Reprinted from Archives internationales de Pharmacodynamie et de Thérapie
Vol. 199 - No. 2 - October 1972

Excretion of Amphetamines in Human Sweat

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Abstract—Amphetamine-like compounds are excreted in sweat of human subject whose sweat production was stimulated by forced labor. This excretion is largely independent on sweat pH. Analysis of sweat may therefore be used in doping control.

Introduction

Electrolytes present in the blood, as sodium, chloride, bromide, iron, are to the same extend excreted by the sweat gland (1, 2). Also various organic compounds as urea and mucus are present in human sweat (3, 4). Several exogenous compounds as sulphonamide, hexamine, bromide are excreted by the sweat gland (5).

Sweat originates from the bloodplasma while its composition is mainly determined by reabsorption and exchange mechanisms (8). The pH of sweat may differ considerably in different individuals (1). The production of sweat and urine are to some extend related processes. It is therefore of importance to do a comparative study on the excretion of amphetamines in sweat and urine.

Since athletes, cyclists etc. produce a large amount of sweat, a doping control could also be done by analysis of sweat, provided that the doping agents are excreted in sweat.

Methods

L-dimethylamphetamine HCl, in contrast to D-dimethyl-amphetamine, a relative non-toxic, non-stimulating amphetamine, was given to healthy subjects as an oral dose of 20-25 mg. Sweating was stimulated at regular intervals following ingestion of the drug by letting the subjects make exercises on a bicycle ergometer (Table I). During 10 min of sweating, sweat was rapidly collected from the forehead and the back of the subject. In each sweat trial 3-10 ml sweat were collected. Simultaneously the urine was collected for a period of 60 hr.

TABLE I

Subject	Time[1] (hr)	ml	Sweat[2] pH	μg/ml L-methamphetamine	μg/ml L-dimethylamphetamine	Weight[3] Loss (kg)	Watt[4]	Rotations[5]	Time of[6] excretion
T.V.	1.30	10	4.85	0.118	1.38	0.600	150	80	20 min
dose	5.30	8	4.70	0.75	4.27	0.274	150	80	20
20 mg	8.30	8	4.65	0.50	2.66	0.210	150	80	20
85 kg	25.25	7	4.70	0.21	0.33	0.235	150	80	20
	32.00	7	4.60	0.19	0.29	0.230	150	80	20
	54.00	7	4.50	0.04	—	0.230	150	80	20
C.G.	3.10	3	6.90	0.25	2.50	0.200	150	80	25 min
dose	7.00	3	7.35	0.33	2.70	0.200	150	80	25
25 mg	24.00	4	7.50	0.17	0.49	0.180	150	80	25
80 kg	28.00	5	7.80	0.07	0.16	0.240	150	80	25

[1] Time after ingestion of the drug. [2] The sweat pH is measured in the collected sweat. [3] Weight loss of the subject during the excersise. [4] Load of the bicycle ergometer. [5] Velocity of bicycle ergometer. [6] Time course of sweat production.

L-dimethylamphetamine and its possible metabolite, L-methamphetamine, were determined quantitatively by gas-liquid chromatography (Fig. 1). For details is referred to Vree *et al.* (6, 7).

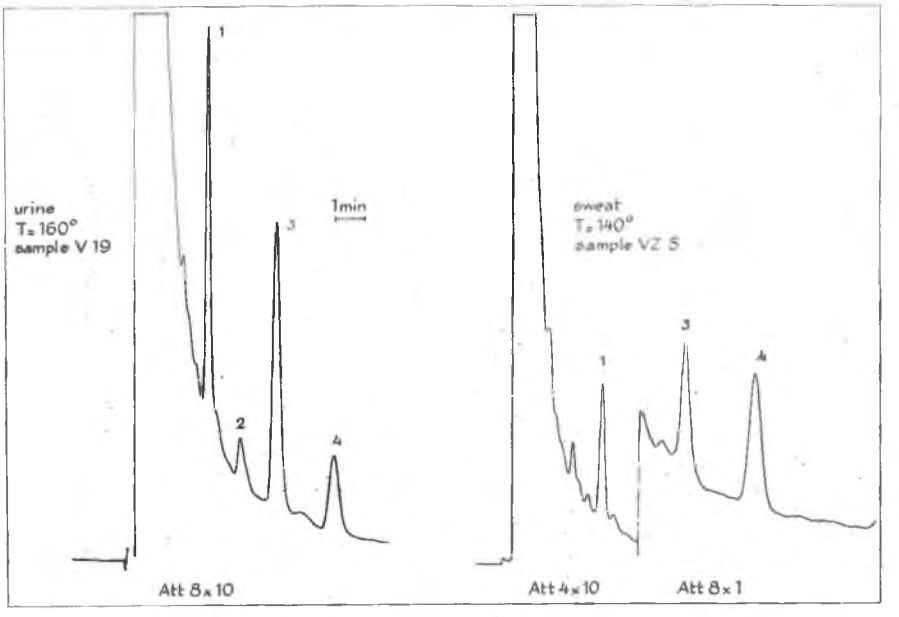

FIG. 1

Gaschromatogram of urine and sweat extract.

