Rheumatology

The Interdisciplinary Concept

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Climate and Rheumatic Diseases

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Weather Sensitiveness of Rheumatics

In a group of average healthy persons, between 30 and 50% of the people claim to be sensitive to changes of the weather [Faust, 1973; Schaich, 1974]. However, the average course of health is about the same for people who claim to be sensitive and those who do not [Richner, 1976]; this supports the old statement [De Rudder, 1951] that all people react to the weather, but only weather-sensitive people relate it with the weather.

A person's statement to be 'sensitive to the weather' offers clear information about the structure of his/her personality. Already Curry [1951] and Lampert [1962] described weather caused types of human reaction. Recently the type of the weather sensitive was defined by the help of the 'Freiburger Persönlichkeitsinventar' [Geiger and Gensler, 1975; Faust, 1978]. Women call themselves more often 'weather-sensitive' than men, young people only to a small percentage; with increasing age, between 30 and 60, the rate rises up to 60% of the total population. These people name, referring to psychic symptoms, the following, by Faust [1976] in decreasing prevalence ordered, complaints: tiredness, ill-humor, unwillingness to work, lack of concentration, problems to fall asleep, nervosity, tendency to make mistakes, indisposition and fear.

During a study with 2,000 participants [Dirnagl, 1985], weather-sensitive and nonsensitive people were questioned about reasons and frequency of their visits to doctors. Symptoms or suspected diagnosis, being the cause of the visit to a doctor, showed that weather-sensitive people named 'rheumatic complaints', besides the symptoms of the so-called 'vegetative dystonia', most often.

Among rheumatics, weather sensitivity is far more spread than among the rest of the population; that is stated in many publications [e.g. Tromp, 1980]. Thompson questioned already in 1951 112 patients suffering from chronic polyarthritis and found out that 83% looked upon their symptoms as weather-related. Levis-Faning [1950] came to the same result: 61 of 369 patients blamed certain states of the weather for their pains. The numerous statistical surveys can be summarized to 75–90% of all rheumatics being weather-sensitive; weather and climate are supposed to play a central role in releasing or intensifying these states of pain.

Possible Meteorological Parameters and Climatic Conditions

People with average weather sensitivity, as well as people with rheumatic diseases come up with complaints about a falling off in health preferably in time and local connection with atmospheric disturbances, i.e. changes in weather or strong variation of particular, meteorological parameters from the seasonal weather course (cf. 'Weather, Climate and Rheumatism'). Also certain climatic conditions shall have effect on the frequency of complaints. The terms 'weather' and 'climate' differ in the following way: 'weather' is understood as a short-term state. As 'climate' is defined the mean state of atmosphere over a specific place, as well as the for this place characteristic average course of weather. Weather and climate are always composed of a certain combination of the meteorological parameters.

Change of Weather, Low-Pressure Area, High-Pressure Area

Variations from the average course of weather are quite common in the middle latitudes; the zone of western winds is quite often characterized by unstable weather. The drifts here are a consequence of moving low-pressure areas (cyclone) and high-pressure areas (anticyclone) combined with rushes of subtropical air far into the northern region, as well as cold air from the polar regions into the south. A low-pressure area is formed when warm masses of air meet air coming from the polar regions: Normally the temperature decreases from equator to pole parallel to the latitude; the isotherms lie in parallel order. This balance is disturbed by the rush of warm and cold masses of air: in the atmosphere a flat temperature wave is generated. Therefore, when different air masses meet each other a deformation of the former even drift, which is called 'front area' (warm front) is formed. To do this the warm air moves over the cold air (slip up); the warm air is at the same time cooled down and condensates. The warm front is characterized by an area of rain in front, with stratus clouds and drizzle resp. rain. At the other side of the low-pressure area cold air slips at the same time under the warm air and lifts it rapidly; the cold front is created. Due to the fast lift of air it comes to fast cooling and strong condensation: Along the cold front cumulus clouds are formed with showers and hail. According to the earth's rotation, a rotation of both fronts around the center of the wave disturbance is formed; the air pressure decreases towards the center. Thus, the general drift of the cyclones is formed. Within 24 h the cold front catches up with the warm front and the fronts close (occlusion). At this point of time the 'aging process' of the low-pressure area takes its course. The aged low-pressure area slows down its moving speed. The whirl grows weary, following air masses fill up the funnel, the air pressure increases and the cloud cover, and therefore the low-pressure area, breaks up.

