

Factors associated with high risk of marginal hyperthermia in elderly patients living in an institution

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Summary

The elderly, the very young, and the sick are known to be adversely affected by high environmental temperatures. In a retrospective open case-note review of 872 patients in a large institution during a hot summer we identified characteristics in the elderly that increase the risk of marginal hyperthermia. Women were more likely to be affected than men (25.6% vs 16.9%). We found an age-related increase in marginal hyperthermia, 15.7% of those below 60 years developed a hyperthermia compared to 18.9% in those between 70–79 years (non-significant), 28.3% in those between 80–89 years ($p = 0.01$) and 50% in those above 90 years ($p < 0.01$). There was also a direct relationship between the incidence of hyperthermia and the ambient temperature (29% in the warmer wards, compared to 17.2% in cooler ones; $p < 0.01$) and with the level of dependence (42.3% of the bedridden group, $p < 0.01$, and 20.4% of the semi-dependent, $p < 0.01$, compared to 11.1% of the mobile group). These factors were more significant as predictors of risk than the diagnosis. Identifying high risk patients early and taking appropriate measures to avoid hyperthermia and dehydration is important to try to decrease mortality during heatwaves.

Keywords: hyperthermia, elderly, thermoregulation

Introduction

External temperature at both extremes increases mortality in elderly people.^{1–3} Heat liability in old age occurs because of changes in the intrinsic regulatory system or because of the presence of drugs that interfere with normal regulation. External factors such as a stressful climate can then become too much for an impaired thermoregulatory system to cope with.⁴ Elderly people do not acclimatize well to external temperatures.⁵ They are less responsive to changes in external temperature; their sweating threshold is higher and their rate of sweating is lower than that of young people. Coexisting heart and cerebrovascular disease impairs their ability to increase cardiac output

and decrease sympathetic vascular resistance during hot weather.⁵ The core temperature threshold for vasodilatation may increase with age.⁶ Drugs that affect the autonomic nervous system and interfere with vasodilatation and sweating also increase the risk of heat related illness. Mortality is high once an elderly person develops severe heat illness⁷ so it is important to try to identify risk factors to improve the detection of high-risk groups. Peaks in daily mortality in nursing homes lagged behind the corresponding peaks in maximum temperature by one day.⁶ Since mortality is highest at the beginning of heatwaves it is essential that quick action is taken to achieve a reduction in mortality.

Malta has a subtropical climate with hot and dry summers. We tried to identify predisposing factors by retrospectively studying 872 patients of various ages lodged in a large institution during a particularly hot summer in Malta.

Patients and methods

The institution studied served as a hospital, nursing home, residential home, and sheltered accommodation for its residents, housing people of varying degrees of disability, mostly (87%) being elderly (> 60 years) and institutionalised for various reasons, ranging from severe disabling disease such as strokes to normal healthy people admitted for social reasons.

We performed a retrospective open case-note review to identify those who were resident during the study period. We also examined the notes of the people who died during that time period. Of 872 patients identified 114 were less than 60 years and 758 were above. Average age was 73 years with a range from 30 to 98. The younger group had proportionately similar levels of physical disability to the elderly group. Evidence of marginal hyperthermia was defined as temperature of 38° Celsius (100° Fahrenheit) or more recorded orally, or if not possible axillary, on at least one occasion. For all the patients in the study we recorded age, sex, and ward location, subdividing them into top floor or isolated buildings considered warmer with no shade from direct sunlight, and ground floor, considered cooler since they were partly shaded from direct sunlight. We also looked at diagnoses and level of dependence. We defined bedridden as being unable to get

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out of bed unaided, semidependent as requiring help with at least one measure of activities of daily living, and mobile as able to walk alone even if they used walking aids.

Daily readings of the peak temperature in the shade and humidity were obtained for the study period and the average weekly value for both was derived.

