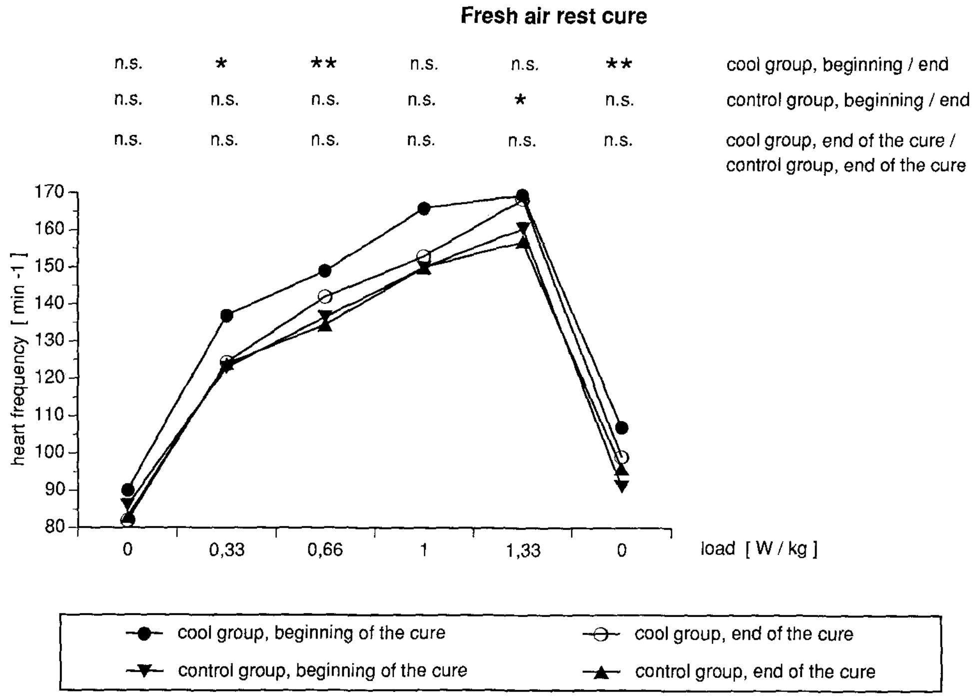

Figure 8. Heart frequency of patients before and after a fresh air rest-cure lasting 4 weeks. Cool group (slightly cool, n = 12) and control group (thermoneutral, n = 11), ergometer test with increasing load.

Heliotherapy

Heliotherapy is the exposure of sick parts of the body or the body as a whole to the sun's radiation. Through heliotherapy, adaptation on various levels is sought. Goals are the avoidance of osteoporosis, an increase of skin peeling in psoriasis, the suppression of the activity of the Langerhans' cells of the skin in allergic eczema, an increase in the endurance capacity, and in the long term an increase in the immunological response. The traditional therapeutic goal of the heliotherapy was the increase of vitamin D production. A recent publication on the multitude of effects caused by UV-radiation has been published by Bühring and Jung[11].

Amongst other results, UV-radiation is supposed to have an effect on the increase of endurance capacity. Several experimental studies using artificial radiation confirm this. Bühring[10] and other authors found a decrease of the heart frequency with and without load after serial UV-radiation. Roediger et al.[35] could prove an increased oxygen uptake. Humpeler and others[17] found an increased oxygen transfer from the erythrocytes to the mitochondria. Other research groups found an increased oxygen partial pressure, a decrease of lactic acid increase under load[28], and improved flow qualities of the blood[2,10,36]. Based on these results, the conclusion is being discussed that UV-radiation induces the same metabolic effects as endurance training.

Our own studies on natural heliotherapy within the framework of the climate cure therapy of Davos shows an increase of endurance capacity brought about by natural UV-radiation[45]. On average the lactic acid level (fig. 9) in the 'sun group' reached significantly lower values under the same load at the end of the 3-week cure. The difference in the strain values at the end of the cure between the two groups is significant: the patients of the 'sun group' show an increase in endurance capacity, i.e. the increase of lactic acid was reduced by 0.5 mmol/l, whilst the control group shows no change of capacity.

The slowing down of additional anaerobic energy production at the end of the 3-week heliotherapy seems to depend linearly on the number of hours in the sun. The results, backed up by the lactic acid level, show a significant improvement of the endurance capacity among the sun group in comparison to the control group. Of course, the same effects cannot be expected from a 3-week heliotherapy as with an endurance training; nevertheless, natural heliotherapy could be a supporting part of an endurance training or, as an 'en repos' training (i.e. slight increase of capacity during periods of rest), it could be used with patients who have to stay in bed.

In addition, it is thought that natural UV-light leads to an increase in well-being. Physical complaints were reduced by natural heliotherapy[43]: the sun group showed a greater reduction of physical complaints than the control group. This difference in improvement of physical complaints can be established statistically.

