EFFECT OF NERVOUS STRESS ON SOME ASPECTS OF HUMAN METABOLISM

Yu. F. Udalov and A. G. Shibuneev

(Presented by Active Member AMN SSSR V. V. Parin)

Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 56, No. 11, pp. 61-64, November, 1963
Original article submitted March 27, 1961

The study of metabolism during nervous stress is of exceptional importance to therapeutic and prophylactic medicine, and it has constantly attracted the attention of research workers [1, 3, 6].

The work of a pilot is characterized by low energy expenditure and considerable mental and emotional stress. Considerable emotional and mental stress is observed in pilots during trials of new aviation techniques and test flights. We have studied the basal metabolism (by the method of Douglas and Haldane) and the dynamics of the changes in the blood sugar and blood cholesterol concentrations and the elimination of neutral 17-ketosteroids in the urine. Together with the study of the principal physiological functions (pulse, respiration, ECG), these indices are of interest for their own account and also as providing confirmation of the presence of a state of physiological stress. A detailed study was made of the metabolism of vitamins C, B_1, B_2, PP, and B_6.

EXPERIMENTAL METHOD

Investigations were conducted on seven subjects; observations were made for a period of 56 days, on 35 of which test flights or trials of new techniques were made, and the other days were used as controls. The subjects received standard diets, the same on every day of the investigation. The blood sugar and cholesterol levels were determined by the usual methods [4]. The level of the neutral 17-ketosteroids in the urine was determined after precipitation and ether extraction colorimetrically by their color reaction with metadinitrobenzene in an alkaline medium. A calibration curve was plotted in respect to androsterone solution. An index of vitamin metabolism was the 24-hour excretion of vitamins C, B_2, B_1, N_1-methylnicotinamide and 4-pyridoxic acid in the urine. Vitamin B_1 was determined by the thiochrome method, vitamin B_2 by the lumiflavine method, and N_1-methylnicotinamide and 4-pyridoxic acid by the method of Naff and Perlzweig. When these methods were used the degree of fluorescence was estimated by means of the "Moskip" fluorometer. Vitamin C was estimated by titration with 2,6-dichlorophenolindophenol.

In one series of investigations the excretion of vitamins and their derivatives was calculated, not in a 24-hour specimen of urine, but per gram of creatinine determined in the particular urine sample. Our previous investigations showed that this method has definite advantages when studying the effect of occupational stresses on vitamin metabolism [2, 5].

EXPERIMENTAL RESULTS

The basal metabolism on flying days (69.5 ± 2.2 Cal/h) was slightly higher than on nonflying days (63 ± 1.7 Cal/h).

The figures given in Table 1 demonstrate that the blood sugar was significantly elevated on flying days. This may be attributed primarily to nervous and emotional stress in the pilot, for the greatest increase in the sugar level was observed in the period preceding the flight.

After the flights the blood cholesterol level was substantially raised. This fact is of considerable interest, for clinicians observe a disturbance of cholesterol metabolism more frequently in persons whose occupation entails frequent nervous and emotional stress.

It may be seen from Table 2 that on flying days the excretion of 17-ketosteroids in the urine was increased, and this, in turn, indicated the presence of physiological stress. Our observations agree with information in the literature reporting an increase in the blood corticosteroid level during high velocity flights [7].

TABLE 1. Changes in Blood Sugar and Cholesterol Levels in Relation to Flying Duties

Conditions of investigation	Time of taking samples	Sugar	Cholesterol
		in mg%	
Flying days	Before flights (morning)	151±10	152±2.5
	After flights (afternoon)	116±5.1	190±1.9
Nonflying days	Morning	105±7.7	153±10.9
	Afternoon	85±6.0	148±8.2

These results demonstrate the presence of some degree of physiological stress, so that the study of the changes in vitamin metabolism in persons on a standard diet may be used to demonstrate the effect of nervous stress on vitamin metabolism.

The 24-hour excretion of vitamins B_1 and B_2 in the urine, and also of 4-pyridoxic acid and N_1-methylnicotinamide, were appreciably lower on flying days than on days with no flying (Table 3).

