# Megadosage of ascorbic acid in an Antarctic expedition

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1. No difference in health was observed between men on megadosage of ascorbic acid and controls during the year of an Antarctic expedition.
2. All men appeared to have a satisfactory intake of ascorbic acid throughout the year.
3. There was a statistically significant decrease in excretion of ascorbic acid by men on megadosage over the year, and by the controls.
4. The decline in excretion by the control group may be explained by dietary change, but the decline in those on megadosage may be due to altered handling of ascorbic acid by the body.
5. No complications due to megadosage of ascorbic acid were observed.

The hazards of ascorbic acid deficiency during Antarctic expeditions have been well documented (Evans, 1937; Lewis, 1972). Typical scurvy did occur and Captain Scott's ill-fated party of 1910–13 were well aware of the problem. Unhappily, however, they appeared less cognizant of 'subclinical' scurvy and in spite of some opinions (Atkinson, 1915; Kendall 1954) other deliberations have favoured ascorbic acid deficiency as a major factor in the disaster (Macklin, 1923; Priestley, 1956). Whatever the truth of that matter, victualling for polar expeditions has improved over the years and morbidity due to hypovitaminosis is now usually considered a problem of the past (Wilson, 1965).

Some interest in ascorbic acid requirements in polar regions has continued. The role of the vitamin in resistance to cold has been considered (Glickman, Keeton, Mitchell & Fahnestock, 1946; Dugal, 1961) and Dugal has shown that animals became more resistant to cold with increasing ascorbic acid administration (Dugal & Thérien, 1947). However, there has been no agreement on the incidence of symptoms or signs attributable to ascorbic acid deficiency in polar expeditions and the necessity of supplemental vitamins is debated (Wilson, 1965).

Perlitsh, Nielsen & Stanmeyer (1961), Van der Merwe (1962), Adams, Stanmeyer & Harding (1962) and Paleyev (1964) found some evidence of hypovitaminosis requiring vitamin supplements, while Kark *et al.* (1948), Rodahl (1954) and Csordas (1958) thought that there was no necessity for additional vitamins. Wilson (1965) and Shamis (1971) decided that small vitamin C supplements may be desirable to maintain optimal health. More recently there has been disputation over the optimal intake of ascorbic acid in common life and the role of the vitamin in various types of stress and pathological states (Goldsmith, 1961; Baker, 1967; Cohen & Duncan, 1967; Pauling, 1970). Megadoses of the vitamin have been promoted to improve health (Pauling, 1970), but there has been concern about subsequent deleterious effects including

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Table 1. *Physical characteristics in February* 1973, *and smoking habits for all subjects, and for the groups taking ascorbic acid, and the control group who were members of the Australian National Antarctic Research Expedition* (1973) *to Casey, Antarctica*

| | All subjects | Ascorbic acid group | Controls |
|---|---|---|---|
| Mean age (years) | 29·8 | 30 | 30 |
| Range | 22–51 | 24–45 | 22–51 |
| Mean weight (kg) | 77·9 | 80·3 | 75·6 |
| Range | 60·5–108·9 | 70·9–108·9 | 60·5–100·2 |
| Mean height (cm) | 177·8 | 177·9 | 177·4 |
| Range | 165–190 | 168–187 | 165–190 |
| Non smokers | 18 | 8 | 10 |
| Smoke 5/d | 4 | 2 | 2 |
| Smoke > 10/d | 6 | 3 | 2 |

rebound scurvy on withdrawal due to altered handling of ascorbic acid by the body (Wilson & Lubschez, 1946; Cochrane, 1965; Rhead & Schrauzer, 1971).

Megadosage of ascorbic acid during the year of a polar expedition has not been previously carried out. The present study with dosed and control groups was made with urinary ascorbic acid estimations and survey of general health.