Compound 1 is the internal standard (10 μg), compound 2 represents the metabolite L-amphetamine, compound 3 the metabolite L-methamphetamine and compound 4 represents L-dimethylamphetamine.

The urine sample V19 is taken 30 hr after the intake of 20 mg of L-dimethylamphetamine HCl. The sweat sample VZ5 is taken 32 hr after the ingestion of the drug.

The identity of the parent drug and its metabolite was checked by analysis of mass-spectra by using the combined gaschromatograph-mass-spectrometer (L.K.B. 9000). Typical mass-spectra are given in Fig. 2 and 3. Characteristic for dimethyl-amphetamine is the base peak of mass 72 and for the metabolite methamphetamine that if mass 58.

Typical excretion curves both with respect to urine and sweat are presented in Fig. 4.

Results and Discussion

L-dimethylamphetamine, as well as its metabolite L-methamphetamine, is excreted in sweat of human subjects (Fig. 4). Following ingestion of 20-25 mg of this amphetamine analogue, the maximum concentration in sweat is in the

order of 2-4 μg/ml. The concentration of these drugs in sweat increases during the first few hours after ingestion, while from 6 hr on there is a gradual decrease of the concentration. The concentration of the parent drug and its metabolite in

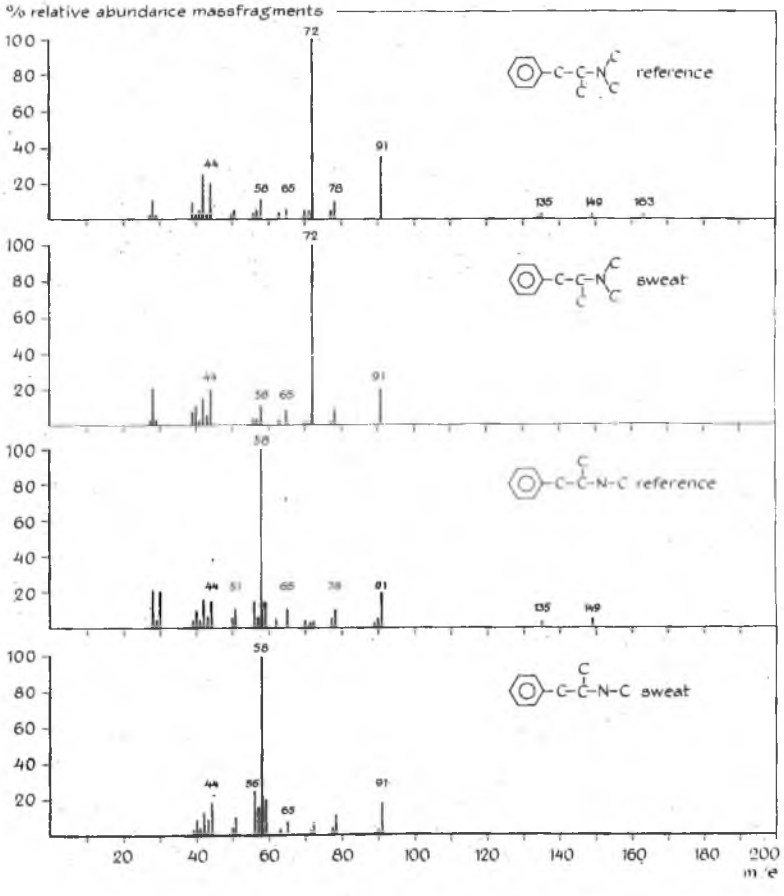

FIG. 2

Mass-spectra of L-dimethylamphetamine and L-methamphetamine. The mass-spectrum of L-dimethylamphetamine as reference compound is identical with the mass-spectrum of the compound extracted from the sweat. The same holds for the metabolite L-methamphetamine.

sweat parallels the rate of excretion in the urine. The concentration of dimethylamphetamine in the sweat of subject C.G., 7 hr after ingestion, was 2.7 μg/ml (Table I), while in the urine the average concentration during the period 5 hr after injection was 2.88 μg/ml. At that time the pH of the sweat was 7.35, while the pH of the urine then was 5.30. So although the pH of the two fluids differ by 2 pH units, the concentration of the amphetamine is in the same order of magni-

tude. Both subjects received ammoniumchloride in order to keep the pH of the urine around pH = 5. Nevertheless, in the one subject the sweat pH remained high (Fig. 4). Tentatively it may be concluded that the pH of the sweat can less easily be changed by intake of acidifying substances than the urine pH.

