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Water Shift in the Muscle of Adrenalectomized Rats.*

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Animals with adrenal insufficiency suffer disturbances in ability to regulate the water and electrolyte content of their tissues and plasma. Increase has been reported in the water content of muscle, liver, and skin,^{1, 2, 3} and decrease in the plasma volume.^{4, 5, 6, 7} The adrenalectomized animal cannot shift water as readily under stresses as does the normal animal.¹ The excretion of water is less, and of chlorides more²; there is a change in the electrolyte content of the plasma,⁸ and a disturbance in electrolyte balance.⁹

Viale and Bruno⁵ suggested that the changes in water content of tissues and plasma might be due to an increase in permeability. The present study was undertaken to determine whether any evidence of a change in permeability could be found in the tissues of animals suffering from adrenal insufficiency. The first series of experiments have dealt with the swelling and shrinking of tissues from normal and from adrenalectomized rats in balanced solutions of varying strengths. According to Gellhorn,¹⁰ a close parallelism frequently exists between imbibition and permeability.

Muscles of normal and adrenalectomized albino rats weighing about 150 gm. were employed in this study. Adrenalectomized animals were used 4 to 7 days after the operation; only those animals giving evidence (loss of weight) of adrenal insufficiency were used.

* Aided by a grant from the Carnegie Corporation of New York to the Carnegie Institution of Washington.

¹ Hartman, F. A., Brownell, K. A., and Lockwood, J. E., *Endocrinology*, 1932, **16**, 521.

² Silvette, H., and Britton, S. W., *Am. J. Physiol.*, 1933, **104**, 399.

³ Hartman, F. A., *Annals Int. Med.*, 1933, **7**, 6.

⁴ Rogoff, J. M., and Stewart, G. N., *Am. J. Physiol.*, 1926, **78**, 711.

⁵ Viale, G., and Bruno, A., *Compt. Rend. Soc. de Biol.*, 1927, **97**, 261.

⁶ Rowntree, L. G., and Snell, A. M., *A Clinical Study of Addison's Disease*, Philadelphia, 1931.

⁷ Swingle, W. W., Pffner, J. J., Vars, H. M., Bott, P. A., and Parkins, W. M., *Science*, 1933, **77**, 58.

⁸ Loeb, R. F., *Science*, 1932, **76**, 420.

⁹ Loeb, R. F., Atchley, D. W., Benedict, E. M., and Leland, J., *J. Exp. Med.*, 1933, **57**, 775.

¹⁰ Gellhorn, E., 1929, *Das Permeabilitätsproblem*, Berlin, (cited in Gellhorn, E., *Am. J. Physiol.*, 1931, **96**, 203.

Animals obviously moribund were discarded. Under ether anesthesia, the *m. extensor digitorum longus* was dissected out, quickly weighed in a glass-stoppered weighing vial, then placed in aerated balanced salt solution at a temperature of 37.5°C ., and with a *pH* of about 7.3. At definite time intervals, the muscle was lifted out, quickly dried on filter paper, weighed, and returned to the solution.

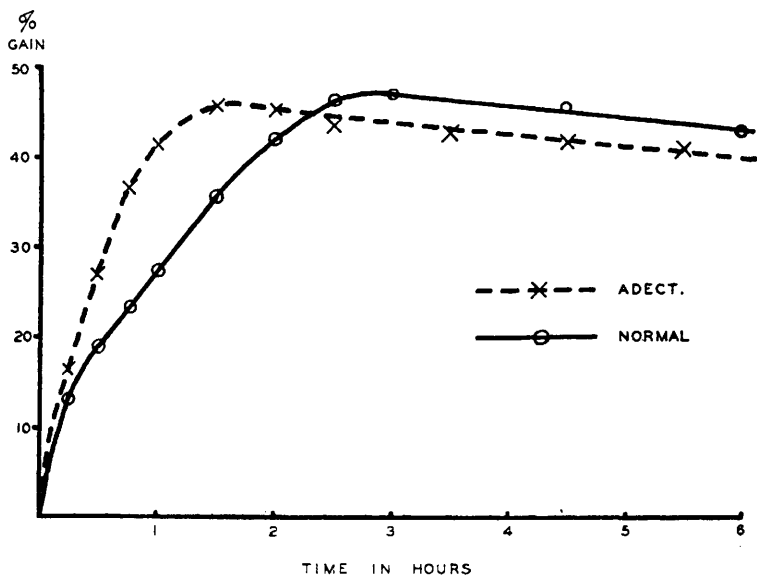


FIG. 1.