The high-pressure areas (anticyclones) are described as 'hill of cold, heavy air' [Möller, 1973], on front- and backside the air moves down (slip down) and warms up. A high pressure area can reach the size of a continent (e.g. a Russian winter high) and remain stationary for weeks; normally small areas with high pressure follow the low-pressure areas of the general drift (intermediary high). The consequence is constantly changing weather.

Variation of Particular Meteorological Parameters

At each change of weather a large number of meteorological parameters change at the same time. To make a more uniform approach possible between this multifactorial process and its contingent effects on man, climatology summarizes the meteorological parameters into so-called 'effect complexes' (fig. 1).

The thermic effect complex is of special importance: It takes into consideration air temperature, air humidity, wind speed and infrared radiation. The generic term 'air humidity' has to be differentiated into relative air humidity and absolute air humidity, the so-called 'steam pressure': the relative air humidity (in percent) quotes the degree of the air's satiation

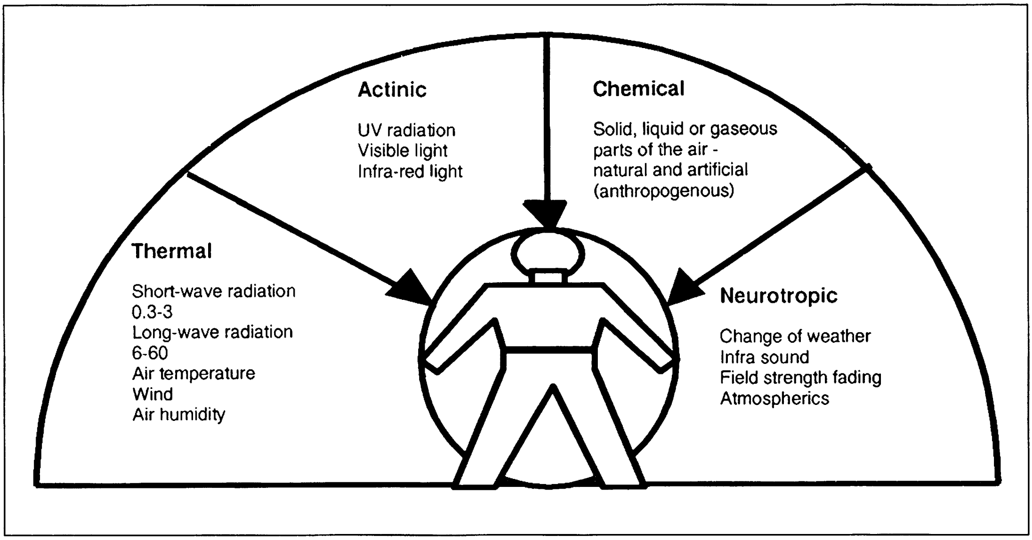

Fig. 1. Atmospheric effect complexes.

with water steam. It shows, under the actual temperature, the still possible absorption of water steam by the air, whilst the steam pressure (in hPa) equals the water steam actually present in the air. The particular factors of the thermic effect complex – besides the weather change as a whole – take up a major place in medical-climatological causal research.

Weather, Climate and Rheumatism

Experimental Bases

Several authors have dealt with the effects of weather on rheumatics (table 1). As indicator for the influence in most cases the objective feeling of pain was referred to; acute states of pain under certain meteorological conditions, as well as increase of pain within the last 24 h before the occurrence of this meteorological situation, was examined.

