Vitamin C and Tolerance of Heat and Cold: Human Evidence

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From a review of the human evidence, there is no question that body temperature regulation is affected by what you take into your body as well as what you put on your body.

Cold Tolerance

In the first controlled human experiment. Nakamura and co-workers (1967) showed that regular amounts of vitamin C can keep you warmer in winter. Specifically, they administered 200 mg of ascorbic acid daily for 17 days to 20 healthy medical students whose diets furnished about 80 mg of vitamin C daily during the testing period.

By measuring the temperature of their skin at room temperature (20°C, 68°F) and 40 minutes after exposure to cold (5°C, 41°F), the authors demonstrated conclusively that skin temperatures in those receiving the vitamin C supplement decreased less after cold exposure than the control group.

They noted that acclimatization to cold increased as the blood ascorbic acid level rose and that a concentration of at least 1.0 mg dl in the blood is essential for maintaining an adequate resistance to cold. Nakamura and his associates concluded that "ascorbic acid seemed to enhance the resistance to cold by raising the body temperature and the basal metabolism rate."

Livingstone (March, 1976) observed on Arctic exercises that there was a decreased cold-induced vasodilator (CIVD) response in military personnel after their tour of duty on that continent. In other words, there was an increased vasoconstriction in the extremities of subjects exposed to cold conditions. He also noted a relative deficiency of vitamin C in these men.

After fortifying the diet of these men with fresh vitamin C-rich fruit and vegetables, he observed a significant increase in the CIVD response. In a group of 11 soldiers, Livingstone found that the average temperature of the middle left finger immersed in ice water after Arctic maneuvers (two weeks in sub-freezing cold) was significantly higher than before the maneuvers began. Vitamin C.

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according to Livingstone, had caused an increased blood flow which led to a heating of the skin surface.

Because of these findings, Livingstone (August, 1976) designed an experiment to observe the effect of 2000 mg of vitamin C each day for one month on the CIVD response. The skin temperature of the middle left finger was recorded each minute in four subjects before and during its immersion in ice-water (0°C, 32°F) for 30 minutes. A second set of measurements were recorded standing in Arctic clothing for 30 minutes at -23°C (-9°F) with the hands bared. Again the middle left finger temperature was recorded each minute. After being off the vitamin C supplement for six weeks, these measurements were recorded again.

Livingstone observed that, in all four subjects, CIVD response induced by cold water and cold air was increased by vitamin C and was decreased after removal of the supplement. He noted that this preliminary experiment is evidence that vitamin C intake plays an important role in the extent of vasodilation response on exposure to cold.

These results prompted Livingstone to recommend vitamin C supplements with military rations for outdoor operations in cold weather.

A group of Russian scientists led by V. M. Krasnopevtsev reported to The IV International Symposium on Circumpolar Health (2-7 October, 1978, Academic City. Novosibirsk, Siberia) that a large quantity of vitamin C, Bl and thiamine are needed for effective adaptation in the extreme North (Krasnopevtsev et al., 1980).

Heat Tolerance

At the other end of the thermic scale, a common heat-induced malady is prickly heat (miliaria, miliaria rubra, lichen tropicus, sudamina). During World War II, this condition caused almost universal distress among our troops in the South Pacific. The intense itching, paresthesias and burning interfered with concentration and sleep, while secondary infection of excoriated areas at times caused temporary disability. The same skin disorder in milder forms occurs widely in this country during summer months, particularly in infants.

Stern (1951) found that 300 to 500 mg of ascorbic acid daily gave dramatic relief to most patients. The itching cleared and the rash subsided, usually within 30 minutes and these effects lasted for six to 24 hours. Although he did not analyze the blood or urine for vitamin C initially, Stern indicated that none exhibited signs of clinical deficiency.

During the summer of 1950, Pawley and Berry of Coachella, California (a desert bordering community) tested the effect of vitamin C on patients with prickly heat. Adults received 500 mg daily by mouth and infants (eight pounds and under) were given 100 mg. Itching was relieved and the rash cleared in every case. Yet none of these people exhibited signs of clinical vitamin C deficiency (Stern, 1951).

Hindson (1968) was first drawn to the efficacy of vitamin C in the treatment of prickly heat while interviewing an Australian Air Force officer who had an acute intertrigin-ous dermatitis in the groin area secondarily infected with monilia. The patient reported that he had the rash for a year previously and that it was resistant to all forms of therapy. However, it cleared up while taking 1000 mg of ascorbic acid daily for a week which he believed beneficial for a cold. Since no effective therapy was known to Doctor Hindson, he placed the officer on one gram of vitamin C daily as the sole treatment. Ten days later, Hindson reported that upon examination "his groin was normal."

Ascorbic acid was then administered by Hindson (1968) to five children with severe recurrent prickly heat in proportion to their weight. While on this treatment, there were no further attacks of prickly heat.

