

### Thiamin in Sweat.

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It is now well known that thiamin requirements are increased with diuresis, exercise, exposure to high temperature, and the administration of thyroid. For this reason we thought it desirable to study the possible loss of thiamin in the sweat as part of a problem on the causation of fatigue. Several authors have published papers on the excretion of various crystalloids in the sweat. The excretion of ascorbic acid was first noted by one of us in 1934 and reported in 1935 at a meeting of the Chicago Tuberculosis Society. Later quantitative estimations were made of ascorbic acid in the sweat by Cornbleet, Klein, and Pace;<sup>1</sup> also by Wright and MacLenathen.<sup>2</sup> The weight losses as a result of sweating have interested many investigators. Snapper and Grunbaum<sup>3</sup> report a loss of 1 to 2 kg in 2 hours of football. Krestownikoff<sup>4</sup> found a sweat loss of 350 to 1530 g per hour in heavy work under ordinary temperatures. Bock and Dill<sup>5</sup> in their research at Boulder City found that physical activities at high temperatures produced great losses of chlorides as well as water from the body—as much as 20 lb of sweat in a 7 hour period. Caspari and Schilling<sup>6</sup> pointed out that subjects living in the tropics may eliminate as much as 3 to 4 kg of sweat a day even when they do not feel any sensible perspiration.

Our first studies were undertaken in a room with a temperature of 160°F, on 4 normal male subjects, one of whom had taken about 50 mg of thiamin one hour before entering the hot room. A pooled sample of about 25 cc of sweat was taken from these 4 individuals; when tested for thiamin, it contained approximately 1.5 $\mu$ g per cc.

Following this observation, experiments were performed with 24 football players from Concordia College in River Forest, Illinois. The men were divided into 4 groups of 6 each. The men in 2 of the groups were given 50 mg of thiamin chloride and 750 mg of ascorbic

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<sup>1</sup> Cornbleet, T., Klein, R. I., and Pace, E. R., *Arch. Dermat.*, 1936, **34**, 253.

<sup>2</sup> Wright, I. S., and MacLenathen, E., *J. Lab. and Clin. Med.*, 1939, **24**, 804.

<sup>3</sup> Snapper, L., and Grünbaum, A., *Bioch. Z.*, 1929, **206**, 319.

<sup>4</sup> Krestownikoff, A. N., *Z. ges. exp. Med.*, 1930, **74**, 200.

<sup>5</sup> Bock, A. V., and Dill, D. B., *New Eng. J. Med.*, Oct. 31, 1933.

<sup>6</sup> Caspari, W., and Schilling, C., *Z. Infektkr. Hyg.*, 1921, **91**, 57.

acid by mouth previous to football practice (fortified group). The men in the other 2 groups were given no additional vitamins (unfortified group). Each subject was weighed, a complete specimen of urine was obtained, and 10 cc of blood were withdrawn before the practice. At the end of one hour of scrimmage Groups I (unfortified) and II (fortified) returned to a warm room, about 80°F, were given 2 cups of warm tea, immediately stripped to the waist and the sweat collected from the chest anteriorly and posteriorly. Groups III (unfortified) and IV (fortified) remained at active scrimmage 30 minutes longer. Another complete specimen of urine was obtained, together with 10 cc of blood, and they were weighed again. The sweat was pooled for each group to insure a sufficient quantity for duplicate determinations.

The analyses for thiamin were made according to a technic based upon the fluorometric determination of thiochrome. Ascorbic acid was titrated with indophenol and read directly and by means of an electro-photometer.

From our findings thus far, (Table I), certain inferences may be drawn.

1. In Group I (unfortified) the concentration of thiamin in the sweat is double that of the urine after 1 hour of exercise. In Group III (unfortified) that had  $\frac{1}{2}$  hour additional exercise the concentrations in both urine and sweat were slightly lowered, but the sweat concentration was still double that of the urine.

2. In Group II (fortified) after 1 hour the sweat concentration was 71 times the concentration of the urine. In Group IV (fortified) that had  $\frac{1}{2}$  hour of additional exercise the concentration of the thiamin in the sweat was only 8.5 times that of the urine.

3. Since the concentration of thiamin in the sweat in Group III (unfortified) which exercised  $\frac{1}{2}$  hour longer is less than in Group I (unfortified), one may conservatively estimate the total loss in sweat on the basis of Group III. Since the average weight loss in this group was 1.13 kg and the concentration was 82.5 micrograms per liter, the total loss would be 93.2  $\mu\text{g}$  in  $1\frac{1}{2}$  hours of sweating. This may be compared with the urine sample collected in the same period which contained 4.6  $\mu\text{g}$  in 107 cc. In 170 cc of urine collected before exercise there were 7.6  $\mu\text{g}$  excreted in this group. Hence the excretion of thiamin in sweat does not seem to be compensated for by appreciable diminution in the urine.