In few studies besides subjective statements also 'hard' connections were considered; Hollander and Yeostros [1963] constructed a climate chamber which permitted to simulate certain weather situations for objective research. The symptoms were evaluated following the 'clinical index';

Table 1. Experimental studies on connections between weather and rheumatism

Author	Rheumatic process	Connection between meteorological factors and weather situation	Methodics	Remarks
Weitbracht and Simon, 1989	lumbal prolapse of disc, increase of pain	1) temperature decrease 2) humidity increase	114 patients, recording of clinical admission	accumulation of admission during the winter month, flow of cold air responsible for increase of pain, cause probably direct lumbal hypothermia
Harlfinger et al., 1986	arthritis, arthrosis, increase of pain (last 14 h)	1) passage of front 2) following advection of cold air (high pressure area with cold air) 3) weather situation with dynamic cold air advection	state of health during Smile test (24 h before), patients with rheumatic pain, > 1,600 interviews	assumed connection between weather and rheumatism; strongest sensations of pain during passage of front, they remain the day after, at cold air advection; patients can feel the upcoming weather (Smile test)
Wiebe et al., 1985	arthritis, increase of pain	increase of humidity	100 patients in the north of Holland	connection in summer stronger than in winter
Patberg et al., 1985	arthritis, intensification of pain	not only process of change, but also actual situation 1) decrease of temperature 2) cold 3) decrease of steam pressure 4) increase of humidity	100 patients with arthritis, pain, questioned over 1 year, lived in sea climate (Holland)	symptoms of arthritis are influenced by weather, but not the disease itself, pain in summer stronger than in winter (in winter, people stay more indoors; the steam pressure is inside higher than outside and the relative humidity is lower)
Latmann and Levi, 1980	arthritis, blood parameters for occurrence of inflammation – sedimentation – C-reactive protein	no connections	patients with arthritis, not pain, but objective blood parameters at the day when inflammation starts	weather influences symptoms of arthritis but not the inflammatory process, weather influences the personal well-being but not the disease itself

Sönning et al., 1979	arthritis, acute rheumatic attack, increase of pain	1) less warm air the day before, increase of cold air advection the following day, at the begin of cold air flow in, i.e. within the front 2) cold sea air 3) thunderstorms (strong vertical exchange movements), connection with change of ground near humidity milieu	123 patients, arthritis: first occurrence of inflammatory symptom after longer time	
Hollander and Yeostros, 1963	arthritis, symptoms according to clinical index	falling air pressure with increasing humidity	research in climate chamber	hypothesis: normal tissue compensates falling pressure (intracellular fluid evacuates into the blood circulation, sick tissue retains liquid) → increased intracellular pressure → pain and swelling
Tromp, 1963	pain release resp. intensification	cold		hypothesis: reason for pain increase is increase of viscosity of synovial liquid
Barcal et al., 1961	arthritis, arthrosis, intensification of pain	1) front side of low pressure areas 2) change of weather 3) not: existing bad weather	> 100 patients, subjective complaints, objective state	announcing pains 15 h before change of weather
Pehl and Weskott, 1955	rheumatics: intensification of pain	1) change of weather 2) decrease of temperature 3) increase of humidity 4) wetness and cold 5) increase and decrease of air pressure	100 patients	significant weather sensitiveness
De Rudder, 1952	rheumatic disposition	1) humid cold 2) lack of sun		experience that patients come back from journeys to southern countries without rheumatic complaints

this index contains according to Hill [1966] the calculation of arthritis activity based on joint stiffness, the amount of ASA necessary to soothe the pain, firmness of the hand's clasp, walking time for a standardized distance and other not relevant measurements of another collection of parameters, the so-called 'articular index'.

