a cerebrovascular accident, but that the percentage of clinical cases really dependent on this atmospheric factor probably does not exceed ten percent of the cases. Far from being the only triggering effect, rapid fluctuations of the atmospheric situation have a marginal effect and are only an additional factor of risk in certain cases. It must be said that the physiopathological interpretation still remains to be done in the future. It will be facilitated by a better definition of clinical criteria and by the availability of computed medical files with a precise spatio-temporal definition.

A better knowledge of the circumstances of the onset of the crisis (was the patient indoors, outdoors or leaving a building?) would seem to be a useful element in future studies along with the introduction of the statistical characteristics of the microclimate within buildings in an epidemiological study.

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Influence of atmospheric factors on the rheumatic diseases

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Key words. Rheumatoid arthritis; gout; systemic lupus erythematosus; climate; weather; meteorology.

Introduction

A vast quantity of literature exists on the influence of atmospheric factors on the rheumatic diseases. This does not, however, translate into great knowledge or a complete understanding of these effects. A review of the literature reveals many reasons for this. Unfortunately, most of the published reports are anecdotal, superficial case studies, or simply personal statements of opinion unsupported by facts. One review of this subject contained 9 spurious or erroneous references out of 43 cited. Some of these spurious references have appeared in identical form in later papers on the subject. An additional problem with some of the published studies was the use of very small sample sizes. The result is a limited number of studies that contribute to our understanding of the effects of atmospheric factors on the rheumatic diseases. Perhaps the most detailed, consistent, accurate, and prolific researcher on the demographics and geographical distribution of the rheumatic diseases was J.S. Lawrence. A major effort was made to illucidate the relationship between meteorological variables and the rheumatic diseases from these studies. Unfortunately, this significant body of work is of only limited value in delineating the effects of atmospheric factors on the rheumatic diseases. This is due to the nature of the effects, rather than any defect in Lawrence's otherwise excellent and informative work.

Tromp's massive review[67] of medical biometeorology in 1963 includes a very useful section on the rheumatic diseases. Although some citation errors are present, the 266 citations listed represent the best literature review up to that time and includes both English and non-English language papers.

This review will attempt to show three aspects of the influence of atmospheric factors on the rheumatic diseases. 1) historical development of the literature, 2) significant discoveries or ideas, and 3) the current state of knowledge and/or theory.

Rheumatic diseases

The rheumatic diseases are an aggregation of diseases and syndromes that are primarily grouped together as a

result of historical events and misunderstandings, rather than because of any major intrinsic similarities. Depending on the classification system used, there can be over 100 pathologies that comprise the rheumatic diseases[55]. This historical family of diseases includes such diverse groups as inflammatory (e.g., rheumatoid arthritis) and non-inflammatory diseases (e.g., osteoarthritis). There are a wide variety of forms caused by infections (e.g. bacterial, viral, fungal) and those with metabolic causes (e.g. gout). Some forms mainly involve joints (e.g. ankylosing spondylitis) and some are non-articular (e.g. fibromyalgia). There are even rheumatic diseases which can be drug induced (e.g. systemic lupus erythematosus) and those that can result from physical trauma (e.g. olecranon bursitis).

One of the major problems of reviewing the literature on the rheumatic diseases is the lack of consistency in the names given to the various types. For example, by the mid 1800's two standard medical textbooks listed only 3 types of rheumatism: 1) acute rheumatism, 2) chronic rheumatism, and 3) gout[11, 68]. By about 1858 a sub-group of acute rheumatism was differentiated and named 'rheumatoid arthritis'[5, 55]. For a period of time this condition was also known as 'rheumatic gout'. During the 1860's this same disease was sometimes referred to as 'osteoarthritis'. However, by the early 1900's 'osteoarthritis' was used to designate a more chronic, less inflammatory form of rheumatism and thereby differentiated from rheumatoid arthirits (which was occasionally referred to as 'proliferative arthritis' at this time). It is not always clear what disease was being investigated in reports from this period. To complicate matters further, some authors simply referred to the disease in question as unspecified 'arthritis' or 'rheumatism'. Great care must be taken, therefore, in the interpretation of this literature.

