64 Pasamanick, B., Dinitz, S., and Knobloch, H., Socioeconomic and seasonal variations in birth rates. Milbank Meml Fund. q. Bull. *38* (1960) 248–254.
54 Prasad, B.G., Srivastava, R.N., Bhushau, V., and Jain, V.C., A study of the seasonal variation of birth at maternity hospitals of some medical colleges in India. Ind. J. med. Res. *57* (1969) 718–729.
66 Richter, J., Miura, T., Nakamura, I., and Nonaka, K., Twinning rates and seasonal changes in Görlitz, Germany, from 1611 to 1860. Acta Genet. med. Gemell. *33* (1984) 121–124.
67 Russell, W.T., Statistical study of the sex ratio at birth. J. Hyg. *36* (1936) 381–401.
68 Sandahl, B., Seasonal birth pattern in Sweden in relation to birth order and maternal age. Acta obstet. gynec. scand. *57* (1978) 393–396.
69 Scaglion, R., Seasonal births in a western Abelam village, Papua New Guinea. Hum. Biol. *50* (1978) 313–323.
70 Shimura, M., Richter, J., and Miura, T., Geographical and secular changes in the seasonal distribution of births. Soc. Sci. Med. *15D* (1981) 103–109.
71 Slatis, H.M., Seasonal variation in the American live birth sex ratio. Am. J. hum. Genet. *5* (1953) 21–33.
72 Stephan, P., Geburtlichkeit und Kindersterblichkeit in einem Dorf im 17. und 18. Jahrhundert. Ärztl. Jugendkd. *75* (1984) 178–189.
73 Stoeckel, J., and Choudhury, A.K.M., Seasonal variation in birth in rural East Pakistan. J. biosoc. Sci. *4* (1972) 107–116.
74 Sugiura, K., Upon the sex of newly born in Japan. J. Kinki Gynec. Soc. *11* (1928) 1189–1217.
75 Takahashi, E., Notes on Japanese birth statistics. Hum. Biol. *24* (1952) 44–52.
76 Takahashi, E., Seasonal variation of conception and suicide. Tohoku J. expl Med. *84* (1964) 215–227.
77 Takahashi, E., Geographic distribution and seasonal variation of sex ratio at birth in India. Minzoku Eisei *38* (1972) 210–222.
78 Takahashi, E., Ecologic Human Biology in Japan. Medical Information Service, Tokyo 1978.
79 Tietze, K., Geburtshilfliche und biologische Notizen aus alten Kirchenbüchern. Geburtsh. Frauenheilk. *3* (1940) 323–327.
80 Timonen, S., Lokki, O., Wichmann, K., and Vara, P., Seasonal changes in obstetrical phenomena. Acta obstet. gynec. scand. *44* (1966) 507–533.
81 Timonen, S., and Carpen, E., Multiple pregnancies and photoperiodicity. Annls Chir. Gynaec. Fenn. *57* (1968) 135–138.
82 Udry, J.R., and Morris, N.M., Seasonality of coitus and seasonality of birth. Demography *4* (1967) 673–679.
83 Warren, C.W., and Tyler, C.W., Social status and season of birth: A study of a metropolitan area in the southeastern United States. Soc. Biol. *26* (1979) 275–288.
84 Zahalkova, M., Multiple births in southern Moravia. Acta Genet. med. Gemell. suppl. *22* (1974) 210–213.
85 Zelnik, M., Socioeconomic and seasonal variations in birth. Milbank Meml Fund. q. Bull. *47* (1969) 159–165.

0014-4754/87/010048-07$1.50 + 0.20/0

Response to meteorological stress as a function of age

by H. Jungmann

Universitäts-Krankenhaus Eppendorf, Universität Hamburg, Martinistr. 52, D-2000 Hamburg 20 (Federal Republic of Germany)

Key words. Age; thermoregulation; weather; climate; altitude.

1. Introduction

The process of aging in humans has two aspects: 1) with increasing age the traces of illnesses, accidents and injuries increase. All such traces can, in a way, be considered as scars. 2) Absence of illness or injuries cannot stop the process of senescence which starts in the third decade of life. With advancing years many changes in the body occur: decrease of endurance, of muscular power, of pulse frequency – at rest and especially under stress – and of the metabolic rate; an increase of the systolic blood pressure and of the occurrence of degenerative rheumatic diseases, etc. Physical training may delay the aging process but cannot stop it.

It is evident that these physiological changes in the aging process must affect the reaction of the organism to the physical environment and thus to meteorological influences. However, significant research on the impact of the environment on the senescent organism is scarce.