4. In the fortified groups the concentration of thiamin in the sweat in Group II was 10 times the concentration in the sweat in Group IV, showing a great pouring out of thiamin early in the sweat period. No estimation of total loss is therefore possible by this method.

TABLE I.  
The Average Results for Each Group of Subjects.

Group	Vitamins given	Urine 1			Urine 2		
		Vol., cc	Ascorbic acid,		Vol., cc	Ascorbic acid,	
			mg/L	thiamin, $\mu\text{g/L}$		mg/L	thiamin, $\mu\text{g/L}$
I	0	157	21	45.7	117	21.6	41.6
II	C, B <sub>1</sub>	164	39.5	46	107	93.9	63.6
III	0	170	15.2	45	107	26.7	41.6
IV	C, B <sub>1</sub>	200	9.07	42	141	21.8	52.3

  

Group	Vitamins given	Blood 1		Blood 2		Sweat		wt loss, kg
		Ascorbic acid, mg/L	thiamin, $\mu\text{g/L}$	Ascorbic acid, mg/L	thiamin, $\mu\text{g/L}$	Ascorbic acid, mg/L	thiamin, $\mu\text{g/L}$	
II	C, B <sub>1</sub>	0.84	7.41	0.78	14.15	3.59	4540	1.15
III	0	0.53	7.60	0.61	11.40	1.76	82.5	1.13
IV	C, B <sub>1</sub>	0.67	7.71	0.62	15.40	4.66	445	1.16

Group I and II (unfortified) were not given vitamin C and B before exercise.

Group II and IV (fortified) were given 750 mg of ascorbic acid and 50 mg of thiamin before exercise.

Group III and IV exercised  $\frac{1}{2}$  hour longer than Group I and II.

5. The thiamin in the blood tended to rise with sweating, especially in the fortified groups where the concentration was practically doubled.

6. The average concentration of thiamin in the sample of urine and blood collected from the subjects studied would indicate a probable low normal intake. There was a slight rise in the fortified groups and a slight decrease in the unfortified groups, indicating body loss mostly through sweat.

Ascorbic acid studies indicate that the subjects are on a low normal ascorbic acid diet. There was a slight elevation in the urine after sweating, especially in the fortified groups where the concentration was practically double. In the blood the ascorbic acid remained practically at a constant level with the sweating, and did not change after exercise or after fortifying the subjects with additional amounts by mouth. In the fortified groups the concentration of ascorbic acid in the sweat was slightly higher in the group that exercised  $1\frac{1}{2}$  hours than in the 1-hour group in contrast to thiamin. This suggests that the peak of ascorbic acid excretion may be reached later than thiamin or may be due to slower absorption of ascorbic acid. In the unfortified group that had exercised  $1\frac{1}{2}$  hours the concentration is lower than the group that exercised 1 hour, suggesting that the peak of excretion had passed. The concentration of ascorbic acid in the urine is roughly 5 to 10 times that in the sweat, but the actual

amount of ascorbic acid excreted during the exercise is roughly the same.

Thiamin is normally excreted in appreciable amounts in the sweat. Since a man may readily sweat (moderate temperature and work) 2 to 3 kg daily without visible perspiration, he may thus lose in the sweat from 5 to 15% of ingested thiamin. In a like manner, a person undergoing hard work at elevated temperatures may lose enough thiamin to cause serious physiological consequences. Our work indicates that the increased excretion of thiamin in sweating is not compensated for by a diminution of the urinary thiamin.

The relationships of the above inference to the problem of work and fatigue are obvious. Clinical studies concerning certain cases of apparently abnormal vitamin requirements are also indicated.

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### Experimental Transmission of Saint Louis Encephalitis to White Swiss Mice by *Dermacentor variabilis*.

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In studies of Russian encephalitis various investigators<sup>1-6</sup> have reported observations which indicate that *Ixodes* ticks play an important part in the epidemiology of the disease. Laboratory experiments conducted by some<sup>4, 6</sup> of these workers demonstrated that members of the genus, *Ixodes*, are capable of transmitting the virus to susceptible animals during larval, nymphal, and adult stages of the life cycle. There was considerable evidence also that the infected

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<sup>1</sup> Editorial, *J. A. M. A.*, 1941, **117**, 1361.

<sup>2</sup> Smorodintseff, A. A., *Arch. f. Ges. Virusforsch.*, 1940, **1**, 468, quoted by 1.

<sup>3</sup> Rijov, N. V., and Skrynnik, A. N., *Report of the All-Union Congress of Microbiology*, 1939 (Jan. 25-31), quoted by 1.

<sup>4</sup> Pavlovsky, E. N., *Report of the All-Union Congress of Microbiology*, 1939 (Jan. 25-31), quoted by 1.

<sup>5</sup> Chumakov, M. P., and Seitenok, N. A., *Science*, 1940, **92**, 263.

<sup>6</sup> Shubladsse, A. K., and Serdinkova, G. V., *Arch. Soc. Biol.*, 1939, **56**, No. 2.