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The Respiratory Quotient of Exercising Muscle.

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Previous work has revealed the fact that the respiratory quotient of amphibian muscle, when excised, is unity both in rest and exercise. The same result has been obtained on excised resting mammalian muscle. On the other hand, in the study of the respiratory quotient of resting mammalian muscle *in situ,* that is, a gastrocnemius muscle with isolated blood supply and intact nervous connections, the respiratory quotient is not unity, but close to that obtained simultaneously of expired air of the entire animal. Therefore, it appeared interesting to see what the respiratory quotient of exercised muscle *in situ* would be.

In our experiments 10 dogs, starved from 5 to 15 days, were studied. The muscles of the lower extremities of these dogs were stimulated by a tetanizing electric current. After 10 and 15 minutes of exercise, and in one case at the end of the fourth minute, simultaneous samples of blood were drawn from the femoral artery and vein and analyzed for CO_2 and O_2 by the method of Van Slyke and Neill. In all cases, the concentration of the blood as revealed by determination of its oxygen capacity was unchanged by passage through the tissues. In most samples of blood there was no change in the CO_2 dissociation curve in arterial and venous blood. In other words, a close approximation to the "steady state" had been established. The average of 16 respiratory quotients was $.81 \pm .05$. Eight determinations, of the respiratory quotient of entire resting animals, by analysis of expired air collected simultaneously with the blood, yielded an average respiratory quotient of $.82 \pm .04$; and in 16 samples, taken from animals while exercising, the average respiratory quotient was found to be $.82 \pm .07$. Since, in the experiments here reported, a small part of the venous return must have come from non-muscular tissues, another series of experiments are now being conducted on gastrocnemii with isolated blood supply.

SUMMARY AND CONCLUSIONS.

The gaseous exchange during exercise was studied in 10 dogs starved for 5 to 15 days. The average of 16 respiratory quotients of the muscles of the lower extremities obtained by analysis of the

blood was .81 ± .05. Eight respiratory quotients obtained from the air during rest yielded an average of .82 ± .04. Sixteen air samples collected from exercising dogs gave an average of .82 ± .07.

The respiratory quotient of the exercising muscle *in situ* is not unity. This indicates that not only carbohydrate foodstuffs but also non-carbohydrate are used in muscular exercise.

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Effect of Insulin and of Muscular Exercise on Protein Metabolism.

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The total urinary nitrogen was determined in hourly periods on normal fasting female dogs weighing 6 to 20 kilos. The urine was collected by catheter and the bladder thoroughly rinsed each time. After 3 preliminary control hours, insulin (usually 5 units per kilo of body weight) was injected subcutaneously and the urine collected for 3 or 4 periods until sugar was given to the animal to relieve the hypoglycemic convulsions.

The changes in protein metabolism after the insulin depended upon the nutritive condition of the animal. After short fasting periods of 1 to 5 days insulin increased the nitrogen excretion. In a typical case, on the second day of fast, the increase was from an average of 99 mg. per hour during the preliminary hours to 137 mg. after insulin. With a longer fasting period of 7 to 14 days, insulin produced no effect, for example 101 mg. per hour before and 100 mg. after the injection. When carbohydrate (50 to 100 gm. of sucrose) was administered every 3 or 4 days to an otherwise fasting animal, the injection of insulin produced the same increase in nitrogen excretion on the 16th as on the 2nd day of fast. Similar results were obtained on a dog in which muscular movement was prevented by amytal anesthesia.

Two fasting dogs were run daily on a treadmill to observe the effect on protein metabolism of decreasing the body carbohydrate through muscular exercise. After 4 hourly preliminary control periods the dogs were exercised for 3 half hour periods and obser-

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