The results of the studies reviewed below are largely based on laboratory tests and less on observations of direct meteorological effects. Nevertheless, they may be of use for future research on the effects of weather and climate on the aging organism.

2. Influence of weather on old people

According to Faust[8], who carried out a study in Basel (Switzerland), 20% of young people less than 20 years old considered themselves weather-sensitive; in the age group of 20–60, 30%; and in the age group above 60 it was 40%. Females are more sensitive to weather changes than males, especially during the climacterium.

Weather-sensitivity obviously increases with age. These subjective reports are in line with the studies of Daubert and Schubert[4], on mortality in the University Medical Centre of Tübingen and in Baden-Württemberg from 1953–1956. They found for the age group over 60 a maximum mortality during active warm fronts accompanying atmospheric low pressure, and a minimum with atmospheric high pressure.

The seasonality in mortality with a maximum from January to March and a minimum in September was confirmed in this study, although it was only pronounced in old subjects, not in the young. At a daily level a difference was found as well: old people often died between 05.00 and 07.00 h whereas the times at which younger subjects died were rather evenly spread over the day. As the weather itself is not pathogenic, a possible explana-

tion could be that existing complaints are aggravated, which can result in critical conditions (myocardial infarctions for example, in cases of coronary insufficiency). In periods of recuperation after illness old subjects are more weather-sensitive than younger ones. Scar pains during changing weather conditions are well-known.
Polypathia (multimorbidity) plays a role as well[9,10]. Schubert found that 5% of the age group over 70 suffered from two different disorders, 20% from three, and 75% from four different disorders or more. A detrimental effect of weather conditions could therefore have a greater impact on old people. Their wish to stay in climates with very few passing depressions and long lasting high pressure periods is understandable.
Whether a stay in a favorable climate prolongs life is difficult to prove, because factors of genetic, social and cultural character interfere. The studies of Leaf[2] are interesting in this respect; the tribes he studied are distinguished by a high life expectancy and an unusual number of 100-year-old tribesmen, despite the fact that they live in remote, high altitude regions (Caucasus, Kashmir, the Andes in Equador). The climatic conditions in those areas are harsh, though probably more equable than in the plains of middle and northern Europe.

3. *Cold resistance in old people*

Is is well-known that old people are less cold-resistant then young people; they sense the cold quicker. Extensive research has demonstrated that the physical thermoregulation effected by the blood circulation diminishes or partly stops with progressing age. Peripheral vasoconstriction as a protection against heat loss is considerably restricted. This could explain the average high skin-temperatures of the feet after cold exposure compared with young subjects. The blood flow in the skin is higher in old subjects and after a cold foot-bath the warming up of their skin is quicker[23]. Consequently, the common complaint of old people of having cold feet could be less the result of the absolute skin temperature than of an increase of the sensitivity of thermoreceptors due to senescence, provided that no organic circulatory disorder exists.
The increase in muscular tone of the main arteries is considerably less than in young healthy people; we found a 6% rise in pulse wave velocity measured in the femoral arteries after intensive cold exposure in old subjects, compared with a 15% rise in the young[23].
In cold pressure tests a group of people over 60 reacted with a small increase of the diastolic blood pressure; in the young group it was twice as high, reflecting a stronger peripheral vasoconstriction; also, the increase in the systolic blood pressure and decrease of the skin temperature after a 2-min immersion of the hand in water at 5°C was less. The centralization of the amount of circulating blood during cold exposure is diminished or has partly stopped in old people.
Based on many studies an explanation could be that the deficient physical protection against heat loss in old people is compensated, at least partly, by an activation of the chemical heat production. Shivering as an indication of a stronger muscular heat production begins at an earlier stage, and with higher body temperatures, in old subjects than in young; in a cold environment they tend to tachycardia, young subjects to bradycardia.
Anaerobic metabolism is probably involved in the onset of the cold-induced increase in heat production, because in old subjects a stronger increase was found in the lactic acid level of the blood[22] whereas the oxygen intake was at a lower level than in young subjects.