Exceeding that, in the past years Latman and Levi [1980] measured the blood parameters BSG and CRP (blood sedimentation rate and C-reactive protein), to correlate the course of inflammation with the actual weather situation. Weitbrecht and Simon [1989] eventually correlated the clinical admission of people with lumbar prolapse of disk and the weather situation. Several authors also published bibliographies (table 2). Studies, based on subjective statements of pain, as well as studies based on measurable states of inflammation of arthritis were described.

Except for one study [Latman and Levi, 1980], each of the in table 1 listed experimentally based studies points out a correlation between a defi-

Table 2. Literature review on connection between weather and rheumatism

Author	Rheumatic process	Connection between meteorological factors and weather situation	Methodics	Remarks
Latman, 1987	arthritis: first signs of inflammation	different parameters	literature references	data material is not evident enough to draw serious conclusions, methodics are often questionable
Dirnagl, 1978	rheumatics: pain frequency and intensity	1) rapid change of weather combined with 2) decrease of temperature	literature references	weather sensitiveness of rheumatics cannot be traced back to standardized weather situation. individually different ways of reaction are assumed
Pilger, 1970	arthritis: intensification of pain	contradictory statements 1) humid cold 2) lack of sun 3) change of weather 4) falling pressure with increasing humidity at the same time	literature references	many studies uncontrollable

nite meteorological situation or a certain course of weather: The frequency of pain is increased when the course of weather changes: The *sudden change of weather* proceeds from high-pressure area to low-pressure area; in the beginning of cold air influx, i.e. within the cold front range, the most complaints about pain are found [Sönning et al., 1979]. During the passage of the front more cold air is brought up into the low-pressure area; in the middle latitudes it is normally humid cold sea air. The major reason is seen either in the cold air advection [Harlfinger et al., 1986; Sönning et al., 1979], or in increase of humidity [Pehl and Weskott, 1955; Wiehe et al., 1985]. This temperature decrease at the front side of a low-pressure area [Barcal et al., 1961], with increase of humidity at the same time, is mainly held responsible for the increasing frequency of pain. During the sudden change of weather with the increase in humidity, the air pressure drops. The connection of these two parameters shall also cause a deterioration of the symptoms – measured at clinical index [Hollander and Yeostros, 1963]: At changes in the climate chamber the clinical index only increased on the combination of falling barometric pressure and increasing air humidity. Sönning et al. [1979] found in addition to that an increased pain frequency at days with thunderstorms; they too see the connection in the change of temperature-humidity milieu.

Some studies do not take the complex process of changing weather – meaning the simultaneous change of several parameters – into consideration, but hold responsible *single meteorological parameters.* Tromp [1963] takes cold in general to be a pain-releasing or intensifying parameter. In the same way already De Rudder [1952], as well as Pilger [1970], believed humid cold and lack of sun to be the main release.

The above listed studies substantiate unanimously the increase of pain frequency at changes of weather, i.e. approaching low-pressure areas in connection with decrease in temperature and increase of relative humidity. Contradictory statements can however be found: Fuss [1981] gives a tendency to pain increase at rising temperature, based on her study; Pilger [1970] points out, following his literature investigation, that many authors particularly claim they did not find any influence of air humidity at all. On the other hand, other authors [Dirnagl, 1985] assume the content of absolute air humidity (steam pressure) to be the really relevant figure; Flach [1938] described singular examples that attacks of pain occurred particularly when the steam pressure in comparison to its normal level decreases. To refer to the steam pressure as indicator for pain stimulating processes has its justification: as rheumatic pain occurs outside buildings as well as inside, one has to look for meteorological parameters which change inside parallel to outside. Entering a room, e.g. the air temperature, air movement and relative humidity change, not the absolute humidity. Unfortunately the influence of steam pressure on rheumatic processes was in none of the controlled studies pursued.

Interpreting the literature, utmost caution is indicated, not only in terms of meteorological process, but also looking at the development of disease: it cannot always be clarified upon which specific form of disease the research was done in the described study. The majority of studies deals with 'rheumatoid arthritis', some authors however only talk about 'rheumatism'; a differentiation between inflammatory and degenerative clinical picture is not made.