## METHODS

### *Subjects and location*

Twenty-nine men of the Australian National Antarctic Research Expeditions (ANARE) spent one year, January 1973 to January 1974, at Casey Station, Antarctica. This station at 66° 17′ S, 110° 32′ E is 28 km north of the Antarctic Circle and experiences quite severe climatic conditions with a marginal polar night and polar day.

After a 9 d voyage from Australia, changeover at the station was carried out from 22 to 28 January 1973. At the beginning of February the party was briefed on the experiment and fourteen men selected to take 1·0 g of ascorbic acid daily for the ensuing year. The remaining fifteen men were to take no supplemental vitamins. Consideration was given to personal wishes in this choice as co-operation with the programme was essential. An even division among field party personnel was attempted. There were field activities by eight men in the autumn and spring with 9 weeks and 12 weeks away from the station respectively. All expeditioners performed some outdoor work when they were exposed to ambient conditions, dressed in appropriate clothing. However, the average time out of doors for station men is only in the order of 10% (Soucek, 1963). The field party travelled in enclosed tractors and tracked vehicles with more cold exposure and spent time exposed to the environment in the course of their glaciological and surveying work. A summary of the physical characteristics of the expeditioners including their smoking habits is shown in Table 1.

### *Urine collection and analysis*

In February and at monthly intervals, 24 h collections of urine were made into 2 l polythene containers charged with 100 ml of a saturated solution of $NaHSO_4$ (20 g/100 ml). This maintained the collection at a pH of 2–3 as checked with litmus paper when the urine was tested at the end of the 24 h period. The containers were kept in the access corridor of the station which was dark and at a temperature around freezing during the summer months. In winter the urine was frozen. With this method of collection, loss of ascorbic acid in the urine should be minimal (Ralli & Sherry, 1941). Estimation of ascorbic acid in the urine was by titration with 2:6-dichlorophenolindophenol tablets B.D.H. (Harris & Ray, 1935). Freshly prepared solution was made on the day of testing. Ascorbic acid supplements were withheld for 24–36 h prior to collection of the first urine sample for the 24 h collection. Field party men when away from the station checked urinary ascorbic acid with Ascorbistix (Ames-Miles Laboratories, P.O. Box 203, Springvale, Victoria, Australia) on the appropriate day. The test strip was held in the urine stream at each micturition and the colour change compared with the reference strip on the bottle, giving a readout in mg/100 ml of ascorbic acid. On the autumn traverse 24 h collections of urine were also kept and returned to the station for titrationwhen the party returned. This proved unsatisfactory and was therefore abandoned.

### *Other data*

At the time of the monthly urine collections routine physiological measurements were made as part of a continuing physiological programme. Details of general health, specific illnesses, appearance of the gums and the results of a Hess test were also recorded. Field men noted similar details on a pro-forma while they were away from the station; they were also interviewed and examined on return. A day-to-day medical log was kept throughout the year. Haemoglobin estimations were made in June and September 1973 and January 1974 with spectrophotometric examination of cyanomethaemoglobin.

## RESULTS

### *Ascorbic acid excretion*

The monthly determinations of 24 h urinary ascorbic acid excretion are shown in Fig. 1. There was considerable variation between subjects but in the latter half of the year the ranges were smaller and fluctuations between months are more clearly shown together with a declining excretion in both groups. An occasional wildly high figure was usually due to a discernible error: not abstaining from ascorbic acid supplement or drinking a large can of fruit juice on the day of urine collection.