4. *Heat resistance in old people*

In a warm environment the organism regulates its heat production by vasodilatation in the skin and extremities. The heat loss is effected by contact and convection, radiation and evaporation, whereby evaporation of sweat is the most effective. Lind et al.[26] were able to demonstrate that in the aging organism the onset of sweating is retarded and the quantity is reduced; the aging organism is not able to increase the peripheral blood flow. As a result, a significantly sharper rise in skin temperature is found in a dry-heat environment, compared with young subjects[28]. Comparing skin temperatures and peripheral blood flow it was found that the peripheral blood flow in hands and feet after heat exposure was only 35% in the age group 50–71; for 20–30-year-olds it was 80% in the foot and as high as 200% in the hand[23].
The pulse-rate of elderly people (average 52 years old) after 12 min in the sauna (90°C) increased on the average to 94/min, in students it was 105/min. With a similar heat stress of +0.8°C rectal temperature, the values for children of 1–6 years of age was 110/min; for babies 150/min[1]. The diastolic blood pressure in old subjects decreases less than in young subjects during heat exposure, which could be explained by diminished vasodilatation[11]. The protective mechanisms of the organism against heat stress are generally reduced in their functioning[15]. The body temperature during heat stress rises at an earlier stage and to a higher level in old subjects, compared with the younger ones. This means that old people doing physical work in a tropical climate have a higher chance of heat stroke because of a less adaptive blood circulation. A positive feature of this deteriorating circulation with insufficient vasodilatation is the reduced chance of orthostatic collapse[29].

5. *High altitude and old age*

The existence of cable cars makes traveling to high altitudes (to 4000 m in the Alps) possible nowadays also for old people. Experience shows that altitudes of 2000–4000 m can be endured by the aged. According to mountain guards, collapse, for example on arrival, occurs far less in old than in young subjects (Inama, pers. comm.). Haus et al.[13] found in young people immediately after ascent a vagotonic deterioration in the circulation, with bradycardia and a decreased blood pressure, followed for several hours by a sympathicotonic induced circulatory reaction with tachycardia and an increase in cardiac output. The occurrence of collapse in young subjects may be explained by a overreaction of the first phase of these circulatory changes. In elderly persons this phase of vagotonic change was not found[22].
Ergometric tests at 400 m and 3000 m with healthy old subjects[20] showed that after 3 h at high altitude the pulse

frequency and systolic blood pressure under physical stress differed significantly from those found at 400 m. Changes which were similar, though tested at higher Watt levels, occurred in young, healthy subjects at a lower level of 1800 m.[12]

In the old subjects, on the other hand, a remarkable increase was found in heart rhythm disorders. During and after ergometric tests at 400 m, only in one of the fourteen old subjects were four ventricular ectopic beats registered, whereas after 3 h at 3000 m, 273 were measured in 5 subjects. Swiss scientists found in students at 3500 m a tendency to arrhythmia, though not to the same extent. This might be caused by the essential higher adrenalin and noradrenalin levels of the blood induced by hypoxia under physical stress[7].

Non-cardiogenic pulmonary edema is found almost exclusively in young people; Hultgren et al.[19], in a detailed study, found that of 41 cases, 15 were less than 10, the oldest was 40 years old, and the average age was 16. This might be explained by the findings of Bolt et al.[3] in 9 healthy subjects aged 61–82 years. In hypoxia tests, under conditions comparable with those at an altitude of 4000–5000 m, it was found that the pulmonary arterial pressure did not increase, but in general decreased from 27/12 to 20/9. One 82-year-old subject showed a decrease from 29.7/10.9 to 27.8/11.4 mmHg. It is generally assumed that the rise in pulmonary pressure is a reaction to hypoxia, resulting in a better circulation in the lungs. While this effect in old people is reduced or even absent, in young people it can cause a overreaction leading to pulmonary edema. The pulse frequency in old subjects increased during hypoxia only to an average 80/min, in young subjects to 90/min.[21] Dill et al.[6] found a decreased vital capacity soon after arrival at 3800 m in 30% of 80-year-old subjects; this effect had not been found in the same subjects sixteen years earlier.

On the basis of these studies it seems evident that old people react less to high altitude than young ones. The hypoxia-induced incidents in the latter could be explained by an overreacting organism, while in old people they could be the result of the provocation of a pathogenic condition, for instance heart rhythm disorder.

6. *Acclimatization*

Whether the aging organism has the same ability to adapt to unusual climatic conditions as the young one has not been sufficiently studied. On the other hand, despite the observed overreaction, young people can acclimatize ultimately.

Physical training improves the condition in old people also[16,17]. Dill et al.[6] found according to the maximum possible oxygen intake during their ergometric tests at 3800 m, that subjects up to the age of 71 show clear indications of hypoxia acclimatization after 4–6 weeks stay.

Robinson et al.[27] tested 4 subjects under heat stress on a tread-mill (40 °C, 25% RH). The average age was 30. The same subjects were tested 21 years later under the same circumstances. According to pulse-rate under physical stress, the rectal and skin temperatures and the acclimatization to heat were unchanged compared with 21 years earlier. Only the quantity of sweating was slightly reduced.

The results discussed here are not sufficient to establish the extent of adaptation of the aged organism to climatic stress. In our opinion, however, there is no doubt that this adaptation diminishes with advancing age.

