# Changes in the level of serum vitamin C in mineworkers

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**SYNOPSIS**

The levels of serum vitamin C in the blood of mineworkers were determined on the first and fifth days of the normal heat-acclimatization period (i.e., before and after exposure to heat) and again after 1, 2, and 4 months of underground employment. Supplementary vitamin C was administered to the men during the heat-acclimatization period. Six groups of 20 men featured in the study and, except for one of the two 4-month groups, all the values were obtained after a full shift of underground work.

It was found that adequate levels of serum vitamin C were maintained during the heat-acclimatization period, and the 250 mg of vitamin C given daily to each man must therefore be regarded as sufficient. The serum vitamin C decreased significantly with time of exposure to underground conditions, showing that the vitamin C utilized during heat stress is more than that provided in the men's diet. At the end of 4 months, not a single subject had more than 0,4 mg of serum vitamin C per 100 ml, most of them having only 0,3 mg per 100 ml; 90 per cent of the men had had more than 0,4 mg per 100 ml during the acclimatization period. It is therefore recommended that the mineworkers' diets should be supplemented with 100 to 200 mg of vitamin C per man per day.

**SAMEVATTING**

Die vlak van serumvitamien C in die bloed van mynwerkers is op die eerste en vyfde dag van die normale hitte-akklimatiseringsperiode (d.w.s. voor en na blootstelling aan hitte) bepaal en weer na 1, 2 en 4 maande se ondergrondse werk. Aanvullende vitamien C is gedurende die hitteakklimatiseringsperiode aan die manne toegedien. Ses groepe van 20 man het aan die studie deelgeneem, en behalwe in die geval van een van die twee 4-maande-groepe is al die waardes na 'n volle skof van ondergrondse werk verkry.

Daar is gevind dat toereikende peile van serumvitamien C gedurende die hitteakklimatiseringsperiode gehandhaaf is, dus moet die 250 mg vitamien C wat elke man daagliks kry, as voldoende beskou word. Die serumvitamien C het betekenisvol afgeneem volgens die periode van blootstelling aan ondergrondse toestande wat toon dat die vitamien C wat tydens hittespanning gebruik word, meer is as wat die manne se dieet voorsien. Na 4 maande was daar nie 'n enkele geval met meer as 0,4 mg serumvitamien C per 100 ml nie en die meeste manne het gedurende die akklimatiseringsperiode meer as 0,4 mg per 100 ml gehad. Daar word dus aanbeveel dat die mynwerkers se dieet met 100 tot 200 mg vitamien C per man per dag aangevul word.

## Introduction

Because the level of serum vitamin C in the blood of Black mine workers has been shown to decrease significantly during the course of their underground employment[1], it was suggested that this vitamin should be supplemented in their diet[2]. The extent of supplementation recommended was 235 mg of vitamin C per man per day. However, when the climatic-room acclimatization procedure with supplementary vitamin C was introduced[3], it was felt that the initial decline due to heat stress would be obviated and that the need for supplementary vitamin C would decrease. The present study was undertaken to determine whether the supplementation regime employed during heat acclimatization is effective in maintaining adequate levels of vitamin C during the acclimatization process, and whether vitamin C should be supplemented in the hostel diet to maintain these levels during four months of underground employment.

## Methods

The levels of serum vitamin C in six different groups of Black mine workers were determined at the following time points of their contracts: day 1 and 5 of the acclimatization procedure (i.e., before the daily supplementation of 250 mg of vitamin C and after 4 hours of heat exposure) and 1, 2, and 4 months after heat acclimatization. To ensure adequate levels of serum vitamin C, workers were given one 250 mg vitamin C tablet each day for three days prior to and during heat acclimatization. The taking of blood samples for the determination of serum vitamin C levels was done in the climatic room or during the afternoon after the completion of an underground shift, and usually at between 4 and 5 p.m. except for one of the two 4 month groups, which was sampled on a Sunday morning. On days 1 and 5 of acclimatization, the two groups served as their own controls with respect to levels before and after heat exposure. No differentiation with respect to job categories or ethnic groups was made, but the subjects hailed mainly from Rhodesia and Mocambique.