The question, whether not only the weather, but also the average state of atmosphere, i.e. the *climate,* can be correlated with the occurrence and deterioration of rheumatic diseases, has yet not been finally clarified: Lawrence [1963] describes – based on epidemiological surveys – that arthritis can be found most often between 50° and 60° northern latitude, and that it decreases outside this zone in higher or lower latitudes. That corresponds with the figures in table 3, according to which the numbers for England and Scandinavia are the highest (4–7%), decreasing to the north (Alaska 1%) and near the equator, Puerto Rico (0.92%). In the Federal Republic of Germany about 1 million people (1.6%) suffer from chronic polyarthritis; 0.7% of the total population, i.e. 419,016 people in 1985, claimed medical or professional rehabilitation measures because of rheumatic diseases [Mikrozensus, 1987]. The results of surveys by Mendez-Bryan et al. [1963] in Puerto Rico showed a significantly smaller incidence of arthritis compared with studies in temperate climate zones; there the lowest rate anyway was found. In two later studies, Lawrence [1966] and Lawrence et al. [1966] could not find differences between the population of Middle America (18° n. lat.) and Europe (54° n. lat.) and between the inhabitants of Jamaica and Southern England (table 4).

Studies dealing explicitly with climatic influences in degenerative changes more or less do not exist. One exception is described by Lawrence [1977] in his review, though without reference: According to that, among the population in Jamaica's warm climate (18° n. lat.) only 21% degenerative changes could be found, whilst the percentage of North England's inhabitants (52° n. lat.) is around 50%.

Already in 1966, Hill pointed out that the evidence of the so far existing studies is reduced by the fact that there were no standardized diagnosis criteria and no standardized selection of the population examined; these studies therefore did not allow definite conclusions. The deficit in controlled, worldwide coordinated studies of connections between rheumatic diseases and climatic conditions could not be solved until the present day.

Lawrence [1969] and Fleming et al. [1976] report in their studies that the pain frequency with chronic polyarthritis is also influenced by the season, pointing out the summer and warmth as positive, coolness and winter as negative; Patberg et al. [1985] note in their study with 100 arthritis patients a stronger pain increase in summer than in winter (table 1). The authors explain this assuming that meteorological factors affect the body mainly in summer and less in winter, as in winter one is less outside and more often inside buildings, where the climate, compared to that outside, differs in almost all meteorological parameters: mainly there is less relative humidity inside.

Table 3. Arthritis frequency in different climates and different parallels of latitude

Population, latitude	Arthritis incidence rate	Author
50–60° n.L.	'most frequently'	Lawrence, 1963
Federal Republic of Germany	1.6%	Microcensus, 1987
Puerto Rico	0.92%	Mendez-Bryan et al., 1963
England, Scandinavia	4–7%	Mikkelsen, 1966
Africa, near equator	'minor incidence'	McKinley, 1967
North America	3.2%	Engel and Burch, 1967
Alaska	1.0%	Blumberg et al., 1961

Table 4. Comparisons of arthritis frequency between different populations

Population, latitude	Arthritis incidence rate	Author
America and Europe between 18 and 54° n.L.	no differences	Lawrence et al., 1966
Jamaica and Southern England	no differences	Lawrence et al., 1966
Red Indians in Montana (48° n.L.) and Arizona (33° n.L.)	pain incidence higher in the north (Montana)	Burch, 1966, quot. acc. to Pilger, 1970