This problem has been greatly reduced in the more recent literature by the development of classification (diagnostic) criteria for several of the major forms of the rheumatic diseases[2]. Although these criteria are often less than perfect, (for example; a sensitivity for definite rheumatoid arthritis of 70% and specificity of 91%) they do represent a standardization of disease definition[46].

This review will examine the literature as it relates to three of the most common forms of the rheumatic diseases, 1) rheumatoid arthritis (RA), 2) gout, and 3) systemic lupus erythematosus (SLE). As a result of the historical development, it must begin, however, with a review of the published research on unspecified forms of arthritis.

1. Unspecified arthritis

One of the earliest reports which provided some statistical evidence of the possible effect of weather on arthritis symptoms was by J.T. Everett in 1879[23]. Prior to that, most of the evidence was anecdotal. Everett sought to correlate the occurrence of storms, changes in barometric pressure, rain, snow and clouds with pain in 50 people with various pathologies, 14 of which were cases of 'chronic rheumatism'. From 1935 storms, he reported a correlation with pain in the people with chronic rheumatism, with only 39 false or negative indications of a forthcoming storm. These impressive results must be interpreted very carefully, however, since he reported that 'many other patients had such negative symptoms as were useless in establishing results; they are here omitted'. The data was, therefore, skewed with arthritics that responded to the storms. These positive responders can be termed 'weather sensitive'. He concluded, in general, that: 1) pain is most intense in advance of a storm, 2) intensity of pain is related to the speed at which the storm moves, 3) pain subsides upon arrival of the storm, 4) humidity and, to a lesser extent, barometric pressure are related to the pain, and 5) temperature has very little influence on the pain.

In 1907, Greenwood and Thompson reported a study of the monthly variation of admissions to the London Hospital from 1873 to 1903 for acute rheumatism[26]. They sought to correlate this to the mean monthly rainfall, barometric pressure, ambient temperature, and relative humidity. An annual rhythm was detected with a nadir during March, April, and May (0.63 to 0.67 daily average number of admissions) and a peak in October and November (1.12 to 1.16 daily average number of admission). No significant correlation was found between the admissions and any of the meteorological factors. They concluded that hospital admissions were probably inappropriate for this type of a problem, especially without reference to a normal population for control. This was, perhaps, a very valuable observation to make for future research design.

The discomfort (pain) of 367 people hospitalized with arthritis was examined in relation to meteorological variables and reported by Rentschler et al. in 1929[51]. Although they specified that the sample was composed of 300 patients with non-specific infectious arthritis, 32 with gout, 19 with 'senescent type of arthritis', 10 with a 'static type', and 6 with a 'traumatic type', the data was reported for the entire group and not segregated by type of rheumatic disease. As the barometric pressure fell, 72% of the time their sample experienced an increase in pain, with relief as the pressure increased. The reverse was experienced 21% of the time. The correlation coefficient between pain (measured on an arbitrary scale of -10 to $+10$) and daily change in barometric pressure ($\pm$ mm Hg) was 0.267. When another illness was superimposed, Rentschler et al. reported a loss of correlation between pain and barometric pressure. When an association was investigated between pain and general weather conditions (i.e. clear and sunny, fair, cloudy, rain or snow) a correlation coefficient of 0.425 was found. Approximately 90% of the time, the presence of a storm was associated with an increase in pain. Therefore, they concluded that arthritic pain was associated with the approach and/or presence of storms. No conclusive association was found between humidity or temperature and arthritic pain.

2. Rheumatoid arthritis

Rheumatoid arthritis (RA) is an inflammatory disease of unknown etiology which primarily involves connective tissue. As an inflammatory disease, the four cardinal signs of inflammation are the basic signs and symptoms of RA: redness, swelling, heat, and pain. Since articular cartilage (type II collagen) is characteristically involved,

stiffness and functional abnormalities of the joints can be added to the cardinal signs and symptoms.

