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Salivary Gland Function and Electrolyte Composition in Potassium-Deficient Rats.* (27003)

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Previous investigations(1-6) have shown that dietary deprivation of potassium, in addition to altering electrolyte and water content of specific tissues, may also lead to changes in their function. Alteration in function has been observed in contractile(1-4) and some secretory tissues(5,6). This investigation was undertaken to determine the effects of dietary deprivation of potassium on function and on tissue electrolyte content of another secretory system, the salivary glands, with a view of correlating possible changes in function (altered composition or volume of secretion) with gland electrolyte changes.

Methods. Long-Evans rats, 6 weeks to 4 months of age, weighing 100 to 200 g, were used in these experiments. Experimental animals were placed on a potassium-deficient diet (Nutritional Biochemicals Corp.) composed of cornstarch, 64.2%; casein, 30%; butterfat, 3.5%; calcium carbonate, 1.3%; sodium chloride, 1.0%; and complete vitamin supplements. Potassium content, determined on an ashed sample, was 0.54 mM/100 g of diet. Animals drank tap water (potassium less than .04 mM per liter) or distilled water. Control animals were fed a standard laboratory diet. After 45 days on the diet, animals were fasted 24 hours, lightly anesthetized with Nembutal, and the left parotid, submaxillary, and sublingual glands were removed, individually weighed on a torsion balance, and subsequently dried in Vycor crucibles to determine tissue water content (expressed on a dry weight basis). The duct from one of the remaining salivary glands (in some cases, all 3) was freed from surrounding tissue and cut. Pilocarpine nitrate (2.2 mg) was injected subcutaneously and ensuing secretion was collected, either directly in a small tared vessel(7) or, by micropipette placed at the duct orifice. After saliva collection, the secreting gland was removed for weighing and water and electrolyte analysis. Gland electrolytes were determined on samples dry-ashed (525°C) in Vycor crucibles and are expressed as milliequivalents per kg wet weight (meq/kg

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w.w.) of tissue. Rate of salivary flow is expressed as milligrams of fluid obtained per minute per milligram of gland (mg/min/mg), since flow data included were obtained by weighing saliva collected in a timed interval. Additional values for salivary flow were obtained by measurement of time required to fill a calibrated micropipette, and these volume/time values (per unit mass of gland), and electrolyte concentrations based on them, agree closely with values given. To obviate further the possibility that fluid density differences could affect comparisons of flow and electrolyte composition of the secretions, direct determinations of density were made by weighing known volumes of secretion contained in tared micropipettes. The densities of individual secretions of control and potassium-deficient animals showed differences among themselves, which, for purposes of this investigation, were insignificant: agreement was within 2%, even with weighing errors resulting from necessary use of small volumes. Moreover, density determinations indicate values for specific gravities of the secretions which, for use here, are equivalent to unity. In the experiments, random muscle and blood samples were removed from K-deficient and control animals and electrolyte levels determined so that evidence of potassium deficiency might be established(1). For histological examination, salivary gland samples were preserved in Zenker's-formol and stained with haematoxylin and eosin.

Results. Sodium, potassium and water content of unstimulated parotid, submaxillary and sublingual glands of young rats maintained on a K-deficient diet for 45 days are shown by the data in Table I. These values are compared with those from a group of control animals of similar age maintained on standard laboratory diet. Water content of parotid and submaxillary glands of K-deficient animals was unchanged from that of controls, whereas sublingual glands of K-deficient animals showed a small change in water content (Table I). The potassium level of parotid and submaxillary glands in K-deficiency was lower and sodium higher than in controls; in sublingual, however, sodium and potassium did not change from control levels, even when the small difference in water content between control and experimental glands was taken into account.

TABLE I. Effect of Potassium Deficiency on Sodium and Potassium Content of Unstimulated Rat Salivary Glands.

	K-Deficient Mean ± S.E.*	Control Mean ± S.E.	Signif. of Diff.
Parotid	32 Rats	14 Rats	P
Na	53.7 ± .97	45.5 ± 1.74	.0000
K	64.4 ± .97	68.0 ± 1.33	.0000
Water/Dry	2.5 ± .09	2.5 ± .07	—
Submaxillary	31 Rats	14 Rats	—
Na	49.0 ± 1.73	36.4 ± 1.54	.0000
K	79.0 ± 1.36	89.0 ± 2.02	.0000
Water/Dry	3.2 ± .08	3.3 ± .07	—
Sublingual	24 Rats	10 Rats	—
Na	41.8 ± 2.05	41.2 ± 2.10	.3855
K	69.5 ± .94	73.4 ± 2.34	.1151
Water/Dry	3.0 ± .14	3.5 ± .036	.0012

* Mean and standard error, expressed for Na and K as meq/kg w.w.