The positive effects of UV-radiation have been clearly shown in dermatology: for the treatment of diseases of

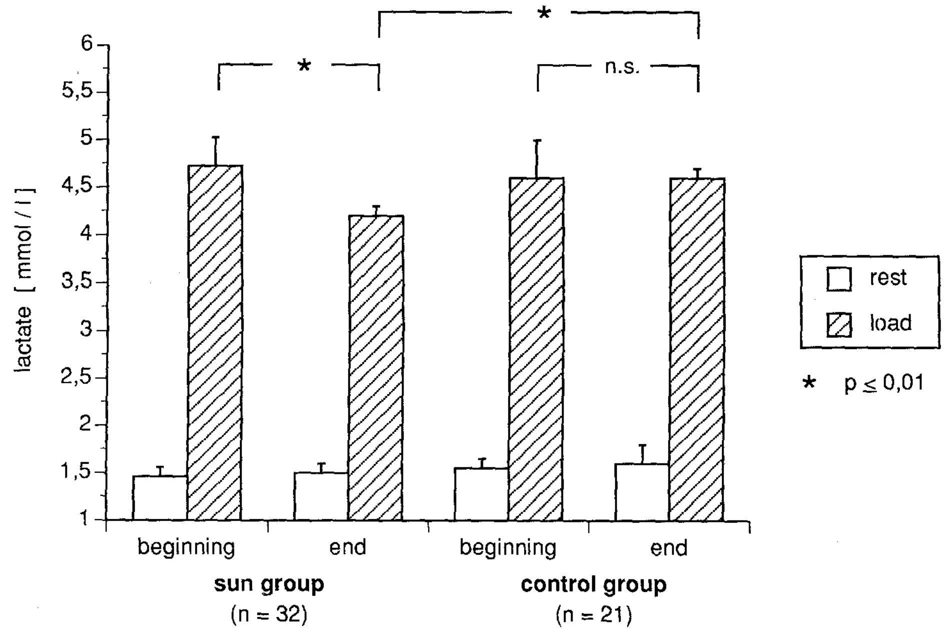

Figure 9. Lactic acid level of the 'sun group' (n = 32) and the control group (n = 21) during bicycle ergometry at rest and at the same highest achieved load, in the beginning and at the end of the 3-week heliotherapy.

the skin like psoriasis and neurodermatitis with heliotherapy[6,7,26,27,49] there are proven results. The same is the case with disorders of the skeleton like osteoporosis and osteomalacia[12,29,48]. Functional diseases of the cardio-circulatory system are also considered to be influenced by heliotherapy[11,65]. The therapeutical success with other diseases, such as a predisposition to infections[22,36], seasonal depression[34], arthritis[22] and diseases of the respiratory system[4] still remain to be examined in further studies.

Dosage. The dosage criterion for heliotherapy is the energy of the erythema effective ultraviolet part of the sun's radiation, the UV-B-radiation (see Ambach and Bhumthaler in Part 1 of this review). Using a dosage just below the individual minimum erythema dosage, following today's scientific knowledge, one can assume that there will be no danger or damage, as can happen through chronic over-exposure to UV-radiation, or an overdose. This limit, however, is being reevaluated again.

Practice of climatotherapy in health resorts: climate cure concepts

In the past decades, climatotherapy was only practised in the Swiss villages of Davos and St. Moritz in the high Alps, and in some German sea health resorts like Norderney. The reason for this lay mainly in the prevalence of medicine-based treatment methods, which made climatotherapy look superfluous and too time-consuming. Furthermore, cures in health resorts were mainly not understood as a special therapy, but as an addition to the various possibilities of physical therapy. Therefore none of the forms of climatotherapy described above were offered to treat a particular disease. The consequences were a clear drop in the amount of scientific research on climatotherapeutic methods and their application in practice.

At the moment, climatotherapy is being differentiated again, and newly structured following objective parameters. Recent climatotherapeutic results[41] have led to the conclusion that the different methods of exposure should not be separated from each other, but have to be combined, so that they complement each other and support each other in their therapeutic effects. The way the methods are combined will always depend on the indication.

The effect of the combination of the different methods of climate exposure on specific diseases is an area where further research is needed. Firmly-established results have until now been presented on terrain treatment under cool conditions as a treatment of functional cardio-circulatory diseases, and on the combination of a fresh air rest-cure and terrain treatment in treating patients with states of exhaustion[40]. There is also Inama's and Halhuber's[18] research on the effects of alpine terrain treatment on patients with hypertonia (see fig. 4).

The positive individual factors included in a therapeutic regime using the climate can only then be fully effective when they are offered in the correct sequence. It has to be examined whether terrain walks have to be conducted every day or only every second day, which types of rest or lying-down breaks are useful, how the transition from climate exposure to a rest phase is to be designed, and what measures of physical therapy should support climate exposure. Each climate cure needs – after a particular indication has been ascertained – a special concept concerning the time and the measures to be used, covering the whole course of the cure.

The new concepts for climate cures – especially for health resorts at medium altitudes – therefore consist mainly of a suitable combination of the following therapy forms: physical training, goal-oriented usage of climatic and weather factors, rest, and supporting physiotherapeutic measures. The use of this form of therapy, and of the elements contained within it, during a cure, should take place in a chronobiologically correct rhythm of load and rest. This new concept of climate cures takes into consideration not only the correct sequence of the effects of climatic and weather factors, but coordinates this with other physical and therapeutic factors which are also part of the climate cure.

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