Five sequences of results are excluded from this set of figures. One man who started on ascorbic acid supplements ceased these in June after recurrent attacks of angioneurotic oedema (which continued to occur). Two men proved consistently unreliable by their own admission; one took his ascorbic acid most irregularly and the other, a control, was unreliable with his urine collections. Two other men exchanged

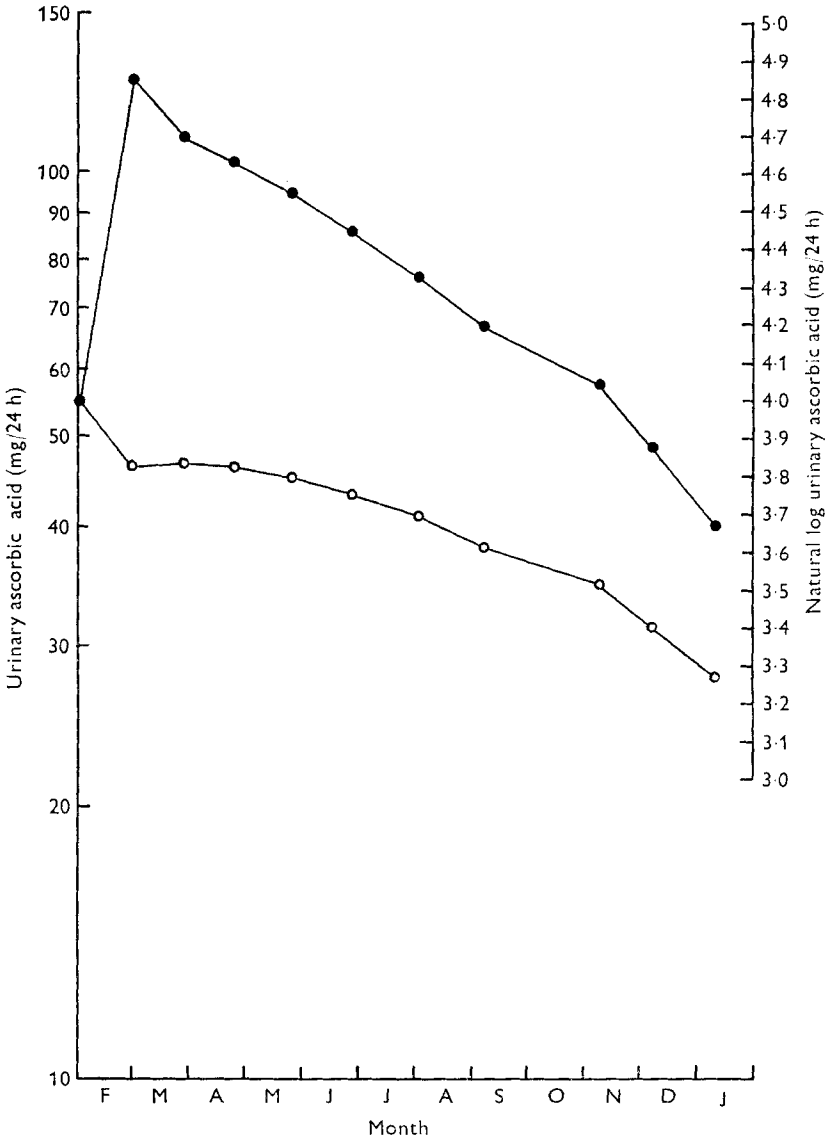


Fig. 1. Monthly urinary excretion of ascorbic acid in ascorbic acid dosed (●) and control (○) groups in Antarctica 1973.

their field versus station category and their results were excluded for the purpose of analysis.

The initial figure for urinary ascorbic acid excretion in February shows the results from seventeen men. The remainder had been selected to take supplements throughout the year but had commenced them before the first control test. There were 12 missing values throughout the year due to temporary absence from the station or mistakes in the procedures.

Table 2. *The number of subjects in the control group and those taking megadosage of ascorbic acid and the incidence of illnesses and result of Hess test in the two groups who were members of the Australian National Antarctic Research Expeditions* (1973) *to Casey, Antarctica*

| | Ascorbic acid group | Control group |
|---|---|---|
| No. of subjects | 13 | 15 |
| No. of URTI* | 26 | 21 |
| Mean URTI | 2 | 1·4 |
| Other illnesses | 26 | 45 |
| Mean illnesses | 2 | 3 |
| Subacute sinusitis | 5 | 1 |
| Gingivitis | 3 | 2 |
| Hess test positive | 0 | 4 |

* URTI, Upper respiratory tract infection.

