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The effect of darkness on vitamin D in adults

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Summary

Circulating 25-hydroxy vitamin D measurements were made on Caucasians in the Antarctic. Following a period of 3 months' complete darkness there was a significant fall in 25-hydroxy vitamin D values. These results emphasize the importance of u.v. light on skin synthesis of cholecalciferol and support the view that the geriatric and immigrant population should be adequately exposed to sunlight to prevent vitamin D deficiency.

Introduction

A seasonal variation in calcium absorption and excretion in human subjects is well known. Maximum excretion and absorption has been observed in July and August in Great Britain and minimum excretion and absorption observed in February and March (McCance and Widdowson, 1943). More recently a seasonal variation in the serum values of 25-hydroxy vitamin D (25-OHD) has been found in Great Britain. This variation correlates significantly with the mean daily sunshine values 2 months before the taking of serum samples for assay (McLaughlin *et al.*, 1974).

One of the authors (A.L.) has recently spent 12 months in the Antarctic as a Medical Officer with the British Antarctic Survey. This afforded the authors the opportunity to study the effect of an Antarctic environment, in particular the prolonged period of darkness, on circulating 25-OHD values in normal volunteers.

Subjects and methods

Ten Caucasian male subjects aged 21–39 years took part in the study. These men were scientific members of the British Antarctic Survey and were stationed on an Antarctic base at Halley Bay. This base (75°31'S) is situated on the Brunt ice shelf 1·5 miles inland from the Weddell Sea. It is the most southerly of the British bases and has complete darkness for 2·5 months of the year with a mean annual temperature of −20°C.

Blood samples were collected in November from each volunteer after an overnight fast immediately before departure by ship from the United Kingdom. The blood was allowed to clot for 1·5 hr at room temperature and the serum separated and stored at −20°C in plain glass tubes until analysis. Subsequently, blood samples were taken from the subjects in March, May, July (Antarctic winter) and September, November and January (Antarctic summer) of the first year of their stay in the Antarctic. The samples obtained on base were separated and stored as described above. These specimens were later transported deep frozen to the United Kingdom where measurements of calcium, magnesium, total protein, parathyroid hormone (PTH) and 25-OHD were performed. Calcium and magnesium were estimated using a Pye Unicam SP 91 atomic absorption spectrophotometer and total protein values were obtained using a refractometer technique. Serum PTH was estimated by a double antibody radio immunoassay (Fairney, Jackson and Clayton, 1973; Wills *et al.*, 1974) (antiserum generously provided by MRC London) and 25-OHD by a competitive protein binding method identical to that previously described by McLaughlin *et al.* (1974) (Fairney, Naughten and Oppé, 1977).

All subjects were asked to complete exposure cards at monthly intervals, giving an account of the number of hours spent outside over a weekly period and showing the extent to which the body was exposed to direct daylight. A clothing rating was used as follows:

1. Minimum area uncovered; subjects were wearing anorak with hood, goggles and gloves.
2. Face and hands uncovered.

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3. Face, arms and open neck uncovered.
4. Upper trunk uncovered.
5. Wearing shorts only

In addition, the volunteers completed a dietary questionnaire every 2 months giving a complete record of one day's intake of food and drink. These data have been analysed using the tables of McCance and Widdowson (1960) to assess the daily vitamin D and calorie intake of the subjects studied. Meteorological data were recorded on the base throughout the period of study.

Results

A seasonal variation in serum 25-OHD values with the maximal values occurring soon after the Antarctic summer (English winter) and minimal values occurring soon after the Antarctic winter (English summer) was observed. The serum 25-OHD values showed a significant fall during the period of darkness at Halley Bay ($P < 0.01$) (Fig. 1). The mean fall was 14 ng/ml (43·3–29·5 ng/ml) despite an adequate oral vitamin D intake. The initial higher values of serum 25-OHD probably represent the subjects' increased exposure to sunlight on board ship whilst travelling to the Antarctic.

The series of results obtained in this study was then directly compared with the results of the U.K. seasonal variation previously obtained by the same method (McLaughlin *et al.*, 1974). The seasonal variation of serum 25-OH vitamin D was found to be the reverse of that previously documented for the U.K. so that in March (end of Antarctic summer) in the Antarctic the mean serum 25-OH vitamin D was 43·3 ng/ml ± 6·1 (s.d.) and in the U.K. in March (end of European winter) the mean 25-OH vitamin D was 17 ng/ml ± 6·3 ($P < 0.001$) (Fig. 2).