To obtain direct factual evidence of the influence of nervous and emotional stress on vitamin metabolism,

TABLE 2. Excretion of Neutral 17-Ketosteroids in the 24-Hour Urine on Days Differing in the Character of Their Activity

Conditions of investigation	Neutral 17-ketosteroids (in mg)
Flying days	19.5±1.1
Nonflying days	15.3±1.2

TABLE 3. Excretion of Vitamins in the 24-Hour Urine on Days Differing in the Character of their Activity

Conditions of investigation	Vitamin B_1 (in μg)	Vitamin B_2 (in μg)	N_1-methylnicotinamide (in mg)	4-pyridoxic acid (in μg)
Flying days. .	9±0.54	23±2.4	4.9±0.4	1100±50
Nonflying days	13±1.0	52±9.4	6.76±0.7	1300±120

we modified the experimental method and determined the excretion of vitamins on days when the subjects were exposed to considerable nervous and emotional stress, and on days without such stress (controls). Collection of urine on days of exposure to stress ceased immediately before the work and were resumed after the work was completed. To make the results comparable, the values of excretion of vitamins and their derivatives were calculated per gram of creatinine, estimated at the same time in the particular urine specimen by Folin's method.

The fact that the work was accompanied by considerable nervous and emotional stress is demonstrated by the increase in the pulse rate from 72-84/min 1 h before the work to 108-160/min immediately before it began. Changes of a similar character were observed when the respiration was recorded. The respiration rate rose from 16-20/min 1 h before the work to 30-42/min immediately before starting.

TABLE 4. Changes in Vitamin Metabolism under the Influence of Nervous Stress

Subject	Time of observation	Excretion in urine per gram creatinine				
		vitamin C (in mg)	vitamin B_1 (in μg)	vitamin B_2 (in μg)	N_1-methyl-nicotinamide (in mg)	4-pyridoxic acid (in μg)
S-n	Control	3.1	58	146	13.1	943
	Before work	0.32	31	42	11.4	819
	After work	0.167	29	34	2.79	727
S-v	Control	3.36	87	90	13.4	506
	Before work	2.05	39	39	2.9	342
	After work	1.33	45	23	2.7	268
E-n	Control	2.79	378	172	19.4	1017
	Before work	2.51	31	33	5.5	986
	After work	2.4	28	42	1.22	794

The ECG taken shortly before starting the work revealed sinus tachycardia with no change in the character and amplitude of the waves.

The results given in Table 4 demonstrate a fall in the values of the indices of vitamin metabolism immediately before the work, giving direct evidence of the influence of nervous stress on vitamin metabolism. It is interesting to note that after the work was over the indices of metabolism of vitamins C, B_6, and PP continued to fall, whereas the excretion of vitamins B_1 and B_2 was unchanged.

The changes in vitamin metabolism in the period before the work could not be associated with changes in the creatinine metabolism, for its excretion in the urine on days when different activities were performed was practically the same. For instance, on control days, the mean creatinine excretion was 1.39 ± 0.06 g, compared with 1.42 ± 0.07 g on days on which the subject had to perform the work.

The fact that changes in certain aspects of metabolism and in certain physiological functions arise, not only as a result of the action of the occupational factors of flying duties, but also during the period preceding these duties, suggests that some of the metabolic changes which we have found are directly associated with the nervous and mental state of the subjects.

SUMMARY

Metabolic changes (a rise of the BMR, of the blood sugar level and of the 17-ketosteroid urinary excretion) pointing to the presence of nervous strain were noted during flights and air plane equipment tests.

In these conditions there was also a rise of the blood cholesterol level and a reduction of the metabolic indices of vitamins C, B_1, B_2, PP, and B_6. This, in turn, indicates their increased expenditure during nervous strain.

LITERATURE CITED

1. V. M. Vasyutochkin, Abstracts of Proceedings of the 13th Scientific Session of the Institute of Nutrition, USSR Academy of Medical Sciences [in Russian], p. 18, Moscow (1959).
2. R. V. Kudrova, M. I. Kuznetsov, and Yu. F. Udalov, Abstracts of Proceedings of the Fourth All-Union Conference on Vitamins [in Russian], p. 138, Moscow (1957).
3. O. P. Molchanova, Abstracts of Proceedings of the 13th Scientific Session of the Institute of Nutrition, USSR Academy of Medical Sciences [in Russian], p. 7, Moscow (1959).
4. O. V. Travina, Textbook of Biochemical Investigations [in Russian], Moscow (1955).
5. Yu. F. Udalov, Abstracts of Proceedings of the Fourth All-Union Conference on Vitamins [in Russian], p. 152, Moscow (1957).
6. B. H. Ershoff, Nutr. Rev. (1955), 13, p. 33.

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