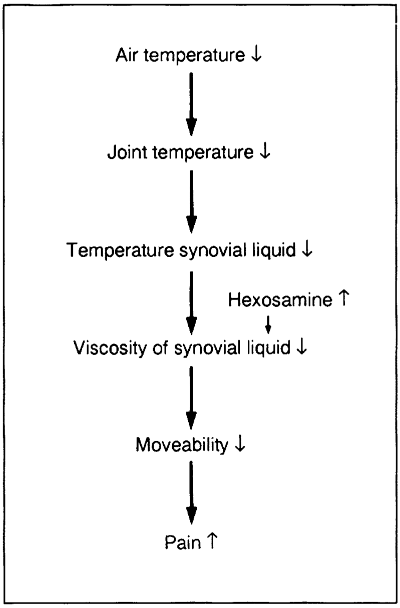

Fig. 2. Hypothesis concerning pain increase at chronic polyarthritis caused by decrease in air temperature, resp. coldness.

Despite these different statements, patients with rheumatic diseases are sent in regions with dry-warm climate only based on 'practical knowledge'. Hill [1966] supposed that the little changes in weather in these regions have a positive influence on the 'weather sensitivity' of rheumatics; convincing physiological reasons for the improvement of the complaints do not yet exist.

Hypotheses about Influencing the Rheumatic Process

Considering the connection weather-rheumatic process, analyzing the effectors, i.e. the meteorological parameters and their interrelationship, effect priorities result for the temperature-humidity milieu. Receptors for changes in temperature-humidity milieu are at first the body's periphery and the respiratory system: skin and upper respiratory tract react directly on changes in the environment's temperature and humidity.

Most convincing are those hypotheses about influence of weather and climate on rheumatic diseases, which establish the reference to the patient's sensitiveness to cold (fig. 2): Latman [1987] and Rothschild and Masi [1982] proceed on the assumption that a short stay in strong cold or a longer stay in a cool environment causes a temperature decrease in the joint. As the joints are not covered by protective muscle or fatty tissue, the temperature of synovial liquid falls faster than rectal or muscle temperature. The synovial liquid becomes the more viscous the lower the temperature is [Hertel and Ingenpass, 1974]. This temperature decrease of synovial liquid causes a greater stiffness of the joints [Hunter et al., 1952]. Tromp [1963] also figures the increase in viscosity of synovial liquid to be a reason for the pain increase. It is known [Tromp, 1963] that cold environment condition lowers the hexosamine output of healthy people. In empiric studies, Tromp and Bonma [1966] found that the hexosamine content in rheumatic's urine was significantly lower than in healthy person's. The authors concluded that rheumatic pains are the consequence of low environment temperatures which lead to a concentration of hexosamine in the synovial liquid and therefore to an increase in viscosity. By that the joint is additionally limited in its movability: pain is the consequence.

Hollander and Yeostros [1963] point out in their hypothesis that pain is increased when the air pressure falls, and at the same time the relative humidity grows, as follows: Normal tissue is able to compensate falling air pressure by evacuating intracellular liquid into the blood circulation. Afflicted tissue, however, is not as permeable and retains the liquid. Therefore, increased pressure exists in afflicted tissue, compared with healthy tissue. This pressure gradient leads to increased pain and to the swelling of the afflicted tissue. All authors though leave open which meaning the increasing air humidity has in combination with falling temperature or falling air pressure.

Conclusion

Certain weather conditions lead with high probability to increase of frequency and intensity of pain, the weather influencing the symptoms of rheumatic diseases (pain, well-being), though not the disease itself: no connections were found with objective parameters (e.g. inflammatory factors). The weather sensitiveness of rheumatics cannot be drawn back to a homogeneous meteorological process; the reactions are individually different. Most often, increase in pain frequency and intensity correlates with a change of weather in the form of an approaching low-pressure area combined with temperature decrease and increasing relative humidity (fig. 3). Additionally, the releasing, resp. intensifying effect of coldness, particularly humid cold and lack of sun, on pain can be proven.