2.1 Seasonal fluctuations. Several studies have examined the status of RA during various seasons. In a study of 265 patients, 42% of the patients reported feeling worst in the winter and 34% felt best in the summer[44]. Almost half of the patients (49%) did not consider the symptoms to vary with the seasons. In a similar survey of 236 patients, 18% felt worse in the winter and approximately 16% felt better[62]. In this sample 53% reported no seasonally related change in symptoms.

Seasonal fluctuations of RA onset have also been examined in several reports. Three of these reports provide evidence that there is a much greater 'incidence' of RA during the winter months (November to April) than the summer (May to October)[12, 25, 62]. Since the sample sizes are quite small, the results are of questionable reliability. A longer study of 467 subjects reported an onset of 59% during the winter months and 41% during the summer[18]. This is a smaller, but perhaps, more reliable difference. Lawrence has suggested that sub-clinical signs and symptoms, such as pain that may be present, becomes exacerbated as a result of a change in temperature and other weather conditions in the winter[43]. This exacerbation could then motivate the person to see a physician, by whom the case appears as an onset. This could account for an apparent increased onset in the winter. These studies provide useful and consistent data as to the effects of meteorological factors of RA if we assume that each season varies appropriately in weather and there are no other seasonal variables that are causative.

2.2 Weather. A questionnaire given to 112 RAs revealed that 83% thought that weather affected their symptoms[66]. A similar study on 369 patients reported that 61% indicated that weather affected their symptoms[44]. Of these 369 patients, 37% reported adverse effects associated with wet, showery, or damp and cold weather. Dry and warm conditions were considered favorable by 33% and hot sunshine was favored by 14%. A slightly different approach to this question was conducted on 286 RAs in relation to cold, moisture, and heat[62]. They found that while 46% of the patients believed cold did not effect their symptoms, 50% thought cold made them worse and 4% experienced a favorable effect. Moisture was considered detrimental by 57% and favorable by only 3% of the patients, but of no importance to 39%. When queried about heat, 40% expressed a lack of effect on their symptoms, while 52% thought heat had a beneficial effect and only 7% reported an adverse association. This suggests that approximately 50 to 60% of the RA population was weather sensitive. It might be noted, however, that the authors of this paper (Short, Bauer, and Reynolds) questioned how much these responses were influenced by what the patient may have thought was the correct answer. One of the problems with the literature reviewed up to this point is the total reliance on subjective opinion rather than objectively measurable variables of the disease activity.

2.3 Controlled environments. In 1948, Edstrom et al. reported the effect of a continuous hot, dry microclimate on 18 patients with RA[19]. The patients were housed in a climate controlled hospital ward with a constant ambient temperature of 32 °C and relative humidity of 35% for an average of approximately 100 days. Edstrom et al. reported (but did no document) a remission of periarticular and capsular swelling, reduced pain, and increased mobility. Of the 18 cases, 8 were considered clinically free of symptoms, 6 improved, 2 had a recurrence, and 2 deteriorated.

As a result of previous studies by themselves and others, Hollander and Yeostros exposed 8 RAs, 6 of which were known to be weather sensitive, to a variety of ambient temperatures, relative humidities, pressures, and ionizations in a controlled climate chamber[34]. Previous work by Hollander had shown that a variation of single factors, regardless of degree or speed, had no effect[30]. Simultaneous changes in multiple environmental factors were compared to changes in the Lansbury Index of clinical symptoms of RA. An increase in humidity combined with a drop in barometric pressure resulted in an increase in the Lansbury Index (i.e. worsened symptoms) in 73% of the tests on 7 RAs. The one weather insensitive patient did not respond. Two of the patients responded 100% of the time. Stable, unchanging humidity and pressure, even at the extremes of the test parameters, resulted in a reduction in symptoms. A previous study by others[38] produced equivocable results. This previous study, however, was limited to atmospheric pressure changes on only two rheumatoid arthritics.