Statistical analysis of these monthly excretion results has been carried out and the decrease in ascorbic acid excretion in both the control group and those on ascorbic acid supplements is found to be highly significant. Analysis of the results according to field or station category showed no significant difference in either ascorbic acid or control groups. Comparison of excretion between smokers and non-smokers was made as the former have been shown to excrete less ascorbic acid in the urine (Pelletier, 1968). No appreciable difference in the results was observed.

The 24 h excretion of ascorbic acid by field party men on return to the station in January 1974 gave mean values of 40 mg (19–68 mg) for those on supplements and 25 mg (20–34 mg) for the controls which is in accord with the generally lower excretions of all men at that time. These results and the other urinary estimations made at the station throughout the year on the field party men are incorporated in the results in Fig. 1.

*Illnesses*

A summary of the incidence of upper respiratory tract infections, gingival disease, other illnesses and the results of Hess tests are given in Table 2.

Respiratory infections were uncommon after changeover in 1973 and even on the return voyage, when colds are prone to occur (Allen, Bradburne, Stott, Goodwin & Tyrrell, 1973), the only obvious cases were among the relief crew. Rhinorrhoea and other upper respiratory tract symptoms due to inhalation of cold air are common (Wilson, 1965) and some men complained of symptoms of subacute sinusitis. Four of the six cases presenting for medical attention for such symptoms had a past history of the complaint and, as seen from Table 2, ascorbic acid supplementation had no negative effect on the incidence of cases. The only remarkable case attributable to infection occurred in one man on supplements who suffered an ephemeral illness in October. After a sudden onset with vague abdominal symptoms he developed headache, photophobia, rhinorrhoea and malaise with a temperature of 38·8°. The condition resolved completely in 36 h with symptomatic treatment and was thought to be a viral infection. The case was an isolated event. Viral upper respiratory tract infections are known to occur sporadically during Antarctic isolation (Allen *et al.* 1973).

The findings on examination of the gums throughout the year were unremarkable. One man on ascorbic acid in the field party suffered recurrent gingivitis when not attending to dental hygiene. Simple measures and a toothbrush resolved the condition on return to the station. Another man on ascorbic acid had suffered chronic gingivitis for years. The condition proved quite unresponsive to dental hygiene measures and to the year-long high-dose ascorbic acid.

The Hess test carried out at monthly intervals with the application of a sphygmomanometer cuff at 80–90 mmHg for 5 min produced no petechiae during 1973. At the last test in January 1974, however, five men showed petechiae with counts of 1, 2, 3, 4 and 5. One spot may be classified as normal (Nour-Eldin, 1972) although others (Vilter, 1967) using a similar test consider under ten spots normal. Accordingly, four tests have been marked as doubtfully positive. The man with the single spot was the subject who ceased ascorbic acid supplements in June following angioneurotic oedema and the remaining men were controls.

The three sets of haemoglobin estimations were all within normal limits except for one result in June when a control sample registered 11·1 g/100 ml. No cause was found and all other tests were normal. No treatment was given and later estimations were within normal limits.

Blood coagulation times were estimated at monthly intervals by the method of Lee & White (1913). This was a separate programme but it may be noted here that the results showed no difference between those men on ascorbic acid and the controls.

Examination of the physiological parameters – temperature, blood pressure, pulse, body weight and skin-fold thickness – showed no general differences between the ascorbic acid and control groups throughout the year.

## DISCUSSION

This study was primarily intended to observe the health of men subjected to the rigours of a year on the Antarctic continent, to estimate their ascorbic acid status and determine any differences between a group on megadosage of ascorbic acid and a control group. The merit of performing the study at all was indicated by the concern of the expeditioners about vitamin supplementation. At the initial briefing of individuals on the experiment many were anxious to take supplemental ascorbic acid; they had some idea it might be beneficial.