Rate and duration of salivary flow from submaxillary and parotid glands of K-deficient animals were markedly lower than from glands of control animals, following maximal stimulation with pilocarpine. Individual submaxillary flow rates (13 K-deficient and 10 control animals), calculated from volumes of fluid obtained in the first 3 to 7 minutes of flow following pilocarpine administration, are shown in Fig. 1. Flow rate of submaxillary saliva averaged .072±.013(S.E.) mg/min/mg in the control group and .027±.006 mg/min/mg in the K-deficient group ($P=.0013$). Not included are results of 8 experiments in which no measurable flow from submaxillary gland of K-deficient animals could be obtained. Representative individual flow rates from parotid gland of control and potassium-deficient animals are also shown in Fig. 1. From these data, and additional values, an average parotid flow rate of .058±.006 mg/min/mg was obtained for control (17 animals) and .018± .002 mg/min/mg for K-deficient (14 of 30 animals from which flow was obtainable) animals ($P<10^{-6}$). The reduced flow rate, found to be characteristic in K-deficiency, is probably not due to an increased dose threshold, since increased pilocarpine dosage, adminstered to experimentals and controls, did not modify the effect. Electrolyte levels of parotid and submaxillary secretions from the K-deficient animals were generally similar to those of controls, although an occasional ele-

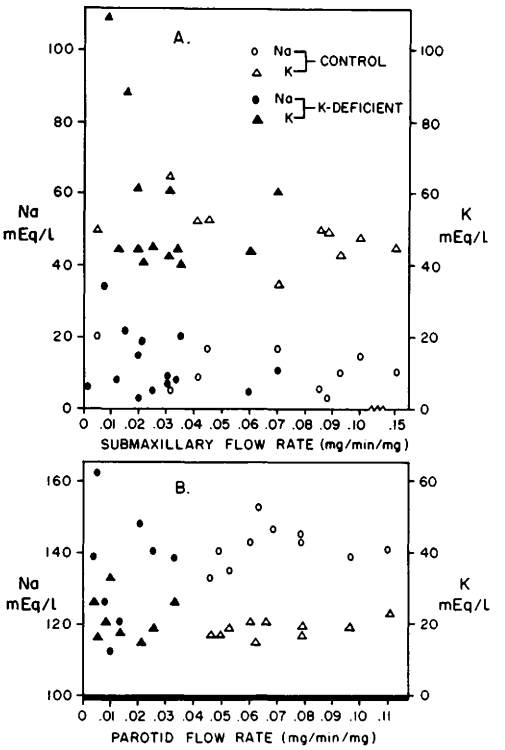

FIG. 1. Flow rate and electrolyte levels of parotid and submaxillary secretions from control and K-deficient animals during first 3 to 7 min. interval of secretion following pilocarpine stimulation.

vated potassium did occur in both secretions from the deficient animals (Fig. 1). This tendency toward elevation of potassium was accentuated when the salivas were collected only for the first one to 2 minutes after start of flow. Sublingual saliva sodium and potassium levels in the 2 cases where adequate saliva volume was recovered, were similar to those of controls(7).

Histological specimens prepared from a few potassium-deficient glands showed no striking changes although a greater number of cytoplasmic vacuoles were evident.

Discussion. It is clear from these investigations that, although potassium-deficiency effected an altered sodium-potassium balance of the parotid and submaxillary glands of rat, this modification did not approach, even in the submaxillary, the marked electrolyte changes induced in muscle(1). Nonetheless, associated with this glandular potassium-deficiency is one striking functional change: capacity to secrete fluid is much reduced. Histological examination did not reveal changes that could account for this diminished secretory capacity. A similar functional change has been reported for kidney(5). In another secretory organ, stomach, secretory volume is reported to be unchanged in potassium deprivation, but sodium and potassium levels of this secretion are greatly modified(6). Mechanisms mediating changes observed in potassium-deficiency are not well understood. Some similarity between effects of potassium deficiency and administration of adrenocortical hormones has been observed(8,9).

In view of numerous investigations(7,10) which suggest a dependence of secretory fluid electrolyte levels on gland levels, it may be noted that gland level changes in potassium deficiency give no evidence of being reflected in corresponding changes in secretion electrolyte levels.

Summary. Modification of sodium and potassium levels of submaxillary and parotid, but not sublingual, glands was achieved by reduction of dietary potassium. Submaxillary gland exhibited a decrease in potassium of approximately 10 meq/kg w.w. when compared with normal animals of the same age, and parotid approximately 4 meq/kg w.w. Sodium increased in both glands (8 meq/kg w.w. for parotid; 13 for submaxillary). The major functional change observed in potassium deficiency was a marked reduction in fluid flow rate; electrolyte levels of the secretions were not influenced by changed gland levels.

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