2.4 Possible mechanisms of action. For the observed effects of meteorological variables on symptoms of RA to occur, the variables must change an underlying physiological activity. In an early, preliminary experiment, peripheral vascular response to alternations of heat and cold suggested that men with RA exhibited a different pattern than healthy men[69]. A slightly more complete study on 14 rheumatoid arthritics reported a 'high grade of basal vascular tone'[49]. That is, they claimed that on cooling, vasoconstriction was more rapid and extreme than in healthy individuals. No documentation of these results, however, was provided. The report suggested that the symptomatic benefit of a constant warm, dry climate might be the result of constant peripheral vasodilation. In their significant paper, Edstrom et al. measured several physiological variables in response to a constant warm, dry climate[19]. These conditions resulted in increased peripheral vasodilation and increased oxygen saturation of blood (from 51% to 82%). Prior to this climate control, these patients exhibited low peripheral skin temperatures, peripheral vasospasms, and low oxygen saturation of blood when compared to healthy individuals. One report has suggested that the vaso-responsiveness to temperature varies with season[35]. The increased vaso-reactivity they found in the winter was not, however, completely convincing.

A very interesting study was reported by Potter and Duthie in 1961[50]. They sought to correlate changes in capillary resistance to environmental temperature changes in 41 hospitalized patients with RA. Of the 41 cases, 34 exhibited a negative correlation while 7 showed a positive correlation. This was a statistically significant deviation from the predominately positive correlation of the non-arthritic controls. On average, a 1 °F decrease in temperature resulted in a 4 mmHg increase in capillary resistance. Treatment of 24 of the RAs with cortisone or prednis-

olone resulted in only 8 negative correlation and 16 positive correlations. The significance of this work becomes more obvious when two observations are juxtaposed; 1) RA is primarily a disease of connective tissue, and 2) capillary resistance is a measure of some characteristic of the connective tissue surrounding small cutaneous blood vessels.

In an examination of 18 RAs, Arab et al.[3] found that maximal digital blood flow was approximately equal between RAs and controls following 'full sympathetic release'. The RAs differed, however, during rest at 20 °C. They exhibited greater vascular tone or constriction and decreased vasodilation. This difference was more marked in women and with more advanced disease states.

In 1965, Tromp[69, 71] reported an 'inefficient thermo-regulation efficiency' (measured by a change in skin temperature) in response to an artificial cooling of the hand in 79% of a group of rheumatics comprised of 65 with 'arthritis', 17 with 'arthrosis', 12 with 'spondylosis', and 10 with 'myalgia'. A 'very poor efficiency' was found in 21% regardless of whether they were measured in the winter or summer. He concluded that this difference in skin temperature was mainly under the control of the hypothalamus and other centers in the brain.

A vascular hypothesis for the pathogenesis of RA has recently been suggested[1, 57].

Characteristically, the joint cartilage is involved in RA pathology. Approximately 47% of the cases will exhibit X-ray evidence of joint erosion at the time of initial diagnosis[48]. The effect of temperature on the synovial collagenase activity on human articular cartilage in vitro has been reported[29]. The enzymatic collagenolytic activity was at least four times greater at 36 °C than at 33 °C. Both temperatures were well within physiological/pathological boundaries. This observation provides several areas for possible application. In a series of experiments Hollander et al. showed that the normal (non-arthritic) joint intra-articular temperatures were about 30–33 °C while the arthritic joint with active synovitis was usually approximately 36 °C[31–33, 35]. A superficial view of this might lead to the inference that an increase in ambient temperature could result in an increase in intra-articular temperature, which would thereby increase synovial cartilage degradation and pain. However, the previously noted surveys[12, 25, 44, 62] revealed that most weather sensitive people felt better and had less pain in warm ambient temperatures. Hollander and Horvath have reported that heat application to joints initially increased the skin temperature, but reflexively reduced intra-articular temperatures[31, 35]. This observation was verified by others[7]. The application of cold packs conversely cooled the skin, but increased intra-articular temperatures[31, 35]. Since prolonged or deeper heating causes an increase in intra-articular joint temperatures, the beneficial, palliative effect has limits of both time and degree.

