SWEAT COLLECTION FROM ATHLETES

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ABSTRACT

The difficulty in taking sweat during heavy physical exercise has drawn the authors into testing a technique of sampling generally used in paediatrics. The fact that the results, which have been dealt with statistically, should coincide with the physiological facts already published allows us to consider a use of the technique in order to investigate the physiological mechanisms in action during sweating under different metabolic conditions.

Key words: Sweat, Exercise, Sampling.

INTRODUCTION

The great technical precision of taking sweat samples by micropuncture has enabled the analysis of the metabolites excreted by the eccrine sweat glands during sweating (Burg and Orloff, 1970; Sato, 1979). Using these techniques, several reports by Sato and Sato (1978) and Sato (1980), by Cage and Wolfe (1970) and by Kuno (1965) have been the origin of experimental models seeking to explain the physiological mechanisms of secretion and reabsorption of metabolites. These studies of an elaborate technical nature are carried out on men or animals from isolated tissues or directly on the person subjected to variations in temperature.

With the miniaturisation of these sampling methods one cannot at present follow an athlete under effort conditions with the aim of taking sweat samples. The technique which we propose in this work is often used in paediatric medicine to measure out the quantity of chloride in sweat. The aim of this work is to show that the observed phenomena during micropunctures can be found again with the use of this method and thus prove its validity. Having observed good results encouraged us to carry on the research on athletes practising physical exercises under different metabolic conditions.

METHODS AND SUBJECTS

Methods

The sweat is taken on the subject's forehead which has been washed with distilled water and dried (Pilardeau, 1979, 1980). The sweat is collected on an absorbent paper whose composition cannot interact with the products to be measured.

The sample is weighed immediately and eluted in 10 ml of distilled water.

The surface of paper is 4 cm². It is held in place for 30 min with a plastic cover and adhesive tape. The average number of glands thus concerned is 1080 ± 100 (Szabo, 1959). The sodium and potassium content is measured by spectrophotometry and chloride by colorimetric assay.

Subjects

The subjects who volunteered for this study were 32 trained walkers (training twice a week). The average age was 29 ± 3 years.

The samples were taken after two hours' exercises (30 min collection time on the forehead).

The kind of exercises during the experiment are the same as the ones in competition, under an outside temperature of 18°C.

RESULTS

TABLE I
Concentration and flow in Na⁺, K⁺ and Cl⁻ in sweat during exercise

	Sodium Na ⁺ Concentration mEq/l ⁻¹	Potassium K ⁺ Concentration mEq/l ⁻¹	Chloride Cl ⁻ Concentration mEq/l	Sweat Flow nl.gl. ⁻¹ mn ⁻¹	Flow in Na ⁺ 10 ⁻⁶ mEq.gl ⁻¹ mn ⁻¹	Flow in K ⁺
$\bar{X}$	78.3	7.6	73.2	12.9	1.097	0.091
S.D.	35.0	4.1	34.0	8.5	1.048	0.062

TABLE II
Concentration in Na⁺/Concentration Cl⁻, in sweat correlation between Na⁺ flow, K⁺ flow and Sweat flow

(Na ⁺) = 0.93 (Cl ⁻) + 10	r = 0.90	p < 0.01
Na ⁺ flow = 0.101 Sweat flow - 0.217	r = 0.83	p < 0.01
K ⁺ flow = 0.0064 Sweat flow + 0.06	r = 0.89	p < 0.01

DISCUSSION

The sweat excreted at the level of the terminal part of the collecting tube is classically hypotonic (Sato, 1979) and the concentrations of Na⁺, K⁺ and Cl⁻ vary according to the volume (Sato, 1979).

Na⁺ 20 mEq/l — 135 mEq/l
K⁺ 3.5 mEq/l — 35 mEq/l
Cl⁻ 10 mEq/l — 100 mEq/l

The sodium concentration at the level of the eccrine cell is isotonic (Slegers, 1966) in relation to the plasma. During its passage into the tubule, the sodium is reabsorbed along with the chloride or against potassium or proton (Mangos, 1973). Its concentration relative to the skin is therefore still hypotonic.

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When the volume of sweat increases, reabsorption reaches its peak, then the concentration of sodium in the sweat increases progressively (Sato, 1970). The concentration in potassium in sweat is hypertonic in relation to the plasma (mechanism of excretion coupled or not with the reabsorption of sodium). The concentration in chloride is lower in sweat than in the plasma because of the passive reabsorption ($\text{Na}^+ - \text{Cl}^-$) and perhaps of an active mechanism too (Frizzel et al, 1975).

In our study we can see (Table I) that the average values in sodium, potassium and chloride are usually the same as those we find when done with techniques using micro-puncture.

The flow in sweat calculated on eccrine gland corresponds to the flows given by Sato et al (1970) and Cage and Dobson (1965) (0 to 40 $\text{nl} \cdot \text{gl}^{-1} \cdot \text{mn}^{-1}$). The calculated flows in sodium, potassium and chloride are coherent too if they are expressed in $10^{-6} \text{mEq} \cdot \text{gl}^{-1} \cdot \text{mn}^{-1}$. Taken separately the values of the concentration and flows of these metabolites are similar whatever the method of sampling.

We then compared the excretion of these metabolites with each other to make sure that the physiological principles described by Schwartz and Thaysen (1955) could apply equally to this technique. Concentration in Na^+ /Concentration in Cl^- (Table II): There is an excellent correlation between the concentration in sodium and chloride in the collected sweat. This phenomenon which can be explained by the parallel movements of sodium and chloride has been described by numerous authors amongst whom are Frizzel et al (1975).

Flow in sodium/Flow in sweat (Table II): The relation between both parameters is significant $p < 0.01$. We can note that on all the points the intersection of the straight line is in the negative part of the y axis (-0.217). According to different authors (Schwartz and Thaysen, 1955; Cage and Dobson, 1965) the value of the intersection of this straight line with the y axis corresponds to the flow in sodium reabsorbed by gland/mn.

The maximum value of this reabsorption rate is still being discussed but the value $0.217 \cdot 10^{-6} \text{mEq} \cdot \text{gl}^{-1} \cdot \text{mn}^{-1}$ is above this value which suggests that the Na^+ flow can still be much superior to the values found in this work.

Flow in K^+ /Flow in sweat (Table II): The flow in potassium increases when the sweat flow rises ($p < 0.01$) but in this case

the intersection of the regression straight line is in the positive part of the y axis. The value which is obtained ($+0.06 \text{mEq} \cdot \text{gl}^{-1} \cdot \text{mn}^{-1} \cdot 10^{-6}$) corresponds to the quantity of potassium excreted by the tube (Mangos, 1973; Sato, 1978, 1980).

We think that the arguments developed from these results are convincing enough to validate this technique which enables us to analyse (in a statistical way) under acceptable scientific conditions, the metabolic variations in sweat according to the type of exercise done (intensity, time . . .) and of the level of the athlete (quality of training).

In short, in this article we propose the use of a simple test of taking sweat whose results, dealt with in a statistical way, coincide with the physiological phenomenon already analysed by other workers. This good correlation allows us by this technique to examine the variations in the excretion of metabolites in sweat under different sporting conditions.

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