

INTERRELATIONSHIP BETWEEN AMINO ACID AND CARBOHYDRATE METABOLISM  
DURING EXERCISE: THE GLUCOSE ALANINE-CYCLE

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In the past decade considerable interest and effort have been devoted to increasing our understanding of the factors regulating energy exchange in exercising muscle. Much of this effort has been directed at studying the utilization and availability of carbohydrate and lipids. Little information is available however, on the influence of exercise on amino acid metabolism. Our own interest in amino acid metabolism in exercise derives from studies which we undertook on the role of substrates in the regulation of gluconeogenesis in intact man (2,3,4).

In examining the pattern of amino acid exchange across resting forearm muscle, alanine was observed to be released to a greater extent than all other amino acids (5). Since alanine comprises only 5-8 % of the amino acid residues in muscle protein (8), the basis for the primacy of alanine output is unclear. Peripheral synthesis of alanine by transamination of glucose-derived pyruvate has been suggested (5). By this formulation, alanine formation and release from muscle would depend not only on the rate of protein dissolution but also on the rate of glycolysis and availability of pyruvate. To test this hypothesis and to characterize further the pattern and regulation of peripheral amino acid release, we have investigated amino acid metabolism during muscular exercise, a condition characterized by increased glucose utilization.

Healthy adult male volunteers were studied after an overnight fast (Fig. 1). Catheters were placed in the brachial artery, femoral vein and hepatic vein, and simultaneous blood samples were obtained with the subjects at rest and after 10 and 40 min of mild and moderately heavy exercise. The exercise was performed in the upright position on a bicycle ergometer, and resulted in a 3-9 fold

increase in oxygen consumption (Fig. 1).

#### EXPERIMENTAL DESIGN

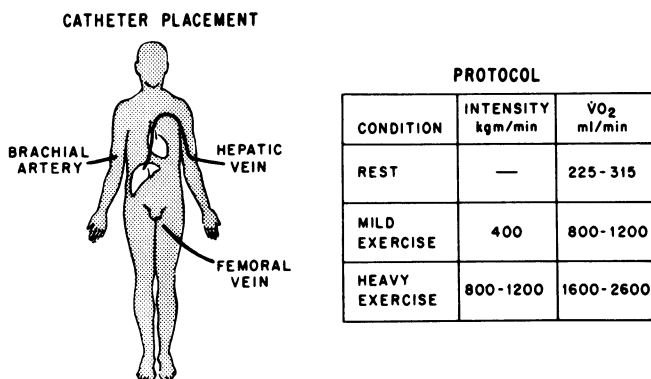


Fig. 1. Experimental protocol and oxygen consumption at rest and during exercise.

Net exchange of amino acids across leg tissue was determined by measurement of arterio-femoral venous differences, a negative A-V difference, indicating net release. As shown in fig. 2, in the resting state there was significant net release from leg tissue, of 13 out of 19 plasma amino acids. By far the largest A-V difference across the leg was that for alanine, which accounted for 40 % of total net amino acid output. A significant positive A-V difference or net uptake was observed for citrulline, serine and cystine.

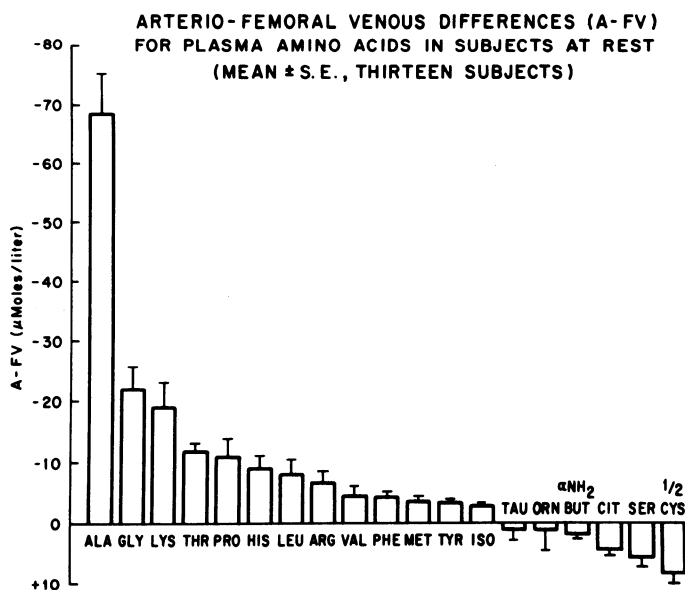


Fig. 2.