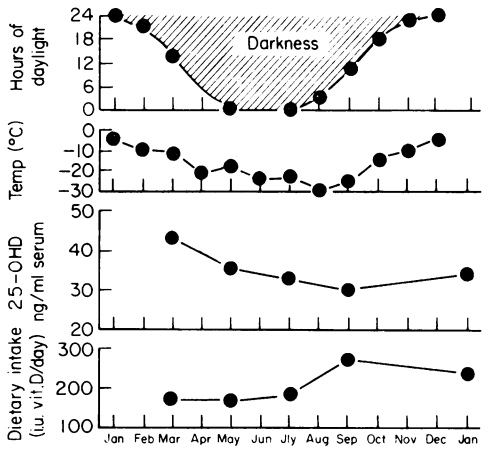

FIG. 1. Mean daily hours of daylight and temperature in the Antarctic compared with mean serum 25-OHD and dietary intake of vitamin D in Antarctic volunteers.

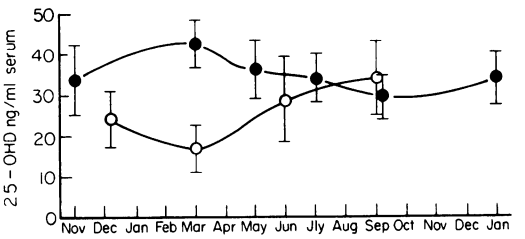

FIG. 2. Mean ± s.d. of serum 25-OHD in Antarctic volunteers compared to U.K. seasonal variation. (●—●) Antarctic; (○—○) U.K.

No significant changes in serum calcium, magnesium, total protein or PTH were observed (Table 1). There was a rise in vitamin D intake in September which coincided with an increase in total calorie intake. It is likely that this reflects increased food intake during the Antarctic winter coupled with a lower level of physical activity. The assessment of exposure to u.v. light was unfortunately inadequate. This was due, in part, to the variation in the amount of field work undertaken by the volunteers and to the inconsistency of the records obtained.

Discussion

Vitamin D_3 (cholecalciferol) is formed in the skin from 7-dehydrocholesterol under the influence of u.v. light. This photolytic conversion is maximal between wave lengths of 280–310 nm (Knudson and Benford, 1938) and light of this wave length only occurs maximally during the summer months in the United Kingdom and the Antarctic.

The results of the study in the Antarctic show a significant fall in circulating 25-OHD values following a significant period of time spent in a dark environment and are in agreement with those found in submariners (Preece *et al.*, 1975).

This fall occurred in spite of an adequate dietary intake of vitamin D and conditions of intense ultra violet light before the period of darkness. It is possible that a low ambient temperature may affect circulating 25-OHD measurements as well as u.v. light. Conversion of pre-vitamin to cholecalciferol is known to be temperature dependent (Hanewald, Rappoldt and Roborgh, 1961) but the volunteers in the present study were clothed so as to protect them from the effects of low environmental temperature.

The significant incidence of rickets and osteomalacia in the Asian immigrant population of the United Kingdom is well documented (Gupta, Round and Stamp, 1974; Hodgkin *et al.*, 1973; Leading Article, 1976). It is likely that the Asian skin is adapted to cholecalciferol synthesis in a high natural sunlight environment. Therefore,

TABLE 1. Serum 25-OHD, calcium, PTH and vitamin D_3 intake throughout the Antarctic year

Time of year	25-OHD ng/ml(±s.d.)	Calcium mmol/l(±s.d.)	PTH pg/ml(±s.d.)	D_3 intake i.u./day(±s.d.)
November	33·6 (8·5)	2·49 (0·14)	537 (153)	Not available
March	43·3 (6·1)	2·38 (0·14)	380 (131)	171 (51)
May	35·6 (6·6)	2·41 (0·07)	392 (113)	169 (84)
July	33·6 (5·7)	2·42 (0·09)	412 (113)	185 (91)
September	29·5 (4·6)	2·39 (0·13)	392 (135)	275 (97)
January	34·4 (6·3)	2·43 (0·03)	417 (179)	236 (106)

Conversion: SI to traditional units
Serum calcium: 1 mmol/l = 4 mg/100 ml.

residence in a country with less sunshine than their native land may produce vitamin D deficiency. In addition, the elderly housebound section of the British population also demonstrate a relationship between lack of adequate exposure to sunlight and vitamin D deficient bone disease (Hodkinson *et al.*, 1973). Ultraviolet irradiation in long-stay geriatric patients may increase plasma 25-OHD values by an amount sufficient to bring the level in depleted subjects into the normal range (Corless *et al.*, 1978).

These findings confirm the role of u.v. light in the synthesis of cholecalciferol. They serve to emphasize the importance of cholecalciferol from the skin as opposed to that derived from the diet, and are of particular relevance to the immigrant and geriatric populations of the country.

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