The Effect of Simultaneous Variations of Humidity and Barometric Pressure on Arthritis

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Since the time of Hippocrates, medical writings have contained references to the effect of weather on human diseases, particularly arthritis and rheumatism. Most arthritic patients claim that they feel worse before weather changes. This sensitivity to climatic variations has defied scientific corroboration or explanation mainly because of a lack of facilities to control weather factors and observe arthritic patients under completely controlled, climatic conditions for significant periods of time. In 1948, Edström showed that arthritic patients were improved by continuous habitation in a climate chamber with constant warm temperature and moderate humidity. His experiments did not include any variations of climate factors, nor was there control of barometric pressure, air ionization, or rate of air flow [1].

In an effort to study objectively the effect of climatic variations on arthritis, a Controlled Climate Chamber was designed and constructed in the Hospital of the University of Pennsylvania to comfortably house two patients for observation periods of two to four weeks. Temperature, humidity, rate of air flow, barometric pressure, and air ionization are continuously controlled and recorded, and may be varied accurately by prescribed patterns without the knowledge of the patients. The construction of the Climatron and the description of the apparatus and method of experimentation have been previously reported [2, 3]. (See Fig. 1.) The general concept of the experimentation has also been set forth elsewhere [4].

The purpose of this report is to present the effects of simultaneous variation of humidity and barometric pressure on the severity of arthritic symptoms and signs. This combination of climatic variations was chosen for study because previous studies, using single variations of the climatic parameters, had been negative [3, 4], and because increasing humidity and falling barometric pressure almost invariably precede a storm—the time when the arthritics had reported they felt worst.

1. Method

Patients with obvious physical signs of arthritis were observed in the Climate Chamber in pairs for periods of at least two weeks each. Six of the eight rheumatoid arthritic patients and all four of the osteoarthritic patients were 'weather sensitive'—i.e., they claimed that climatic changes worsened their arthritic symptoms.

Four times daily, each patient noted on a diary sheet his body weight, intake and output of fluids, oral temperature, the time of onset, the location, severity, and duration of joint stiffness or pain, the number of analgesic tablets required for pain relief, and any changes in environmental conditions or his own well-being that he could detect. Twice each day, and sometimes oftener, clinical observations were made of the strength of hand grip, the time required for the patient to arise from a chair, walk across the Chamber and back to sit again, blood pressure, pulse, and general condition. Particularly important was a 'joint count,' for which each joint of the body was checked for tenderness, swelling, and/or pain on motion. Each day, all data were transposed from the diary sheets and examiner's notes to a continuous 'running data sheet' of the experiment, upon which climatic data were also charted throughout the weeks of each study period.

The condition of the arthritis in the patients was numerically computed by the method of Lansbury [5]. The numerical value of the 'Clinical Index' was derived from Lansbury's tables, using duration of stiffness, number of aspirins needed...
for pain relief, strength of hand grips, walking time, and the articular index (joint count) as the five parameters.

All five climatic factors (temperature, humidity, barometric pressure, rate of air flow, and air ionization) were kept completely constant for the first five to seven days of the experiment. During this time, each pair of patients became adjusted to life in the Climatron, both physically and mentally, and learned the technics of accurate weighing, measurement of intake and output of fluids, reading the oral thermometer, and recording these observations, their symptoms, and reactions on the diary sheets. They also became used to the periodic examinations and the methods employed.

In previous experiments, single climatic factors had been varied in random order, never in close succession, with return to 'standard' conditions between, on various days of the study period. A typical 'run' is charted on Fig. 2, in this instance showing random variations of four of the five climatic parameters (air flow change was omitted in this particular experiment). Changes were not made precipitously, but attempted to reduplicate changes as they could occur outside, singling out one at a time with all others kept constant. No significant effect on the clinical index, charted below, can be seen from any of the climatic variations. The gradually improving index during the three weeks stay was also typical and might be attributed to the prolonged rest with continued, regular treatment. In the original series of ten rheumatoid arthritic patients and four osteoarthritic patients, there were no consistent effects from variations of single climatic parameters, regardless of degree or speed of change [3].

In the present series, studying eight rheumatoid arthritic and four osteoarthritic patients, air flow was kept constant at 1000 cubic feet per minute, dry bulb temperature was kept constant at 76 F, and ionization was kept at 'background count' (positive ions 400 per ml, negative 300 per ml air) throughout the study period.

Humidity at 'standard' level was 30 per cent, and 'standard' barometric pressure was 30 inches of mercury absolute.

After the 5–7-day control period, and without the knowledge of the patient's, the pressure variation control clock was started, first increasing the pressure over a 2-hour period to 31.5 inches, then decreasing over a 4-hour period to 28.5 inches, then back to 30 inches. The cycle was programmed over a 12-hour period. A day or two later, a similar humidity change cycle, with rise...
of humidity from 30–80 per cent and down again over a 12-hour period, was carried out by the automatic programming device. Within the next day or two, the same changes in pressure and humidity were carried out simultaneously. This combined change was repeated at random intervals for the balance of the observation period. In some experiments, the programming clocks were stopped at certain points in the cycle to compare the effects of prolonged, stable high humidity and low barometric pressure with effects of continually changing conditions.