For febrile patients we tried to identify a cause for the hyperthermia by looking at the clinical records and investigation results. There was no infectious disease epidemic at the time and, since the incidence of episodes of hyperthermia correlated with external temperature ($r = 0.64$; $p = 0.04$), for the purposes of this study we assumed that all the episodes of hyperthermia were directly or indirectly related to the heat stress and were included in the results.

Statistical methods

Correlation analysis was performed between external temperature, humidity, episodes of hyperthermia, male and female deaths. The associations between prevalence of hyperthermia, age, sex, diagnosis and state of dependence were examined using regression analysis. Patient groups were compared using the Yates' Chi-square test.

Results

There was a significant correlation between the external temperature and number of cases of hyperthermia ($r = 0.64$, $p = 0.04$). Humidity was negatively correlated to external temperature ($r = -0.75$, $p < 0.05$), but did not show any significant relationship to number of deaths or hyperthermia ($r = -0.55$, -0.38). Out of 268 febrile illnesses 67.6% were attributed to the higher external temperature, 19% to respiratory infections, 8.5% to urinary infections and 4.9% to other causes, including infected bed sores, gastroenteritis, and typhus fever. The difference between men and women was not significant when allowing for disability and specific illness but regression analysis showed that women were affected more than men ($p < 0.05$) when allowing for age, a fact reflected in mortality figures, though the difference was not significant ($p > 0.05$) (table 1). We found that there was a progressively increased susceptibility to febrile illness as one

grew older (table 2), reaching significance ($p < 0.01$) in those above 80 years. The increase in susceptibility in the 90–99 age group was significantly more than the 80–89 group ($p < 0.05$). Bedridden patients were the most susceptible to marginal hyperthermia compared to both semidependent ($p < 0.01$) and mobile groups ($p < 0.01$) (table 3). Patients who had the same underlying diagnosis had significantly more febrile illness if bedridden rather than if mobile. This pattern was observed in conditions that specifically affect temperature regulation and other conditions that may have an indirect role to play. Hence state of mobility seemed to be a more important predictor than the diagnosis itself (table 5). Patients resident in warm wards were also more likely to be affected by marginal hyperthermia ($p > 0.01$) (table 4).

Discussion

'Heat waves' have no precise meteorological definition and are usually determined by what is regarded as local temperature conditions.⁶ We studied a Maltese summer with exceptionally high peak daily shade temperatures: 6–12°C higher than average for the time of year. Since this study was retrospective, we had no control group and we could only look at one manifestation of heat-related illness, hyperthermia. Data on the state of hydration such as urine and plasma osmolarity were only available in a few patients. The high body temperature could have been due to reasons other than the high environmental temperatures; however, since there was a close relationship between the incidence of hyperthermia and external temperature, and there were no infectious disease epidemics on reviewing microbiological culture and serological results, and high environmental temperatures are known to predispose to respiratory infection,¹ the commonest recorded cause for the cases of hyperthermia noted, it was assumed that virtually all pyrexias recorded were directly or indirectly related to, or affected by, the external temperature, and all were included in the study.

There was an increased incidence of marginal hyperthermia in the female group. This finding, together with our mortality figures is compatible with the findings of Macey *et al*⁸

Table 1 Distribution of female and male deaths and cases of hyperthermia in relation to date and average maximum weekly temperature and humidity