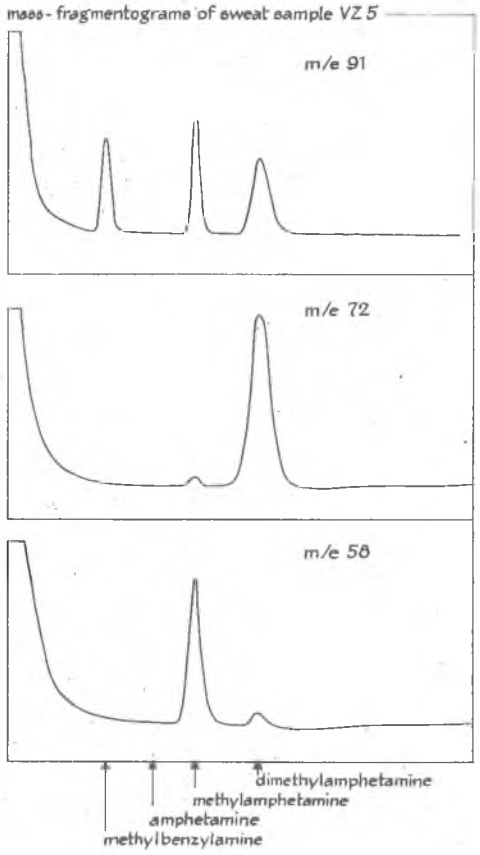

FIG. 3

Mass-fragmentograms of the sweat sample VZ5. With the L.K.B. 9000 combined gaschromatograph-mass spectrometer the single ion m/e 91, m/e 72 and m/e 58 is recorded. The retention times found for L-dimethyl- and L-methamphetamine are identical with those of the reference compounds.

Probably the sweat pH is for each person a typical function of the blood pH. Excretion of amphetamine-like compounds in human sweat is largely independent on sweat pH.

Extensive studies have been made with regard to the excretion of amphetamine and amphetamine-like compounds in the urine of a large number of human

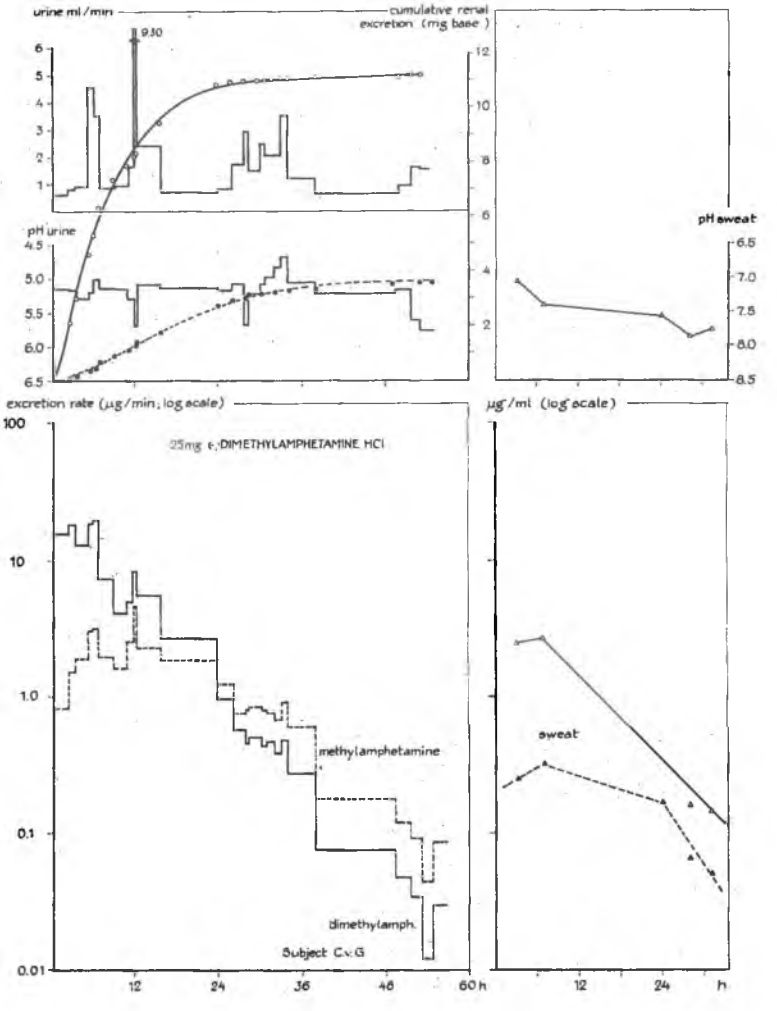

FIG. 4

Renal excretion rate of L-dimethylamphetamine and the metabolite L-methamphetamine. Sweat concentration in µg/ml of L-dimethylamphetamine and L-methamphetamine. Urine and sweat production, urine and sweat pH, cumulative renal excretion.

The drawn lines represent the L-dimethylamphetamine excretion rate in the urine and the concentration in the sweat (△). The dotted lines represent the metabolite L-methamphetamine in urine and sweat (▲).

subjects (9). However, only recently has been shown that the excretion in the urine and saliva parallels the bloodconcentration decay curves (11, 10). In this study it has been shown that the excretion curves of amphetamine in sweat follow the same pattern as that in the urine.

Analysis of human sweat or of sweat in the shirt of an athlete immediately after the athletic performance may be used as a means of doping control.

Acknowledgments—The authors thank Dr. R. A. Binkhorst, Department of Physiology, University of Nijmegen, for technical assistance with the bicycle ergometer and Dr E. Seutter, Department of Dermatdogy, Univ. of Nijmegen, for critical comments.

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Received November 16, 1971.

Printed by the St Catherine Press Ltd., Tempelhof 37, Bruges, Belgium.