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Polarographic Measurement of the Oxygen Consumption of Skin *in Vivo*[1]

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Manometric measurements have shown that oxygen consumption of the skin is markedly changed by inflammatory diseases, neoplasms, hormonal influences, age, irradiation, and vesicants (*1–4*). The present study utilizes a polarographic method for estimating oxygen tension and oxygen consumption of human skin (*5, 6*). The results in normal skin are presented.

Polarographic measurement of cutaneous oxygen consumption is based on the observation that removal of oxygen supply by blanching the skin results in a rapid fall of the oxygen tension to very low levels in 1½–2 min. This is achieved by elevating the tip of an electrode, inserted intracutaneously, until enough pressure is applied to the overlying skin to force the blood out of a 5–6-mm² area (*6*). An estimate of the relative rates of the oxygen consumption of tissues can be obtained from the rate of fall of the oxygen tension.

One hundred and thirty experiments were performed within a 20-cm² area of the extensor surface of the left forearm of 3 healthy white male students. The electrodes were inserted into the skin to depths corresponding approximately to those of the epidermis and corium and into hair follicles. Control experiments were carried out on excised human skin stored for 4 days, and on the abdominal skin of an anesthetized dog after intradermal injection of 0.1 ml of 0.1 *M* sodium azide. Galvanometer readings were recorded every 15 sec throughout the experiment, following stabilization of the electrolysis current.

Elevation of the electrode tip results in a movement artifact, which consists of a partial fall of the electrolysis current. The first reading after the application of pressure was not considered in the evaluation of the experimental results because of the movement artifact.

The fall in oxygen tension in human skin, plotted against time on semilog paper, was found to approach a straight line. The oxygen consumption of normal human epidermis was significantly greater than that of normal corium in the same area. Extremely rapid oxygen uptake was found in about 30% of the experiments in which electrodes had been inserted into hair follicles. It seems possible that in these cases the tip of the electrode entered a sebaceous gland (Fig. 1).

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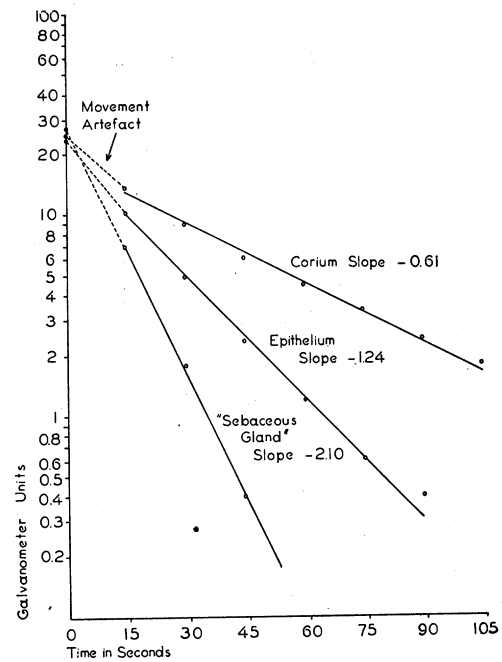

FIG. 1. Relative oxygen uptake of corium, epithelium, and "sebaceous glands" of normal human skin measured polarographically. Oxygen tension is expressed in galvanometer units.

The frequency distribution curve of the slopes obtained from the experiments on normal human skin shows 3 maxima. These correspond to the 3 levels of the skin to which the electrodes were inserted, and are related to one another in the same way as the QO_2 values reported for connective tissue, skin, and glandular tissue in manometric studies (Table 1).

Immediate repetition of the measurements in the same skin area without reinsertion of the electrode significantly decreased the oxygen consumption. This was probably a result of injury to the skin.

TABLE 1

RELATIONSHIP OF RELATIVE OXYGEN UPTAKE OF CORIUM, EPIDERMIS, AND "SEBACEOUS GLANDS" MEASURED POLAROGRAPHICALLY TO QO_2 OF HISTOLOGICALLY SIMILAR TISSUE OBTAINED BY MANOMETRIC METHODS (*1, 7*)

Region of skin	Logarithm of mean slope	$\frac{10}{\text{Slope}}$	Tissue	QO_2
Corium	−0.65	0.44	Connective tissue	0.4
Epidermis	−1.30	2.00	Skin (*1*)	2.1
"Sebaceous gland"	−2.00	10.00	Liver (7)	9.0

When the identical experiment was performed in excised, dead human skin, and in the intact skin of a living, anesthetized dog after the local injection of sodium azide, there was no fall in oxygen tension after the initial movement artifact. This evidence for the inability to utilize oxygen, noted in dead skin, and in living skin the cytochrome oxidase system of which had been blocked by sodium azide, bears out the usefulness of this method for the relative measurement of cutaneous oxygen consumption.

