

Evidence For Direct Utilization of Fructose in Working Muscle in Man.* (24739)

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There is uncertainty in the literature about ability of striated muscle to utilize fructose. Peters(1) doubts whether it is metabolized at all, while other studies(2,3,4) suggest slow uptake and perhaps utilization of this carbohydrate. Van Itallie and coworkers(5) found an appreciable A-V difference in the forearm following constant intravenous infusion of fructose in 10 normal human subjects, but no proof could be obtained for direct utilization of this hexose by the muscle cell. Several investigators(2,4,6) observed a rise in serum lactic and pyruvic acid following fructose infusion. We have had the opportunity to study the problem on a young man with a rare disorder of muscle. The subject was unable to continue moderate work for more than 4 minutes, after which rapid fatigue and transient paralysis developed. Ischemically exercised forearm muscles rapidly fatigued and there was no measurable increase in lactic or pyruvic acid levels in venous blood from the exercised arm in comparison to a 4-fold rise in these constituents in normal subjects under the same experimental conditions. McArdle (7) described the only recorded instance of this disease entity as "a myopathy due to defect in muscle glycogen breakdown."

Methods. The subject, a 19-year-old male, was exercised in the fasting state on a treadmill (10% incline) at 4 mph. Intravenous infusions of normal saline, sodium bicarbonate, 10% glucose or 10% fructose were given. Either sugar was infused at a rate of 0.73 g/kg/hr, for 30 minutes prior to as well as throughout exercise. Edrophonium chloride (Tensilon) was given intravenously in a dose of 10 mg.

Results. In 20 control attempts the subject was unable to walk for more than 4 min

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20 sec (average 3' 20"). There was no improvement after saline, sodium bicarbonate or edrophonium chloride. Glucose infusion increased duration of exercise tolerance more than 20-fold (limit of trial) when plasma glucose levels were elevated above 160 mg %. Fructose infusion similarly improved work performance (Fig. 1) so that exercise was continued with ease for 60 min, except for a transient episode of weakness at 14 min. There was no significant change in plasma glucose levels but fructose levels rose to a maximum of 35 mg %. Following discontinuance of infusion continued exercise was possible for another 23 min after which rapid fatigue and paralysis of the leg muscles developed. Plasma fructose level was then 8 mg %.

Discussion. The uptake and utilization of fructose by liver has been demonstrated(8,9, 10) but only inferential evidence has been obtained for striated muscle(2,11). From the clearcut improvement in work capacity obtained in this study it appears that fructose can serve as a direct source of energy for working muscle. It is unlikely that the improvement was mediated by hepatic conversion of fructose to glucose since there was no significant change in plasma glucose levels during the experiment. Furthermore it was shown that for glucose alone to be effective, its plasma concentration must exceed 160 mg %.

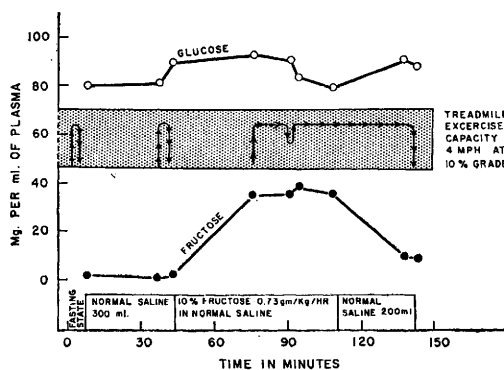


FIG. 1.

The possibility that improved muscular function was due to the additive effect of cellular entry of plasma glucose plus fructose cannot be ruled out.

The results suggest that: a) Fructose is removed from plasma at a rapid rate since the levels remained constant during exercise and the removal equalled the input rate of 0.90 g/min. b) Threshold level of the sarcolemmal membrane for entry of fructose is much lower than that for glucose since at an extracellular fluid level of fructose near 10 mg % muscular work could be performed. Plasma glucose had to be increased to nearly twice the fasting level in order to similarly enhance work. c) Fructose traverses the muscle cell membrane at a sufficiently rapid rate to contribute to muscular work. d) Fructose can be effectively utilized by skeletal muscle as a major source of energy under some circumstances.

Summary. 1. Observations were made upon the effect of infused fructose on work capacity of a young male subject with an unusual metabolic deficiency of striated muscle in which there was a failure to form lactic acid under anaerobic conditions. The defect was tentatively ascribed to inability to utilize glycogen and was manifested clinically by limited exercise tolerance. 2. Duration of work was

greatly improved by infusion of glucose or fructose. Fructose was effective at much lower plasma concentration than glucose. Therefore, fructose can traverse the muscle cell membrane and contribute significantly toward the fuel for muscular work in this patient.

ADDENDUM: The defect in this case has recently been demonstrated to be an absence of phosphorylase a and b in muscle.

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Some Biological Characteristics of Asian Influenza Isolates.*† (24740)

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Occurrence of an antigenic variant of influenza A in Southeast Asia which rapidly spread producing pandemic influenza throughout the world in 1957 has been described(1). Detailed studies in many laboratories have shown that closely related strains of Asian type have replaced previously prevalent A prime or FM1 type influenza A(1-3). Clinically,

infection with Asian strains has been relatively mild(1,3) although extremely high incidence of influenza at the peak of the pandemic did result in significant increase in influenza and pneumonia mortality. Availability of Asian strain isolates provided an opportunity to study biological properties previously employed in characterizing other influenza viruses and to compare these characteristics (1) with earlier A strains and (2) Asian strains recovered from mild and fatal cases of human infection. Asian strains were compared to PR8 and FM1 strains in relation to

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