The levels of serum vitamin C in the collected blood samples were determined according to the method of Roe and Keuther[4] as modified by Lowry *et al*[5].

During the time of this study no supplementary vitamin C was given at the mine hostels where the men resided, except that the marewu contained 10 mg of vitamin C per litre.

## Results

The mean levels of serum vitamin C and the standard errors for the different groups or time periods are given in Table I. Using Mann Whitney tests, Groups 1 and 2 before the acclimatization could not be shown to differ significantly from each other in serum vitamin C at the

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5 per cent level. The difference between day 1 (pre-exposure) and day 5 (post-exposure) is, however, significant ($P<0,001$) according to the Mann Whitney tests. Furthermore, both day 1 and day 5 pre-exposure groups could be shown to have serum vitamin C levels that were significantly higher than those of the 1, 2, and 4 month groups ($P<0,001$) irrespective of hostel. The group that worked for two months underground also had significantly higher values than the 4 month group of Hostel I. Group 3 subjects with 1 month of underground employment could be shown to have significantly higher levels of serum vitamin C than those of Hostel I subjects who had 2 or 4 months of underground employment. ($P<0,01$).

The subjects from Hostel II, who had 4 months of employment (Group 6) but who had not undergone the stress of an underground shift just prior to the taking of blood samples, had significantly higher levels of vitamin C ($P<0,002$) than those of Hostel I subjects (Group 5), who had the same period of underground employment but who had been underground on the day of sampling.

On both days 1 and 5 of acclimatization, 19 of the 20 subjects increased their vitamin C levels following a daily supplement of 250 mg of vitamin C each and 4 hours of heat exposure; and the increase (a mean increase of 0,39 mg per 100 ml on both these days) could be shown to be highly significant ($P=0,00006$ on both occasions).

TABLE I

LEVELS OF SERUM VITAMIN C FOR THE DIFFERENT GROUPS AND TIME PERIODS

| Group | Time period | Sampling site | Mean | Standard error | *n* |
|---|---|---|---|---|---|
| 1 | $d_1$ pre | Accl. centre | 0,74 | 0,054 | 20 |
| | $d_1$ post | Accl. centre | 1,14 | 0,096 | 20 |
| 2 | $d_5$ pre | Accl. centre | 0,72 | 0,047 | 20 |
| | $d_5$ post | Accl. centre | 1,16 | 0,074 | 20 |
| 3 | 1 month | Hostel I | 0,41 | 0,015 | 23 |
| 4 | 2 months | Hostel I | 0,36 | 0,012 | 18 |
| 5 | 4 months | Hostel I | 0,29 | 0,011 | 17 |
| 6 | 4 months | Hostel II | 0,39* | 0,032 | 13 |

*Measured some time after underground work, not immediately after as for the other group