2. Results

In Fig. 3, the linear representations of barometric pressure and humidity changes are shown with the clinical index of the patient below. A white arrow shows the time of onset of the pressure variation cycle (falling), the black arrow the time of onset of humidity rise, and the white and black arrows mark the onset of simultaneous pressure drop with humidity rise. For simplicity, the arrows replace the linear representations in subsequent figures, since the pattern of variation was identical in all experiments.
Fig. 4. Course of rheumatoid arthritis in two patients subjected to humidity cycle (black arrow), barometric change (white arrow), and combined pressure and humidity cycles (black and white arrows).

Fig. 5. Course of arthritis in two other rheumatoid arthritic patients. Note increase of arthritis after humidity cycle alone in upper graph, further increase with successive combined changes. Lower graph shows complete insensitivity of other patient.
In plotting the clinical index, the onset of fluctuations corresponds with the start of subjective complaints, and the height of each peak or plateau is the actual value of the arthritic activity at the time of next examination.

In Fig. 3, the patient exhibits a fairly stable but gradually decreasing clinical index of arthritis, typical during the control period. No significant effect on the index is noted following the barometric pressure variation or humidity variation when each was carried out singly. An obvious and prompt rise in index is noted within four hours of onset of the combined pressure fall and humidity rise. Changes in clinical index were regarded as significant only if the probability of coincidence, as compared with the control period mean value, was less than 1 per hundred by T-test analysis (P = < .01).

On Fig. 4 the clinical index of arthritic activity of two other patients is shown, with only the arrows above to show when the single and combined pressure and humidity changes occurred. One of these shows a peak of increased activity which developed the day of humidity rise alone, but the symptoms had begun prior to the time of onset of the change. Successive cycles of combined, pressure-humidity change are mostly followed by significant increases in arthritic activity.

In Fig. 5, humidity increase alone worsened arthritic activity in one subject, but combination cycles produced greater increase in arthritis. Increased arthritis after humidity change alone occurred in only three instances in the entire series of experiments, and only once did pressure change by itself appear to affect the status. The lower graph on Fig. 5 represents the course in the one patient who exhibited no weather sensitivity in the Climatron, although she had described worsening of her symptoms previously with weather changes. Her arthritis had been relatively inactive and stable for some time prior to admission, but no explanation of this phenomenon is yet available.

Table 1 summarizes the results of experiments with eight patients with rheumatoid arthritis. In seven of the eight there was significant worsening of arthritis within a few hours after onset of humidity rise with barometric fall in 29 of 40 exposures to the combined cycle. The apparent incidence of 73 per cent positive reactions is sharply reduced, however, by inclusion of the patient who was entirely insensitive on six exposures, so the total incidence of response to these weather changes was 63 per cent.

Whereas three of the four patients with osteoarthritic arthritis experienced an apparently comparable worsening of arthritis following such combined changes in humidity and pressure in a majority of exposures, the significance was in doubt as the criteria for clinical index in this condition have not yet been sufficiently tested. Peculiarly, one of these (see Fig. 6) was worsened arthritically following single changes of pressure and humidity, then was unresponsive to two combined changes.

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<th>Table 1. Effect of increasing humidity with falling barometric pressure on the severity of rheumatoid arthritis.</th>
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following which three additional combined cycles produced not only increased arthritis, but also attacks of asthma. Her only previous asthmatic attacks had occurred in summer. The fact that these attacks developed in the Climatron in February, with no possibility of pollen or other airborne allergens entering the air of the Chamber through the absolute filters, has encouraged a study of weather effects on asthma by colleagues who will report results elsewhere when completed.

3. Discussion and conclusions

The frequent occurrence of worsening of the status of the arthritis—subjectively even within a few minutes of onset of the rising humidity with falling pressure and objectively within a few hours—has appeared significant. Worthy of note also was the fairly rapid subsidence of symptoms and signs when stable climatic conditions were resumed. Successive occurrence of the stormy conditions seemed to have a cumulative detrimental effect on the patients. In three experiments, not illustrated on the charts, the cycle was stopped at the point of lowest barometer and highest humidity and kept constant for 24 hours at this level. In each instance, the patients actually showed improvement during the stable period in spite of the continued high humidity and low barometric pressure.

The clinical index of Lansbury has proved valuable for quantitation of arthritic activity. The values have been reproducible, and the parameters sensitive enough to register changes in the short intervals between evaluations in these studies. When checked by the patients' own evaluation of their condition, and the opinion of the expert examiner, the index appeared to be an accurate quantification.

It would be premature to conclude from these findings that barometric and humidity variations together are the only climatic parameters responsible for increased arthritic activity. Other combinations of climatic variables may also have such a detrimental effect. These results still cannot explain why such patients often feel worse even before the barometer starts to drop prior to a storm, or sooner than obvious rise in humidity occurs.

From these results, it would appear that at least one combination of changing weather factors—rising humidity with falling barometric pressure—fairly consistently exerts a detrimental effect on arthritic symptoms and signs. It would also appear that the changing conditions, rather than the high humidity or low barometric pressure, are responsible. It now seems reasonable to conclude that weather effect on arthritis is a definite phenomenon, and not just another old wives' tale. It is not implied that climatic changes have any direct bearing on the cause of arthritis, nor is it believed that a constant climate would have any fundamentally curative effect.

The results to this point are preliminary and have only yielded a method for inducing changes in intensity of the arthritis by climatic means. Further studies are in progress to test the hypothesis that scar tissue, an end result of either inflammation or injury, is inadequate to adjust promptly to external environmental variations. The lack of homeostasis in such tissue might give rise to pain in scarred areas under conditions of environmental change, whereas the normal body tissues would adjust promptly. Additional research into the behavior of inflamed tissues under climatic stress is necessary.

REFERENCES