| | Week | | | | | | | | | | | | | |
|----------------------|---------|----------|--------|---------|---------|----------|-------|--------|---------|---------|----------|--------|---------|---------|
| | 21–27/6 | 28/6–4/7 | 5–11/7 | 12–18/7 | 19–25/7 | 26/7–1/8 | 2–8/8 | 9–15/8 | 16–22/8 | 23–29/8 | 30/8–5/9 | 6–12/9 | 13–19/9 | 20–26/9 |
| Temperature (°C)* | 25.8 | 29.1 | 31.8 | 32.1 | 36.8 | 32.1 | 30.2 | 36.7 | 30.7 | 30.8 | 29.8 | 29.8 | 30.5 | 31.5 |
| Humidity** (%) | 60.4 | 53.4 | 57 | 48.2 | 39.5 | 56.7 | 60.8 | 41.7 | 64.2 | 67.2 | 64.1 | 57.5 | 58.8 | 52.8 |
| No with hyperthermia | 4 | 2 | 7 | 10 | 43 | 63 | 31 | 51 | 26 | 13 | 8 | 6 | 2 | 2 |
| Male deaths | 3 | 1 | 1 | 1 | 3 | 4 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 2 |
| Female deaths | 3 | 5 | 2 | 4 | 18 | 4 | 4 | 3 | 4 | 5 | 1 | 3 | 6 | 2 |
| Total deaths | 6 | 6 | 3 | 5 | 21 | 8 | 5 | 5 | 5 | 6 | 1 | 3 | 7 | 4 |

*Average peak weekly temperature; **average weekly humidity

Table 2 Comparing patients with hyperthermia to sex and age group

| Age group (years) | Males | | Females** | | Combined | |
|-------------------|-------|--------------------------|-----------|--------------------------|----------|--------------------------|
| | n | No with hyperthermia (%) | n | No with hyperthermia (%) | n | No with hyperthermia (%) |
| < 60 | 37 | 8 (21) | 77 | 10 (13) | 114 | 18 (15.7) |
| 60-69 | 62 | 6 (9) | 84 | 17 (20) | 146 | 23 (15.7) |
| 70-79 | 106 | 17 (16) | 173 | 36 (20) | 279 | 53 (18.9) |
| (p > 0.05*) | | | | | | |
| 80-89 | 82 | 16 (19) | 193 | 62 (32) | 275 | 78 (28.3) |
| (p = 0.01*) | | | | | | |
| 90-99 | 10 | 3 (30) | 48 | 26 (54) | 58 | 29 (50.0) |
| (p < 0.01*) | | | | | | |

*Comparing age group with control group below 60 years; **Comparing female to male group with age as a continuous variable; p < 0.05

who found a strong female bias for deaths from excessive heat. Females have a genetic trait responsible for lower sweat rates though the increased fat content in females may be an important predisposing factor. Our mortality figures show that the highest mortality occurred at the beginning of the hottest period and decreased thereafter despite persistent hot temperatures. This is probably because the most susceptible died early in the hot period. Also, others probably began to acclimatize and contingency plans to deal with the problem by providing extra cold drinks, suitable clothing and cooling equipment started operating. This same pattern of early mortality was recorded by Katsouyanni *et al*⁹ under very similar circumstances in Athens.

Table 3 Distribution of temperature by bed state comparing groups to the mobile (control) group

| | Bedridden | Semi-dependent | Mobile |
|---------------|-----------|----------------|--------|
| Febrile/total | 108/255 | 45/220 | 44/397 |
| % Febrile | 42.3* | 20.4* | 11.1 |

*p < 0.01

Table 4 Ward location

| | Top floor wards and isolated buildings (warm environment) | Ground floor wards (cool environment) |
|----------------------------|---|---------------------------------------|
| n | 396 | 476 |
| Patients with hyperthermia | 115 | 82 |
| % with hyperthermia | 29* | 17.2 |

*p < 0.01

We found that there is an increased susceptibility to death from heat stress as one grows older; this risk being most marked in the very old. Mortality figures from three Los Angeles hot spells¹⁰ show that while the overall mortality was two to four times higher than background rate in the general population it was eight times the background rate in those over 85 years, again suggesting the risk is highest in the very old.

