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Effect of Hypotonic and Hypertonic Ringer on Isotonic and Isometric Contraction of Muscle.

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It was shown by Cooke[1] and Meek[2] for striated muscle and by Carlson[3] for heart muscle that the height of contraction produced by a constant stimulus increased when the muscle was put in hypotonic saline solution. Later it was shown by Lapique[4] that the irritability of the muscle was increased (decreased chronaxia) by treatment with hypotonic solutions. All of these observations conform with the idea that active (young) tissues contain more water than inactive (old) ones, that stimulation is due to the heaping up of ions at some membrane and the more water there is the easier it would be for ions to move. However, the fact that an isotonic lever goes higher does not prove that increased tension was developed in the muscle and the muscle therefore able to do more work. There is an inverse ratio between speed and work in muscle contraction and if the tension is due to some kind of surface action one would not be surprised if the tension developed might be independent of the water in the cell. On testing the effect of hypotonic Ringer with an isometric lever we find, as described below, the tension developed does not increase but rather tends to decrease with the uptake of water.

The experiments were performed by suspending a frog's gastrocnemius muscle in a special glass chamber mounted on the stand of an ordinary moist chamber. The glass chamber afforded a means for surrounding the muscle with Ringer's solution when determinations were not actually being made. In all cases the right and left gastrocnemius muscles of the same frog were used; the right was surrounded with isotonic Ringer's solution and served as a control to the left gastrocnemius, which was considered the experimental muscle and was surrounded with 25% hypotonic solution. Single induced break shocks were used in which the strength of the current in the primary was kept constant. Contractions were recorded on a stationary drum at 15-minute intervals over a period of 3 hours. The first contraction in each case was taken immediately after the muscle

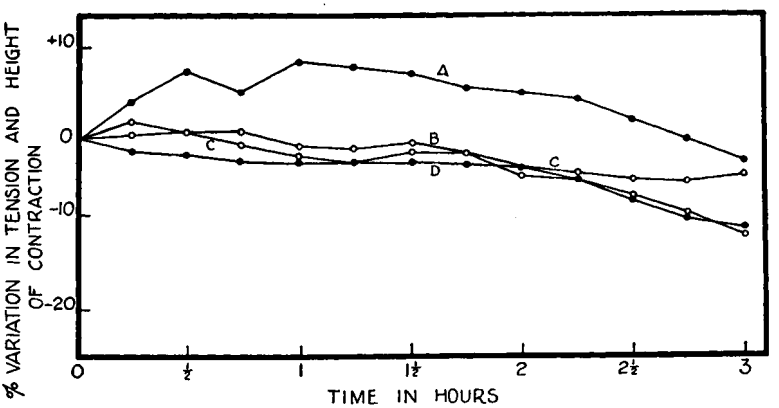
1 Cooke, E., *J. of Physiol.*, 1898, **23**, 137.

2 Meek, W. J., *Am. J. Physiol.*, 1906, **17**, 8.

3 Carlson, A. J., *Am. J. Physiol.*, 1906, **15**, 357.

4 Lapique, M., *Compt. rend. Soc. de biol.*, 1920, **83**, 1033.

was mounted in the chamber to serve as a control, after which the solutions were added to the chamber.



As the plate shows, when the isotonic lever was used, the height of contractions of the muscle in hypotonic Ringer's solution was above that of the control and tended to remain so for at least an hour and a half. Curve A represents the percentage variation in height of contraction of the muscle in hypotonic, and Curve B the control muscle in isotonic Ringer's solution. The results obtained with the isometric lever under the same conditions, however, show no appreciable difference between the control and experimental muscles. (Curves C and D respectively.) The lever used was somewhat similar to that devised by C. F. Palmer Co. and figured in Starling's text. Each curve represents an average of 6 experiments.

It follows, then, that although the muscle definitely took up water and no doubt was more irritable than its control, it was not able to exert any more muscular tension.

Experiments were also carried out to test the effects of 25% hypertonic Ringer's solutions on muscle tension. It was noticed that with both the isotonic and isometric levers the muscles showed a definite decrease in muscular tension compared with the control.

Summary. When muscle is treated with hypotonic Ringer an increased height of contraction is obtained from a constant stimulus with an isotonic lever but if an isometric lever is used it shows there is no increased tension developed by the muscle. Hypertonic solutions lead to decreased height of contraction and decreased tension.