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The Effects of Physical Training on the Metabolic Response to Short-Term Severe Exercise in the Rat

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There have been many investigations of the effects of physical training on various enzyme activities in skeletal muscle (see Holloszy, 1967; Holloszy, Oscai, Don & Molé, 1970), but no studies have been made on metabolite concentrations in blood and liver. In the present experiments a 6-week physical training programme of increasing periods of running was used to study whether there was any metabolic adaptation to exercise accompanying the reported changes in the activities of muscle enzymes. Control rats (48h-starved females) immediately after running for 10min at 27m/min showed a rise in blood lactate concentration from 2.01 ± 1.09 mM (mean $\pm$ S.D., eight observations) to 9.51 ± 2.26 mM and falls in the concentrations of total blood ketone bodies from 3.39 ± 0.99 mM to 1.92 ± 0.65 mM and of plasma free fatty acids from 1.49 ± 0.23 mequiv./l to 1.17 ± 0.10 mequiv./l. In contrast, trained rats showed only a slight increase in blood lactate concentration from 1.53 ± 0.65 mM to 3.54 ± 1.77 mM and a fall in that of total blood ketone bodies from 2.18 ± 1.15 mM to 1.21 ± 0.30 mM, but no significant change in that of plasma free fatty acids. These changes in metabolite concentrations in blood were paralleled by similar changes in the liver in both control and trained groups.

The hepatic concentration of alanine rose from 0.28 ± 0.13 μ mol/g wet wt. to 2.32 ± 0.42 μ mol/g in the control group, and there were simultaneous increases in aspartate from 0.66 ± 0.11 μ mol/g to 2.15 ± 0.38 μ mol/g and in malate from 0.24 ± 0.07 μ mol/g to 0.82 ± 0.24 μ mol/g. In the trained group these increases were of smaller magnitude.

There was a 40% fall in hepatic ATP concentration in the untrained rats after exercise, whereas this decrease was 25% in the trained rats; the size of the total adenine nucleotide pool did not alter in either group.

Both groups of animals showed comparable increases in phosphorylated gluconeogenic intermediates, but the trained rats had higher glycogen and glucose concentrations after 10min of exercise.

All the changes in hepatic metabolite concentrations in untrained rats except the fall in that of ATP could be simulated by the intravenous infusion of L(+)-lactic acid into 48h-starved resting rats (see also Houghton, Hawkins, Williamson & Krebs, 1971).

It is concluded that the smaller changes in hepatic metabolite concentrations occurring in trained rats are mainly due to the lower circulating concentrations of blood lactate in response to exercise. Possible reasons for the fall in hepatic ATP concentration after short-term exercise will be discussed.

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Penetration of Perfused Rat Liver by Exogenous Amyloglucosidase

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Attempts have been made to alleviate certain types of glycogen-storage disease by intravenous administration of a glycogenolytic enzyme (Baudhuin, Hers & Loeb, 1964; Hug & Shubert, 1967; Lauer, Mascarinas, Racela, Diehl & Brown, 1968; Fernandes & Huijing, 1968). It was therefore decided to investigate the penetration of enzyme into liver. In the present experiments isolated rat liver was perfused by the technique of Hems, Ross, Berry & Krebs (1966) with medium containing *Aspergillus niger* amyloglucosidase (EC 3.2.1.3).

To enable accurate assessment of enzyme uptake it was necessary to ensure that all enzyme-containing perfusion fluid was removed at the end of the experiment. This was most satisfactorily achieved by using defibrinated (Baron & Roberts, 1963) whole rat blood instead of aged human erythrocytes, thus permitting removal of perfusion fluid with saline.

After perfusion for up to 4h with 30–50ml of medium containing 30–250mg of amyloglucosidase, the decrease in enzyme concentration in the medium was negligible. Hence the amyloglucosidase was rapidly destroyed neither in the perfusion

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