1 Alder, S., Herz- und Kreislaufbelastung bei kurzen Überwärmungsbädern im Kindesalter. Z. Physiother. *30* (1978) 125–128.

2 Blumenthal, H. T., Das Altern. Klinik Journal, No. 11 (1982) 20–27.

3 Bolt, W., Valentin, H., and Tietz, N., Drucke in der Pulmonalarterie, Herzminutenvolumen und Atmung bei akuter respiratorischer Hypoxie entsprechend Höhen bis zu 4000 und 5000 Meter bei älteren Personen. Arch. Kreislaufforsch. *27* (1957) 19–33.

4 Daubert, K., and Schubert, R., Über die Ansprechbarkeit des alten Menschen auf atmosphärische Reizwirkungen. Medsche Welt *50* (1959) 2478–2483.

5 Dill, D. B., Robinson, S., Balke, B., and Newton, J. L., Work tolerance: Age and altitude. J. appl. Physiol. *19* (1964) 483–488.

6 Dill, D. B., Stanley, D., Hillyard, S. D., and Miller, J., Vital capacity exercise performance and blood gases at altitude as related to age. J. appl. Physiol. *48* (1980) 6–9.

7 Escourron, P., Johnson, D. G., and Rowell, L. B., Hypoxemia increases plasma catecholamine concentrations in exercising humans. J. appl. Physiol. *57* (1984) 1507–1511.

8 Faust, V., Biometeorologie. Hippokrates Verlag, Stuttgart 1977.

9 Francke, H., Polypathie und Multimorbidität bei Langlebigen und Hundertjährigen. Ärztl. Praxis *24* (1972) 1373–1375.

10 Francke, H., Bracharz, H., and Gall, L., Präklinische und klinische Besonderheiten im höchsten Lebensalter. Geriatrie *5* (1975) 59–64.

11 Gold, J., Pathologic effects of heat exposure, in: Medical Climatology. Ed. S. Licht. E. Licht Publ., Baltimore 1964.

12 Günther, M., Jungmann, H., and Klasen, B., Einfluss des akuten Höhenwechsels bis 3000 m auf Kreislauf- und Lungenfunktion in: Medizinische Aspekte der Höhe, pp. 103–109. Eds P. Deetjen and E. Humpeler. G. Thieme Verlag, Stuttgart 1981.

13 Haus, E., and Jungmann, H., Höhenreaktion des Kreislaufs bei Gesunden und Kranken in den Alpen. Schweiz. med. Wschr. *84* (1954) 1265–1270.

14 Hellon, R. F., and Lind, A. R., Observations on the activity of sweat glands with special reference to the influence of ageing. J. Physiol. *133* (1956) 132–144.

15 Hellon, R. F., Lind, A. R., and Weiner, J. S., The physiological reactions of men of two age groups to a hot environment. J. Physiol. *133* (1956) 118–131.

16 Hollmann, W., Venrath, H., and Valentin, H., Training und Altern. Münch. med. Wschr. *100* (1958) 1957–1961.

17 Hollmann, W., and Liesen, H., Altern und körperliches Training. Med. Klinik *80* (1985) 24–32.

18 Horvath, S. M., Radcliffe, G. B., Hutt, B. K., and Spurr, G. B., Metabolic responses of old people in a cold environment. J. appl. Physiol. *8* (1955) 145–148.

19 Hultgren, H. N., Spickard, W. B., Hellriegel, K., and Houston, C. S., High altitude pulmonary edema. Medicine, Baltimore *40* (1961) 289–313.

20 Inama, K., Jungmann, H., and Uexküll, M. v., Sind alte Menschen durch Bergbahnfahrten in grössere Höhen gefährdet? Med. Klinik *79* (1984) 356–360.

21 Jungmann, H., Das Klima in der Therapie. J.A. Barth Verlag, München 1962.

22 Jungmann, H., Human response to meteorological stress as a function of age, in: Progress in Biometeorology, pp. 285–294. Swets and Zeitlinger, Amsterdam 1974.

23 Jungmann, H., Kreislaufreaktionen des alten Menschen auf unterschiedliche Temperaturen. Geriatrie *7* (1977) 23–25.

24 Jungmann, H., Einführung in die naturgemässen Heilmethoden. Steinkopff Verlag, Darmstadt 1985.

25 LeBlanc, J., Coté, J., Culac, S., and Dulong-Durcot, F., Effect of age, sex and physical fitness on responses to local cooling. J. appl. Physiol. *44* (1978) 813–817.