The only available method of studying ascorbic acid in the men was by titration of the urine with 2:6-dichlorophenolindophenol indicator. This has been considered a valid method (Abbasy, Harris, Ray & Marrack, 1935), but the value of urinary estimations has often been criticized (Bartley, Krebs & O'Brien, 1953; Vilter, 1967). For the present study the results are probably acceptable as collected urine was kept around freezing point and the ascorbic acid concentration in the urine was usually high. Up to 24 mg/d of reducing substance other than ascorbic acid may be excreted in the urine (Hodges, Baker, Hood, Sauberlich & March, 1969) but the excretions in this study were almost always above this level.

There was no demonstrable difference in health between the ascorbic acid and

control group. The men accepted for expeditions are medically examined and passed as fit for arduous service, so that a low incidence of disease apart from trauma is to be expected. The anticipated outbreak of upper respiratory tract infections at changeover in 1974 did not occur and no conclusions about general health can be drawn.

The ascorbic acid status indicated by urinary excretion is to be considered. The considerable fluctuations in excretion may be expected (Storvick & Hauck, 1942), but the fluctuation between subjects, both in the ascorbic acid and control groups became much smaller in the second half of the year. Those in the control group excreted nearly 30 mg or more throughout the year. The initial high figure in February for all those who had not taken any supplements may be explained by the heavy consumption of canned fruit juice. This was freely available in the first 3 weeks and many men were observed to drink one or more large (30 oz) cans per day. As soon as stocks were calculated a more modest amount was available and the ration was half can/man per d.

There is a slight decline in the ascorbic acid excretion throughout the year but the results are still high compared with the findings of Ryabinin & Afanas'yev (1969) and Shamis (1971), who estimated the urinary ascorbic acid with the same dye. The present study would suggest that an adequate amount of ascorbic acid was available in the diet. The food supplied to ANARE is varied and of good quality with ample frozen vegetables and meat. Fresh fruit and vegetables keep for the first 1–2 months and frozen, tinned and preserved food only is available for the remainder of the year. There is approximately half a large 30 oz can of fruit juice/man per d throughout the year and all men appeared to drink this. Those men in the field parties took a proportionate quantity on their trips. Nutrition with ANARE has been discussed by Kefford (1956), Law (1957) and Csordas (1958). It is known that ascorbic acid content of many stored foods gradually deteriorates and with the absence of fresh food over an Antarctic year the ascorbic acid of the diet as a whole must inevitably diminish. The use of fresh local fauna to supplement the food supplies no longer occurs. However, the ration of canned fruit juice allows at least 30 mg ascorbic acid/d and this probably explains the high excretion of the control groups. S. Vallance (personal communication) found that the men with British Antarctic Survey had a diet deficient in ascorbic acid and satisfactory levels were only achieved with very high intakes of Califorange which was not always available; the men with ANARE certainly had a constant supply of such fruit juice which they consumed regularly.

The gradual decline in excretion over the year is highly significant statistically and may represent the over-all diminishing intake. The statistically highly significant decline in excretion by those on megadosage supplements throughout the year is noteworthy. No obvious explanation emerged and it may be that this represents an alteration in handling of ascorbic acid by the body confronted with consistently high dosage of the vitamin. Rhead & Schrauzer (1971) and Schrauzer & Rhead (1973) have indicated that hypovitaminosis and even scurvy may occur after prolonged megadosage of ascorbic acid, perhaps due to alterations in metabolism. The gradual fall in excretion according to the monthly 24 h urine tests may be taken to support this view.

It is concluded that all men had a satisfactory intake of ascorbic acid throughout the year in Antarctica and no difference in health was observed between Antarctic

expeditioners on megadosage of ascorbic acid and controls. The significant decline in excretion of ascorbic acid in the control group may be due to diminishing dietary intake. The significant decline in the megadosage group may represent altered ascorbic acid handling by these men.

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