Changes in weight of muscles in hypotonic solution.

Fig. 1 shows the results obtained by such a procedure in a hypotonic solution (73 parts Locke's solution* to 27 parts distilled water). Muscles from adrenalectomized animals imbibe water considerably faster than those from normal animals; the maximum water uptake is about the same in either case, but is reached much sooner in the case of muscles from the adrenalectomized rats.

Fig. 2 shows the change in weight of muscles in a strongly hypertonic solution (balanced Locke's solution, but with 3 times the usual salt concentration). The figure shows that the muscles from adrenalectomized animals lose weight faster in the beginning than do those from normal animals, that they reach the point of minimum weight more quickly, and that once they start to gain weight, they gain more rapidly.

* Locke's solution of the following composition was used: NaCl, 0.9; KCl, 0.042; $\text{CaCl}_2 \cdot \text{H}_2\text{O}$, 0.024; NaHCO_3 , 0.02; H_2O , to 100. Buffer used: NaH_2PO_4 plus NaOH.

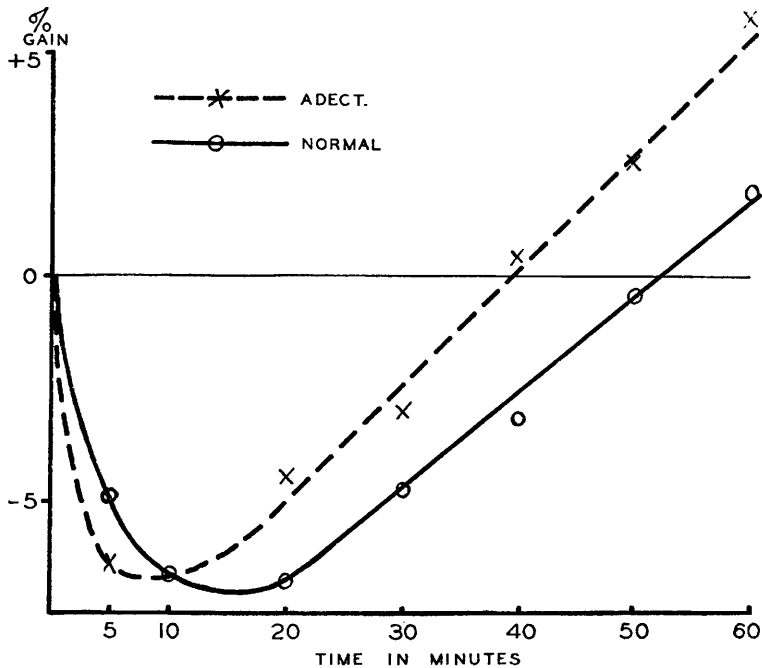


FIG. 2.
Changes in weight of muscles in hypertonic solution.

In all cases, the points on the curves represent averages of 10 or more determinations. Altogether, 51 muscles from 26 normal animals and 40 from 20 adrenalectomized animals were used in this study.

Comparable results were obtained in solutions intermediate in strength; at a salt concentration 30% greater than normal Locke's solution, normal muscles neither gain nor lose appreciably in the first few minutes; muscles from adrenalectomized animals begin to gain immediately. A difference in the rate of change of weight was found in all concentrations tried, with the exception of distilled water. Probably the muscles are injured so rapidly in distilled water that any differences existing in the 2 sets of muscles are obscured.

Changes in weight of a muscle in balanced salt solution represent mostly a shift of water into or out of the muscle; it is evident that this shift occurs more readily in either direction in a muscle from an adrenalectomized animal than in a normal one. It is reasonable to suppose that this change may be due to an increase in permeability in the former.