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Self-Selection of Diet in Relation to Audiogenic Seizures in Rats[1]

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It is known that some laboratory rats when subjected to sounds of high frequency exhibit convulsive behavior (*1, 2*). The pattern of such seizures is fairly uniform and consists of wild, undirected running, followed by tonic-clonic spasms and a comatose stage. Spontaneous seizures of a similar pattern have been reported in animals fed diets deficient in such substances as thiamine (*3*), pyridoxine (*4*), and magnesium (*5*). Likewise, supplementary feedings of thiamine hydrochloride have been found to render rats selectively bred for seizure susceptibility increasingly resistant to the sound-induced convulsions (*6*).

The similarity between patterns of convulsive seizures resulting from inadequate diets and those that occur under auditory stimulation has made it difficult to determine the etiology of the latter type of seizure. It occurred to us that utilization of a self-selection technique similar to that employed by Richter (*7*) might enable us to detect subjects in our colony whose susceptibility to sound-induced convulsions was conditioned by dietary factors. Such a technique might prove of special value in those cases lacking observable evidence of nutritional deficiency.

Sixty-five albino rats, males averaging 45 days of age at the start of the experiment, were studied. Wherever possible littermates were used, and the split-litter technique employed. Essentially the same method of auditory stimulation was employed as in previous experiments on the production of convulsions in rats (*8*).

In order to determine the incidence of audiogenic fits, the subjects were exposed to 3 min of stimulation with a heavy-duty electric bell daily for 14 days prior to the experiment proper. During this period all animals were maintained on laboratory-prepared stock diet, consisting per 1,000 g of diet of the following ingredients:

Graham flour	725 grams
Skim milk	100 "
Casein	100 "
Calcium carbonate	15 "
Sodium chloride	10 "
Butterfat	50 "

Twenty rats, selected on the basis of their degree of susceptibility to sound-induced seizures, composed the experimental group. Ten of the rats showed fits in excess of 50% of the times tested and were designated consistently susceptible animals. The remaining 10 experimental subjects had seizures less than 25% of the times tested and were considered sporadically susceptible rats. Forty-five rats constituted the control group. Of these, 15 showed the seizures consistently, 15 had sporadic fits, and 15 failed to have any seizures.

Three diets were used in the experiment proper: the stock diet referred to above, commercial Purina Dog Chow Checkers, and a self-selected diet. The latter consisted of the following:

Solutions presented in 100-ml graduated inverted bottles affixed to especially constructed living cages:

1% solution of potassium chloride
2% solution of calcium lactate
3% solution of sodium chloride
4% solution of sodium hydrogen phosphate
0.02% solution of vitamin B-1
0.02% solution of vitamin B-6
0.01% solution of calcium panothenate
0.1% solution of nicotinamide
0.5% solution of choline chloride
0.00125% solution of riboflavin
Distilled water
Olive oil
Cod liver oil

In solid form, presented in nonspillable food cups:

Dextrose
Vitamin-free casein

All the experimental animals were placed for 14 days on each of the diets in random order. Tests for susceptibility to audiogenic seizures were given for 3-min periods daily. Of the control rats, 5 animals from each of the resistant, consistently susceptible, and sporadically susceptible groups were maintained throughout the 42-day experimental period on each of the 3 diets. All controls were exposed to 3 min of auditory stimulation daily.

Daily nutritional intakes, self-selection choices, and responses to sound stimulation were recorded. Weekly fluctuations in body weight were measured.

Among the experimental animals consistently susceptible to sound-induced seizures, 2 animals failed to show the fits when placed for 14-day periods on the self-selected diet. Both these subjects were found to have atypical selections of thiamine. One of the rats averaged 2.5 mg/day, the other 4.0 mg/day, intake of thiamine hydrochloride. These amounts were in excess of the normal

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