These findings prompted Hindson (1968) to carry out a double-blind trial of ascorbic acid in 30 children (four months to eight years old) with heat rash. The dosage (15 mg/kg) was calculated to the nearest 25 mg and based on the observation with the Air Force officer who weighed 154 pounds and was taking one gram daily. Where a child was too young to swallow vitamin C tablets, the parents were instructed to administer them crushed with food. Of 15 children given ascorbic acid for two weeks, 14

improved and 10 of these were free from lesions. Improvement occurred in only four (two of these free of lesions) of the 15 given a placebo. All 30 were then given vitamin C and no further rash was noted during the next two months. Their history prior to this experiment revealed that they suffered from multiple attacks of heat rash each summer.

Although the mechanism of action of ascorbic acid in prevention of prickly heat is not clearly established, it appears to exert its therapeutic action by reducing sweat-gland fatigue. Thus, vitamin C may take over the action of or replenish some fatigued enzyme system such as the succinic-dehydrogenase system which has been shown to be the first to disappear on excess sweating.

To explore this concept, Hindson and Worsley (1969) induced sweat-gland fatigue by wrapping one arm of 36 apparently healthy servicemen for 48 hours in a plastic bandage. Eighteen subjects were given one gram of ascorbic acid daily and 18 received a placebo.

One week after unwrapping the arms, 17 placebo subjects still had clinical evidence of hypohidrosis. Ten of these were still classified as marked hypohidrosis. In the vitamin C group, however, only slight hypohidrosis could be detected in two of the 18 subjects.

Poda (1979) recently cited two case reports which illustrate the regulatory role of vitamin C in heat acclimatization.

Following a heatstroke in 1951, a salesman subsequently would become weak and shocklike if the temperature rose to more than 29.5°C (85°F). Since air conditioned cars were not common then, he could not conduct his sales work. Remembering a World War II army tale, Poda administered 100 mg of ascorbic acid three times daily. Even though temperatures stayed at between 32°C (90°F) and 40.6°C (105T). he was able to drive his non-air conditioned car and resume his regular work hours. Heat intolerance returned on several occasions when he forgot to take the vitamin C.

In 1970, a tennis professional who had had heat exhaustion found that he could not teach or play tennis between 10:00 a.m. and 4:00 p.m. Following Doctor Poda's instruction to take 500 mg of vitamin C once or twice daily, the tennis pro returned to his daily tennis routine.

Weaver (1948) has shown that ascorbic acid is an effective preventative against heat exhaustion in industrial workers exposed to high temperatures and humidity. The subjects were rayon plant workers who were regularly exposed to temperatures ranging from 95°F to 105°F. Many of these employees had previously suffered heat strokes.

During a 29 day period, in the summer of 1939, when the rayon plant's primitive air cooling system collapsed. Weaver administered 100 mg of ascorbic acid at 8:00 a.m. to a group of 31 male workers. A control group of 42 men continued to receive only the salt and dextrose tablets that were routinely administered to all workers. Not one of the 31 men receiving vitamin C developed symptoms of heat illness. However, in the control group of 42 workers receiving only salt and dextrose, there were nine cases of heat exhaustion.

Following this, Weaver introduced a factory-wide program whereby every worker was encouraged to take a vitamin C supplement. Records kept for the next nine years showed that heat exhaustion decreased as the employees realized the value of vitamin C. According to Weaver, there were 27 cases in 1938, prior to the institution of the vitamin C regimen, and none in the years since.

Heat acclimatization must be achieved before work or exercise can be performed at high environmental temperatures. Strydon and associates (1976) conducted a controlled study to determine whether vitamin C can speed up the adaptation to heat in 60 mining recruits. Of this group, 19 received 250 mg of ascorbic acid daily: 21 received 500 mg once daily; and 20 received a placebo tablet daily.

On the first day, in a comfortable environment, the subjects performed a prescribed exercise program for four hours. Then, for the next ten days this was repeated in a hot, humid climate chamber. Acclimatization was assessed by recording the rectal temperature at 0, 1, 2, 3, and 4 hours of exercise each day. The subjects receiving 250 or 500

mg of ascorbic acid daily achieved an optimal 4th hour rectal temperature of 38.2°C (101°F) in 5.7 days. There were no differences in the two levels of supplementation. Placebo subjects, however, required 6.7 days for heat adaptation. Statistical analysis showed that acclimatization was significantly faster ($p < 0.05$) in the vitamin C group. The authors' analysis also showed that a significant proportion of the vitamin C groups (35 percent) attained an optimal body temperature in three to four days (mean 3.5 days). Only one subject (5 percent) in the placebo group adapted to the heat in a period of four days and some did not achieve acclimatization in ten days.

Conclusions

This review of human evidence concerning a relationship between the body's vitamin C status and its tolerance of heat and cold indicates that this nutrient is operative at both ends of the thermal spectrum.

According to the published evidence, vitamin C enhances cold tolerance by increasing cold-induced vasodilation. This warms the exposed skin surface by enhancing blood flow through it.

Heat tolerance is, reportedly, improved by abolishing heat rash. The mechanism is thought to be a reduction of sweat-gland fatigue. Through this and/or other mechanisms, vitamin C has been shown to be effective in enhancing heat acclimatization; and, as a preventative agent for heat exhaustion.

The information cited provides a research base for the clinical application of ascorbic acid in thermal tolerance.

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