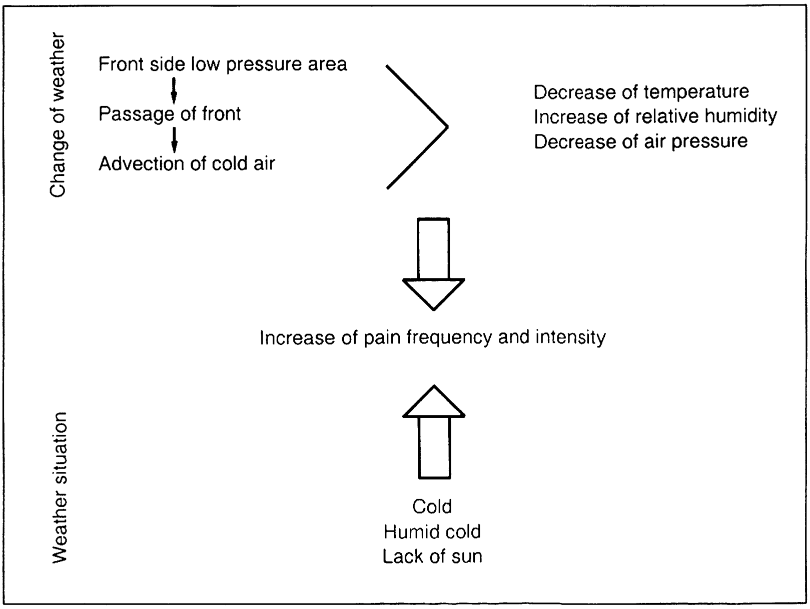

Fig. 3. Increase of pain frequency and intensity caused by change of weather, resp. certain weather states.

Climate Therapy with Rheumatic Diseases

The climate therapy of rheumatic diseases has to express as major goal the prophylaxis against weather sensitiveness. By goal-oriented endurance training, with cold adaptation at the same time – within the scope of a terrain cure under cool conditions – weather sensitiveness can be significantly reduced [Schuh, 1989]. Base has to be a cautious acclimatization to temperature influences and variations, which is achieved by exposition to outdoor conditions, and slight hardening against cold stimuli.

The reduction of weather sensitiveness by acclimatization to climatic stimuli is also an aspect of the thalassotherapy. In his literature review, Jordan [1978] describes the contemporary state of knowledge concerning thalassotherapy of chronic polyarthritis and concludes that climate therapy on cool ocean coasts can be considered as prophylactic and therapeutic 'hardening measure' in the sense of a 'cold desensitization', although there are not enough secured facts.

In climate therapy in middle and high mountain regions, besides the treatment of skin diseases, the treatment of rheumatic diseases is in the foreground: to treat diseases of the inflammatory-rheumatic form even in 1934 a clinic for rheumatics in Davos existed [Neergard, 1934]. Some of the earlier authors [Amelung and Evers, 1962; Böni, 1959] write about positive results treating PCP; experimental studies do until today hardly exist. An exception is Fellmann's study [1972], in which, in a study with 30 patients suffering from PCP and morbus Bechterew, he could prove a subjective success of the climate cure: the cure's success was rated higher by the patients than what could be objectively found. The comparison of the objectively measurable results with other, with these diseases not so usual forms of climate therapy, leads to the conclusion that the climate cure can positively influence the course of disease of chronic-inflammatory rheumatic diseases and of the progressive-chronic polyarthritis, but still does not reach the success of the other therapeutical measures. Unfortunately, in the study it is not pointed out which elements the described climate cure consisted of.