Level of dependence was an important predictor of susceptibility to marginal hyperthermia. There was a significantly higher incidence of hyperthermia in bedridden patients compared to the mobile group. The

Risk factors for heat stress

- environmental and room temperature
- extreme old age (> 80 years)
- female
- state of dependence (bedridden > semi-dependent > mobile)
- drugs, especially phenothiazines, antidepressants, alcohol, diuretics
- medical conditions:
 - cardiovascular: congestive heart failure, ischaemic heart disease
 - neurological: cerebrovascular disease, autonomic impairment, head injury, cerebral tumour or abscess
 - mental condition: dementia, confusional states
 - endocrine: hyperthyroidism, diabetes mellitus, hyperpituitarism
 - skin disorders: impairing sweating
 - infections: respiratory, gastrointestinal and septicaemia

Table 5 Hyperthermia in relation to diagnosis and state of dependence

| | Bedridden Febrile/afebrile | Semi-dependent Febrile/afebrile | Mobile Febrile/afebrile | Febrile/total | % Febrile | * | ** |
|----------------------------|-------------------------------|------------------------------------|----------------------------|---------------|-----------|----------|----------|
| Ischaemic heart disease | 55/77 | 18/84 | 21/142 | 94/397 | 23 | NS | p < 0.01 |
| Congestive heart failure | 40/38 | 8/42 | 18/69 | 66/215 | 30 | NS | p < 0.01 |
| Hypertension | 28/46 | 6/43 | 14/96 | 48/233 | 20 | NS | p < 0.01 |
| Chronic airflow limitation | 10/11 | 6/18 | 5/61 | 21/111 | 18 | NS | p < 0.01 |
| Cerebrovascular accident | 22/35 | 4/20 | 1/19 | 27/101 | 26 | NS | p < 0.05 |
| Psychiatric | 4/10 | 6/32 | 5/56 | 15/113 | 13 | NS | NS |
| Dementia | 39/44 | 13/28 | 3/49 | 55/176 | 31 | p < 0.01 | p < 0.01 |
| Mental retardation | 12/21 | 6/6 | 5/18 | 23/68 | 33 | NS | NS |
| Diabetic | 19/41 | 7/54 | 13/91 | 39/225 | 17 | NS | p < 0.01 |

*Comparing the semi-dependent to the mobile group; **comparing the bedridden to the mobile group. NS = non-significant

Learning points

- peak mortality occurs at the beginning of heatwaves and mortality is high once the elderly person develops heat illness
- early identification of high risk groups both in hospital and especially community setting is essential to reduce mortality
- take appropriate preventive measures:
 - monitoring temperature and ensuring a cool room temperature
 - plentiful supply of cold drinks
 - cold meals like salads
 - light, loose clothing
 - avoid heavy exercise in direct sunlight

semidependent group also showed an increased incidence compared to the mobile group. This pattern was observed in patients both with identified conditions known to contribute to hyperthermia such as ischaemic heart disease, congestive heart failure, cerebrovascular disease, diabetes mellitus, mental retardation, and dementia,⁶ and other conditions such as hypertension and chronic airflow limitation. Hypertension may have an indirect effect on thermoregulation due to an increased incidence of cerebrovascular and cardiovascular disease and drugs used in its treatment such as diuretics. Chronic airflow limitation may increase susceptibility to respiratory tract infections during periods of high environmental temperature. Our findings also suggest that the

state of dependence is a more important predictor of risk of marginal hyperthermia than the diagnosis itself. Large hospital buildings in hot climates are likely to have some wards warmer than others for various reasons, we therefore looked at the incidence of heat-related stress in warmer and cooler wards. The warmer wards were isolated buildings or top floor wards that were exposed to continuous sunlight throughout the day without any shade. The results show that patients in such wards were affected to a greater extent, hence the need to identify such areas and to take steps to protect patients at times of exceptionally high environmental temperatures.

This study differs from many previously published studies in looking mostly at the survivors rather than the casualties of a hot period. Since mortality seems to be highest at the start of a hot spell,⁹ carers must act quickly to minimise morbidity and mortality, hence the need to target those elderly patients with the highest risk profile; that is, the very old and immobile. Lye and Kamal¹¹ recommended the monitoring of body temperature of ill patients between 13.00 and 16.00 h during heat waves. Monitoring of room temperature would also alert carers to the risk of heat-related stress and prompt the provision of lighter clothing, cold food and drinks, and increase ventilation.

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