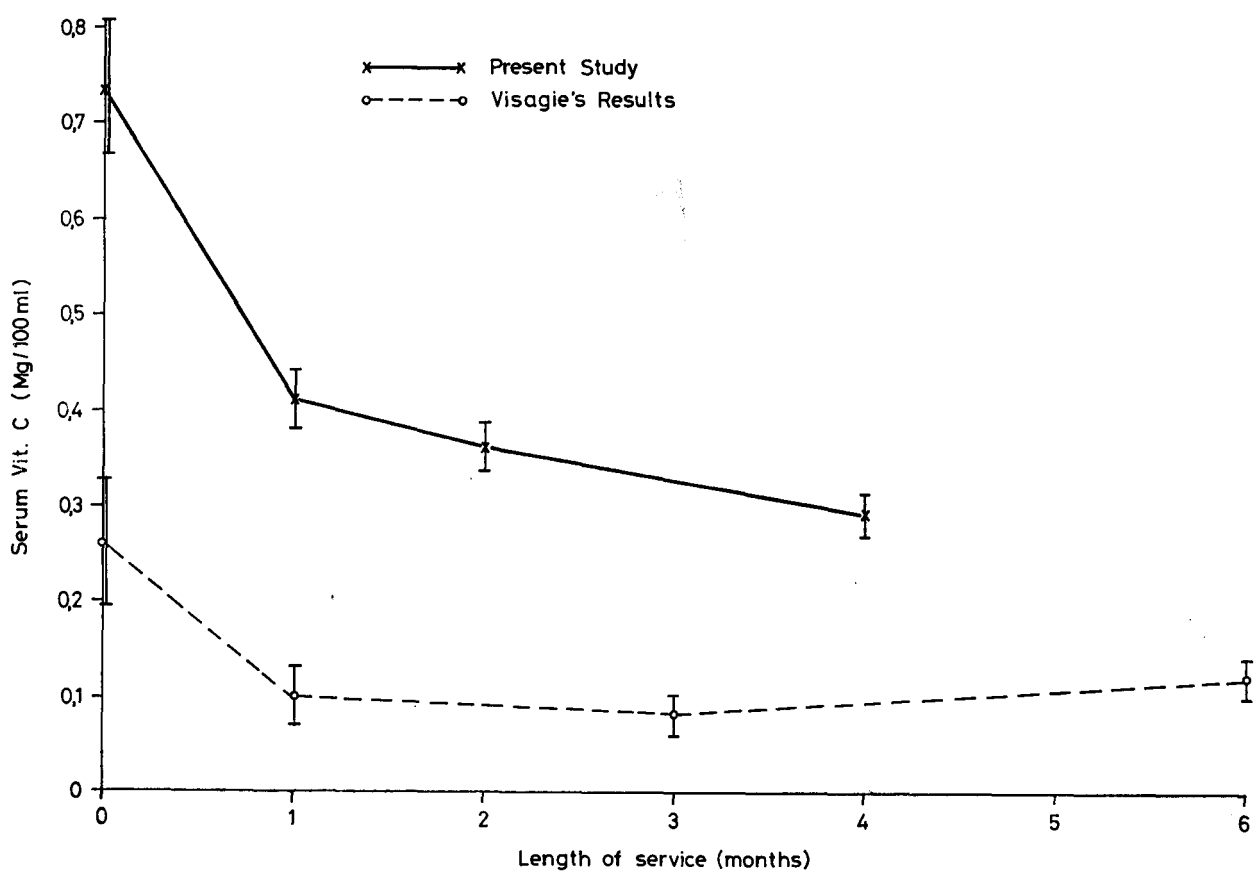


**Fig. 1—Mean levels of serum vitamin C (± 2 std errors)**

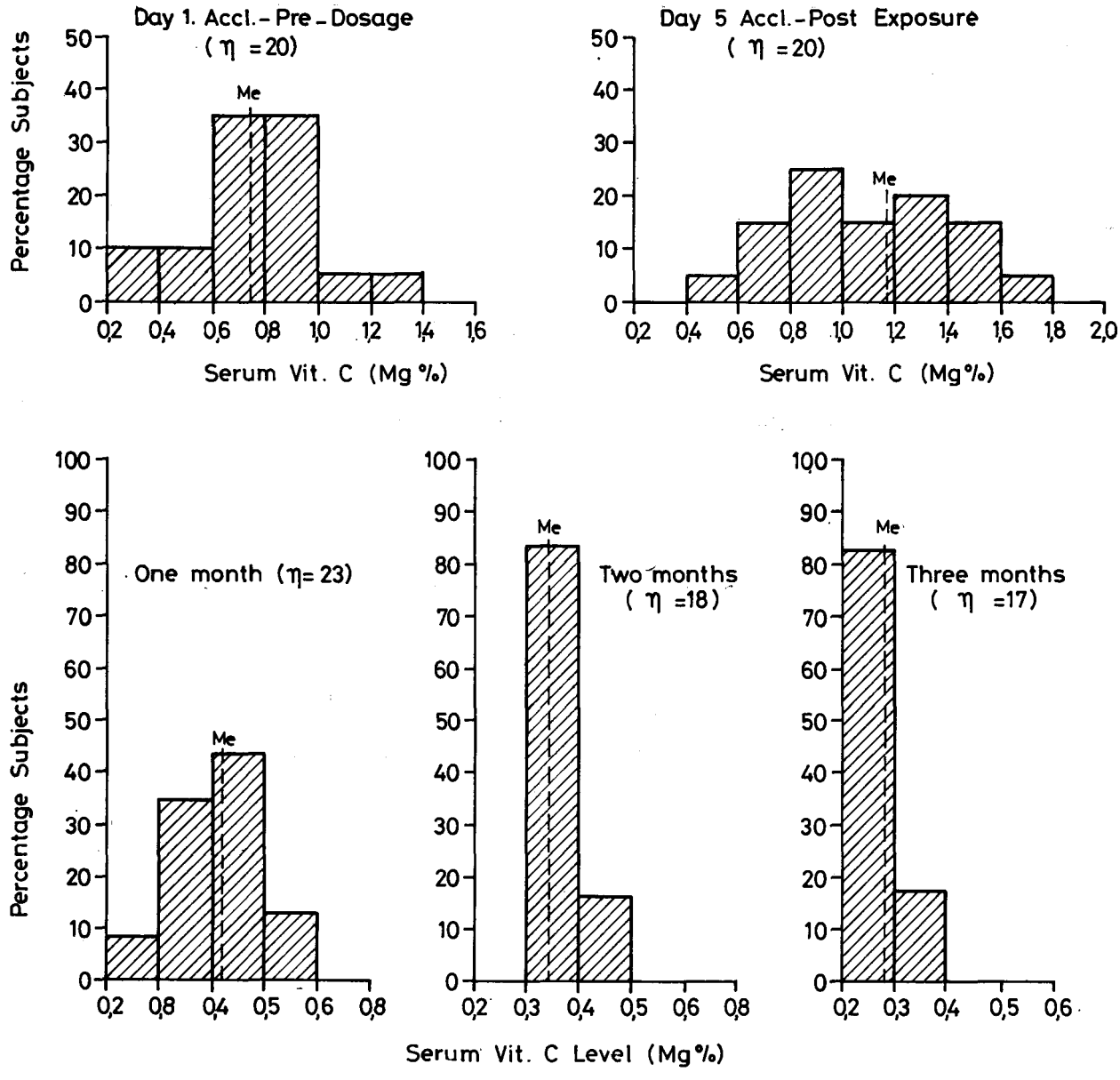


**Fig. 2—Percentage distributions**

The mean levels of serum vitamin C in this study and in that of Visagie *et al.*[1] for subjects from Mocambique are illustrated in Fig. 1. Time O refers to mean levels of serum vitamin C during acclimatization ($d_1+d_5$) for these results and to that of new arrivals in the case of Visagie's data. Fig. 2 gives the percentage distributions of serum vitamin C levels during the vitamin C supplemented acclimatization period (day 1 pre-exposure and day 5 post-exposure) and after subsequent periods of 1, 2, and 4 months of employment (Hostel I data) during which no further supplements of vitamin C were added to the diet.

## Discussion

The results of this study show basically the same trend as those of Visagie *et al.*[1] with time of exposure, although the levels reported by them are decidedly lower than those recorded in this study (Fig. 1). Visagie *et al.*, who took blood samples from men who had been free of heat stress for at least 18 hours, reported mean serum vitamin C values of 0,09 mg to 0,11 mg per 100 ml over the period 1 to 6 months, while none of the post-heat-stressed men in the present study had levels of less than 0,2 mg per 100 ml. It would seem that, if an employee's level of serum vitamin C has been increased (or rather prevented from decreasing) during the initial impact of heat stress, i.e., during heat acclimatization, he is significantly better off later on.