26 Lind, A. R., Humphreys, P. W., Collins, K. J., Foster, K., and Sweetland, K. F., Influence of age and daily duration of exposure on responses of men to work in heat. J. appl. Physiol. *28* (1970) 50–56.

27 Robinson, S., Belding, H. S., Consolazio, F. C., Horvath, S. M., and Turrell, E. S., Acclimatization of older men to work in heat. J. appl. Physiol. *20* (1965) 583–586.
28 Shoenfeld, Y., Udassin, R., Shapiro, Y., Ohri, A., and Sohar, E., Age and sex difference in response to short exposure to extreme dry heat. J. appl. Physiol. *44* (1978) 1–4.
29 Szadkowski, D., and Guillery, K., Normverhalten und Altersabhängigkeit von Blutdruck und Pulsfrequenz. Ärzt. Praxis *22* (1970) 5203–5205.

0014-4754/87/010054-04$1.50 + 0.20/0

Mediterranean climate and geriatrics

by J. P. Besancenot

French National Center for Scientific Research (CNRS), Climatology Research Center, University of Dijon, F-21000 Dijon (France)

Key words. Climate; health; human bioclimatology; meteoropathology; geriatrics; Mediterranean area.

The fascination exerted by the regions around the Mediterranean on elderly people living in western and central Europe has given rise to two forms of residence: seasonal residence, continuing the tradition of winter holidays, and permanent residence, as more and more elderly people move to these areas for their retirement[12]. This second form is still restricted to the northern shores of the Mediterranean, but the holidays of senior citizens are now often directed to North Africa, particularly Tunisia. In both cases the motives are numerous, but almost always the pleasant weather conditions and the desire to evade the harsh winters of the North are decisive. In short, everyone expects that the climate near the Mediterranean assure pleasant conditions and good health.
But is reality not sometimes quite different from the expectations and the transfer therefore accompanied by bitter disillusionment? In other words: *is the Mediterranean climate really suitable for elderly people?* The answer to this question implies a discussion of the biological peculiarities of elderly people in relation to climatic conditions. Then, three questions must be asked: 1) has the Mediterranean climate a favorable effect on the physiological stability of aging organisms? 2) has it a beneficial influence in relation to the most common diseases of people over the age of sixty? 3) does it provide a delay, however short, of the end of life? Of course, this threefold analysis will not provide a simple answer. But it might help to produce a better realization of the strong diversity of the Mediterranean area, even if we limit ourselves to the southern parts of Europe and to northern Africa, excluding thereby the Near and Middle East, to which few elderly people migrate. Other areas with climates of the Mediterranean type are also excluded. These are California, which seems to have a similar attraction for retired people, Central Chile, Southwest Australia and the Cape region in South Africa.

1. Specific physical reactions of elderly people towards climate

Though it sometimes seems otherwise, no living organism remains the same with time; time changes all that lives. The question here is whether the changes accompanying old age affect the capability to adapt to a new climate or to the variability of a present one. Surprisingly, two entirely opposite viewpoints exist in answer to this question. The first one is proposed by Nicolas[25]. He sees old age as a period of reduced susceptibility to the exterior environment. The organism defends itself better and better, as the years go by, against attacks from the outside. This is because the biological processes have a typical rhythm for each age. In children the speed of these processes is high, as the body goes through a multitude of reactions and adaptations. But the opposite happens in old age; the body processes are slow and there are few evolutionary phenomena. Therefore the difficulties of adaptation are reduced; atmospheric changes do not interfere with internal evolutions, because they have largely different frequencies.
Moreover, it is well known that the human body reacts only to exterior influences if a certain threshold of excitability has been reached. These thresholds are at a low level in children, whose biological regulatory systems are easily disturbed, but their level increases with age. Therefore, according to Nicolas[25], a climatic stress which forces the body to readjust quickly will be severely felt by young children, but will have little effect on elderly people.
Unfortunately, research during the last 25 years on the forms and mechanisms of aging has taught us that these ideas are illusory[6, 11, 32]. It is true that the physiological speed of internal processes follows the described sequence, but at the same time the body deteriorates, almost imperceptibly, and it becomes more and more vulnerable. The combination of senescence, difficulties of existence and the development of degenerative diseases causes serious and irretrievable transformations which result in a stronger submission to the exterior environment[7]. The defence mechanisms of the old body become less and less vigorous and their reactions less predictable, and the organism therefore restores itself more slowly and with greater difficulty than when it was younger. Some authors feel that the best period to adapt to new climates, or to adjust to climatic stress, is between fifteen and thirty or forty years of age[14].
Under these conditions, the constitutional fragility of elderly people makes it desirable to submit them only to