Very low ambient temperatures (−6 °F) or prolonged exposure at less extreme low temperatures can cause a decrease in intra-articular joint temperatures. In fact, the synovial fluid temperature decreases more than rectal or muscle temperatures. This drop in temperature has been associated with joint stiffness[36, 37]. In vitro studies demonstrate that the stiffness is, at least in part, the result of an increase in synovial fluid viscosity with a decrease in temperature[37]. They further showed that the degree of change in viscosity is a function of the mucin content of the synovial fluid.

Tromp has reported[68] that cold ambient temperatures reduced the excretion of hexosamine in 4 or 5 normal subjects. Tromp and Bouma reported in 1966[70] that the hexosamine excretion by 'rheumatics' was significantly less than that of 'normals' under the same meteorological conditions. They, therefore, concluded that some rheumatic pains (and I infer stiffness) was, at least in part, the result of cold temperature induced retention of mucin in the synovial fluids, thereby increasing viscosity. (A note must be added here that the study appears to assume that the hexosamine measured in the urine was totally, or at least primarily, derived from synovial fluid mucin. Secondly, 100 unspecified 'rheumatics' appear to have been compared to a normal, control group of only 4 or 5 individuals for which virtually no demographics were provided.)

2.5 Iatrogenic sensitivity to light. No evidence could be found in the literature for photosensitivity in the RA. However, several studies have been published which indicate that some of the non-steroidal anti-inflammatory drugs (NSAIDs) can induce photosensitivity in people with rheumatoid arthritis[10, 14, 15]. It is not, at present clear as to the precise nature of this phototoxicity.[10, 14, 15, 27]. Benoxaprofen, naproxen, piroxicam, and tiaprofenic acid appear to be especially potent at inducing this photosensitivity to ultra-violet light (320 nm). The signs and symptoms observed include erythemia and urticarial weals. Since the NSAIDs are the primary class of drugs used to treat the inflammation of RA, this could be a significant complication of treatment.

2.6 Symptom versus process. Most of the research to date has involved the effects of weather on signs and symptoms of rheumatoid arthritis. These were mainly the subjective signs and symptoms of the inflammatory process. More objective measures of the inflammatory activity are the erythrocyte sedimentation rate (ESR) and the plasma concentration of C-reactive protein (CRP). They represent different physiological mechanisms that are thought to reflect the inflammation in RA. As a result, a high degree of variability has been reported in their correlation with each other and other signs and symptoms of RA. Using these objective laboratory measures as indicators of the underlying inflammatory process, Latman reported that there was no seasonal variation in inflammation in approximately 2800 RAs[40]. The conclusion was that 'seasons and climate may effect some of the symptoms of RA, but not the inflammatory disease process in RA as represented by the ESR and CRP'. It is, therefore, thought that atmospheric factors may effect the comfort of a person with RA, but not progression of the disease. This is supported, in general, by the worldwide distribution of RA and severity unrelated to latitude.

3. Gout

Gout is a rheumatic disease of metabolic abnormalities involving an increase in uric acid production and/or reduced uric acid excretion[75]. Its manifestations generally

involve an interaction of many factors including gender, diet, age, heredity, and environment. The proximate cause of gout is the increase in plasma urate concentration (hyperuricemia). The risk of asymptomatic hyperuricemia developing into acute gouty arthritis with the associated signs and symptoms increases in direct relation to the plasma urate concentration[75,76]. For example, in one study of 2283 men, about 16.7% that exhibited a serum uric acid concentration between 7.0 and 7.9 mg/dl developed gouty arthritis, while 25% of the men with a concentration between 8.0 and 8.9 developed the arthritis. In the same study, 90% of the men with a serum uric acid concentration above 9.0 mg/dl developed gouty arthritis. There is, therefore, a strong positive correlation between serum uric acid concentration and the risk of developing acute gouty arthritis. As the plasma becomes saturated or supersaturated, various factors can cause the formation of micro-crystals in the synovials fluids and membranes. These evoke an acute periodic inflammatory response which produces some of the signs and symptoms of acute gouty arthritis[47,53,54].