It is encouraging to note that the levels of serum vitamin C were maintained during the acclimatization period despite the relatively high heat stress to which the men were subjected. The daily dosage of 250 mg of vitamin C prior to entering the climatic room must be rated as more than adequate, and it actually resulted in an increase in serum values towards the end of the four-hour period. The subjects who had levels of serum vitamin C in excess of 0,7 mg per 100 ml amounted to 60 per cent before the daily supplementation, and to

87,5 per cent after the supplementation and 4 hours of heat exposure (Fig. 2).

The intake of vitamin C in the hostel diets was obviously less than the amount of this vitamin utilized, and hence the continuous significant decrease in serum vitamin C with time of exposure. Only 56,5 per cent, 16,7 per cent, and 0 per cent of the subjects employed for periods of 1, 2, and 4 months respectively had serum vitamin C levels in excess of 0,4 mg per 100 ml, as compared with 90 per cent of the subjects during the acclimatization period (see Fig. 2). Even though these values represent the post-stress position with regard to serum vitamin C, and even though the requirements of serum vitamin C are controversial, it must be concluded that the observed decrease is not acceptable and that it should be countered by a supplementation regime at the workers' hostels. According to Goodman and Gilman[6], levels of serum vitamin C of less than 0,5 mg per 100 ml should be designated suboptimal. The tendency to accept low levels of vitamin C as satisfactory because of the absence of obvious clinical symptoms of scurvy is contrary to good medical practice[7]. Furthermore, it should be noted that the final diagnosis of scurvy rests upon roentgenological evidence and is therefore difficult to establish in a large population, and that scurvy can be avoided by administration of moderate dosages of vitamin C, which can only be beneficial.

This investigation does not resolve the question of the extent of vitamin C supplementation required for underground workers. As the initial drastic drop in vitamin C levels was eliminated by the supplementation regime during heat acclimatization[3], the high maintenance dosage of 235 mg of vitamin C proposed by Visagie *et al.*[2] would seem too liberal. Publications dealing with heat exposure, together with the knowledge that vitamin C is involved in the metabolism of carbohydrate[6], which is the major source of energy available to the physical labourer, may serve as temporary guide lines to a sound hostel supplementation programme. Dluzniewska *et al.*[8] recommended in 1965 that the diet of workmen employed in hot industries should be supplemented with 100 to 200 mg of vitamin C daily. The present practice at mines to provide a daily supplement of 100 mg of vitamin C per man therefore seems to be a good start, but further studies are required.

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# Note: Ultrasonic flowmeters


by A. E. HALL*


Accurate water-flow measurements on underground columns are difficult to obtain. Orifice plates permanently installed in water lines are susceptible to fouling and corrosion, and measurements are made without knowledge of the condition of the plate. In addition, in high-pressure water systems such as refrigeration lines, the presence of taps on either side of the plate can constitute a safety hazard if they are tampered with. Special valves or locking devices must therefore be fitted to avoid this. Experiments with insertable turbine-type flowmeters have been done, but these also have disadvantages[1].

It is apparent that, if a flowmeter acting externally on a pipe can be used with adequate accuracy, this will solve many of the flow-measurement problems. Anglo American Corporation are currently experimenting with two ultrasonic flowmeters to determine their suitabiliy for underground use. One was purchased by Vaal Reefs ventilation department and is a battery-operated unit called the Det 7. The other is a United Automation Type P100 and was purchased by Technical Development Services, Welkom.

Both instruments work on the same principle — a sensing transducer is attached to the outside of a pipe with a suitable bonding agent. The transducer transmits an ultrasonic signal at a controlled frequency through the pipewall into the flowstream. The signal is reflected back to a receiver from any entrained discontinuities in the fluid, such as bubbles, particles of solid matter, or density interfaces. The frequency of the reflected signal received from a flowing fluid is shifted by the Doppler effect, and the Doppler shift is proportional to the flow velocity. The signal is amplified and filtered, and the doppler shift is processed by a digital-to-analogue circuit and displayed on a velocity-indicating meter. The Det 7 has a range of 0 to 15,2 m/s, and the UA P100 has a range of 0 to 3 m/s. The UA P100 is slightly more sophisticated than the Det 7, and has rechargeable batteries and a meter that indicates the level of the Doppler signal.


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