The climate-therapeutical exposition method which seems, according to the nowadays state of knowledge and besides the hardening, to be the actual agent of climate therapy, is the heliotherapy. The body is exposed to the sun. With heliotherapy, adaptations in a variety of levels are to be achieved; one of the most known goals is an increase in vitamin D production. In his review paper, Peter [1990] summarizes the actual state of knowledge on therapeutic effects of ultraviolet, resp. heliotherapy treating locomotor and support system. According to Peter [1986, 1989], inflammatory activity and pain intensity of chronic polyarthritis is improved by whole-body ultraviolet radiation in the same way as by moor-baths; also Grigoriewa et al. [1987, quot. acc. to Peter, 1990] report a reduction of inflammatory process and improvement of joint function after increasingly dosed whole-body radiation. Peter lists in his paper also a number of recently published studies [e.g. Bühring, 1988 and Lemke et al., 1988, both quot. acc. to Peter, 1990], which confirm that heliotherapy for a variety of diseases of bone, like osteomalacia and osteoporosis, still has its justification. The mode of action of ultraviolet radiation on rheumatic diseases is still relatively unknown. According to Peter [1989], an unspecific stimulation of the immune regulation can be supposed: amongst others the fall of increased immune complex values and of immunoglobulin G to normal values and the increase of the at first decreased number of T lymphocytes is described. Although herewith first results are presented, there is still research and the securing of results to be done, concerning therapeutical

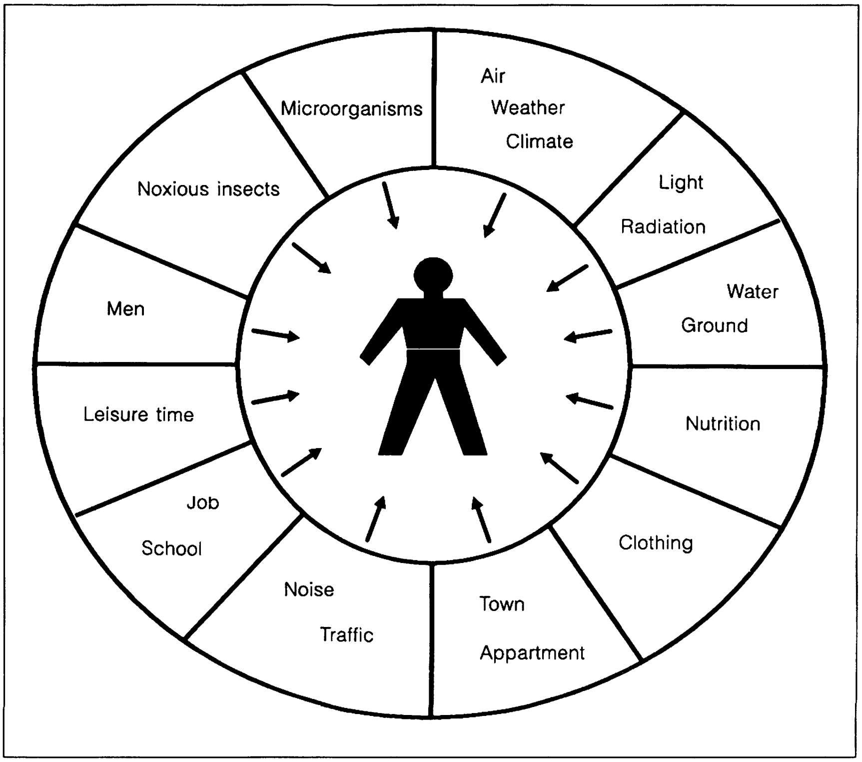

Fig. 4. Relevance of weather influences on rheumatic diseases.

success of heliotherapy and the physiological details it is based on, particularly in terms of arthritis.

In contrast to the variety of climate-therapeutical elements within a climate cure, in a therapeutical sense the long-term change into a different climate, according to today's state of knowledge, cannot be recommended: the knowledge so far still has to be worked upon.

Outlook

The influence of weather and climate on rheumatic diseases can, at least in terms of intensifying pain, be looked upon as secured; the deterioration of health state cannot be definitely correlated with certain meteorological parameters or weather conditions. It is obvious that weather-caused pain additionally stresses the course of disease of rheumatics. However, the relevance of weather influences on rheumatic diseases together with other possible reasons have to be integrated into a common system of references (fig. 4). In the complete course of rheumatic diseases weather-caused influences only form a small part besides many other influences.

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