3.1 Temperature. Loeb has published an interesting study on the effect of temperature on the solubility of urate in plasma[45]. He found that the solubility of urate was 6.8 mg/100 ml at 37 °C but decreases to 6.0 at 35 °C and to 4.5 at 30 °C. This data provides two possible mechanisms for the periodic exacerbations of acute gouty arthritis symptoms; 1) cold weather could reduce the urate solubility sufficiently to result in micro-crystal precipitation which would trigger an inflammatory response, and/or 2) cold weather could transform a urate saturated plasma into a supersaturated solution, which, upon stimulation by a gout attack provoking simuli, such as physical trauma to the joint, would result in local micro-crystal precipitation and inflammation. In addition, this could provide a mechanism which explains why periodic acute gouty arthritis attacks often appear self-limiting. The inflammation resulting from micro-crystal precipitation increases the local temperature which could increase the solubility of the urate and reduce or limit the precipitation.

An epidemiological study of 85 people with gout provided some, limited support for this interaction[61]. This study reported that of 226 attacks of gouty symptoms, 23 were attributed to cold, damp weather.

The actual importance of the relationship between urate solubility and temperature, may be of more fundamental importance than merely as another cause of gouty attacks. It may represent a major underlying, predisposing factor which explains some of the observed variation in attacks. For example, in one study of over 5000 people, 0.3% of the people with a plasma urate concentration of less than 6.0 mg/100 ml developed gout and only 82% of the people with values in excess of 9 mg/100 ml developed gout[28]. Only 15 to 20% of the people with hyperuricemia will eventually develop acute gouty arthritis[75]. It is logical to conclude, therefore, that there are factors other than hyperuricemia which may precipitate gouty arthritis or predispose someone to an attack. In some people, one of these additional factors may be a change in temperature. While a drop in environmental temperatures, therefore, may not necessarily precipitate an attack of acute gouty arthritis, it may sensitize the person with hyperuricemia to other precipitating causes.

Onset of an attack often occurs in the early morning hours at which time the circadian temperature rhythm of the body is at its nadir[60]. For example, an individual with hyperuricemia that smites his big toe may not develop gouty arthritis unless a cool temperature predisposed micro-crystal precipitation.

4. Systemic lupus erythematosus

Systemic lupus erythematosus (SLE), an inflammatory disease of unknown etiology which effects multiple tissues, organs, and organ systems, is considered one of the rheumatic diseases by the American Rheumatism Association, Arthritis Foundation, and National Institutes of Health. The disease can further be characterized as a connective tissue disease with the production of variable auto-antibodies[58,59]. The pathogenesis is closely associated with antigen-antibody deposition and antibody induced damage to tissues. In this disease, anti-nuclear antibodies develop against components of cell nuclei, including DNA, RNA, histones, and soluble non-nucleic acid molecules[52]. These anti-nuclear antibodies (ANA) attack the nucleus of damaged cells. One of the important factors in this mechanism is the apparent inability of the ANA to attack normal, healthy cells. The etiology and pathogenesis of SLE appears to be the result of three major influences: 1) a genetic predisposition, 2) factors which damage healthy cells, and 3) immunologic responses to the damaged cells[42,64,67].

4.1 Light. Systemic lupus erythematosus was named in 1851 by Alphie Cazenave, at which time he associated it with some direct action of the atmosphere[9]. This was followed for almost 100 years by anecdotal reports relating onset and exacerbation with exposure to sunlight[13]. A survey of 400 SLE patients revealed that approximately 70% said they experienced an exacerbation after exposure to the sun[11].

In 1927, Feit argued the case for light (ultraviolet radiation) as an 'exciting cause of LE'[24]. Following a similar argument, Brain, in 1933, reported a case of sunburn damage evolving into LE[6]. Under experimental conditions, Cahn et al. exposed portions of skin of 17 people (4 with SLE) to various light sources. They reported the induction of lupus-like lesions with prolonged exposure to ultraviolet radiation[8]. This supported previous observations of 6 cases in 1939 by Rose and Pillsbury[56].

The most significant study was that of Epstein et al. in 1965[21]. They exposed 21 patients with SLE and 4 with discoid lupus erythematosus (DLE) to various phototests. Six of the SLE and 3 of the DLE patients were known to be photosensitive (i.e. exposure to sunlight aggravated their condition). Four of the photosensitive SLE and 1 of the photosensitive DLE patients responded to ultraviolet radiation (i.e. less than 320 nm wavelength). None of the patients responded to higher wavelengths of light. None of the patients that lacked a history of photosensitivity responded to any wavelength. This study helped establish that, 1) light is not essential for SLE origin or pathogenesis, 2) not all SLE patients are photo-

responders, and 3) only wavelengths of less than 320 nm illicit a response in photosensitive people. In a review of the literature, Baer and Harber concluded that exacerbation of SLE by ultraviolet radiation does occur in a percentage of cases[4]. They speculated as to the pathophysiological mechanisms for the exacerbation.

At the time of diagnosis approximately 36% of SLE cases exhibit a history of exposure to the sun prior to onset[64], though a range of 27 to 58% has been reported[17]. Reports of photosensitivity once the disease occurs has varied from 17 to 50% of the cases[22, 58].

4.2 Possible mechanisms of action. In 1953, Kestin and Slatkin suggested that the effect of ultraviolet light in SLE was an example of a Koebner phenomenon[39]. Tan provided evidence in 1968 that ultraviolet irradiation of DNA in vitro resulted in denaturation. This denatured DNA was capable of illiciting production of anti-DNA antibodies[63].

In a critical experiment in 1969, Tan and Stoughton demonstrated that ultraviolet radiation could induce alteration of DNA in the skin of 3 healthy people[65]. Therefore, it was very possible for the ultraviolet wavelengths in sunshine to damage DNA which could then evoke auto-antinuclear (DNA) antibodies.

More recently, Emerit and Michelson have provided evidence of another possible mechanism for the involvement of sunlight in SLE. They found that lymphocytes from SLE patients are photosensitive in the 360 to 380 nm range and release a chromosome-damaging agent into the plasma[20]. This 'clastogenic factor' was shown to induce photosensitivity in lymphocytes from healthy, non-SLE individuals. Not only was the clastogenic factor photosensitizing, but it was also photoactivated. Since super-oxide dismutase (SOD) inhibited the chromosome damage, the super-oxide radical was suggested as the mechanism by which the 360–380 nm radiation induced chromosome damage. That is, they suggested that irradiation activated the clastogenic factor which resulted in an increase in the chromosome-damaging super-oxide radical.

The involvement of light in the onset and exacerbation of SLE is probably the most researched and best accepted of all the associations between meteorological factors and the rheumatic diseases. Several reviews have been written which highlight various aspects of this relationship[16, 64, 67].

Summary and conclusion

There appears to be ample evidence to conclude that various meteorological factors do exert a significant impact on some people with various rheumatic diseases. The data is, however, crude relative to our general understanding.

Most of this research on RA has dealt with the primary signs and symptoms of inflammation. We know, however, many of the chemical mediators of inflammation. It seems like a logical progression of research to determine the effects of the meteorological/atmospheric factors of concern on these specific intrinsic mediators of inflammation.

In general, gout can be very well controlled through medication. The evidence suggests, however, that we may gain a much better understanding of how atmospheric factors such as temperature can effect the body through changes in its physico-chemical processes by using Gout as a model.

The work with SLE has already yielded useful applications. Sun screening pharmaceuticals have been quite successful in reducing exacerbations of symptoms. But we don't know why only some people are photosensitive.

The previous research on the effects of atmospheric factors on the rheumatic diseases has illustrated key issues in methodology: A) large sample sizes are critical, B) objective and quantifiable disease variables are important, C) the variables measured must be specific to the questions investigated, D) the diseases investigated must be as specifically and accurately defined as possible, and E) the various aspects of 'weather' to be investigated must be specifically defined and quantified.

It is apparent that there is much more important and useful work to be performed before we can understand the effects of atmospheric factors on the rheumatic diseases.

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