that found in the control containing "standard serum" only. Both methods are simple, rapid, and particularly suitable for serial determinations. The results obtained with these assays showed good agreement with microbiological and other radiometric methods. Various aspects of the assays are discussed.

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Serum Glutamic-Oxalacetic Transaminase Levels after Exercise in Men.* (27283)

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The report of LaDue, Wróblewski and Karmen(1) stimulated much of the interest in glutamic-oxalacetic transaminase (GOT), and led to the use of the transaminase analysis as a diagnostic test for confirming the existence of a myocardial infarct. Wróblewski and LaDue extended this test to include detection of infectious hepatitis(2,3).

This research led other workers to more widespread and diversified investigation of GOT. Vagotomy in the pigeon resulted in increased GOT activity of heart, muscle and hepatic tissue(4). The metabolic stimulant, 2,4-dinitrophenol, increased GOT activity in muscle and hepatic tissue(5). Barbieri discovered that GOT was most concentrated in those chambers of the heart doing the most work(6). Katsura and Yamamoto reported endocrine tissue had a relatively low transaminase activity(7). These later investigations suggested a relationship might exist between GOT and muscular or metabolic activity. Perhaps increased tissue activity could result in an increased GOT content within that tissue, which could be mobilized from the serum or synthesized in the active tissue itself. This hypothesis was tested in humans by measuring SGOT titers before and after 3 three-minute rounds of boxing(8). A significant increase in SGOT level was observed immediately thereafter. Rats compelled to walk for 16 hours responded with an increased level of SGOT(9). These investigations did not exclude the possibility of tissue damage from the blows struck in boxing and in the exercised animals there was histologic evidence of damage to skeletal muscle. Such damage has been shown to result in elevated serum levels of GOT(10-14). Experiments

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reported here were designed to exclude the effects of tissue damage on SGOT and further to test the exercise theories.

Materials and methods. As physical training may influence GOT response to exercise, it was decided to test the hypothesis by utilizing both untrained men (members of Dept. of Physiology and Pharmacology) and well-trained men (volunteers from freshmen and varsity track squads) on the Harvard Step Test(15). Members of the varsity team also volunteered to take part in an experiment to measure their SGOT levels immediately after a time trial in their particular track event.

Control and experimental blood samples were obtained by venipuncture technic. Blood samples for analysis of the control level of SGOT were drawn the day preceding the test. The sample of blood was transferred to a centrifuge tube and the clot was allowed to retract. The blood was centrifuged at 1500 RPM and the serum was separated and stored in the cold until analyzed. Hemolyzed samples were discarded. Analysis was performed within 4 days after serum was collected. The enzyme reportedly is quite stable when refrigerated for this period(1,16).

SGOT was determined by a modification (17) of the tissue method proposed by Tonhazy, White, and Umbreit(18). These modifications were: 1) A 0.3 ml aliquot of undiluted serum was used. 2) Concentration of alpha-ketoglutaric acid was altered from 0.1 M to 0.2 M and volume was changed from 0.2 ml to 0.1 ml. 3) The shaking period at the toluene extraction step was standardized to 10 minutes to insure complete recovery of the pyruvate formed. Serum transaminase activity was expressed as micrograms of pyruvate per milliliter of serum. These values, if multiplied by the factor 1.2(19), are equivalent to the spectrophotometric units originally proposed by LaDue, Wróblewski, and Karmen(1).

Statistical comparison of experimental mean values to control mean values was made by Student's "t" test of significance. Chauvenet's criterion(20) for rejection of suspected data was applied to all series of experiments. The null hypothesis was rejected at the 2% level.

Results. The effect of the Harvard Step Test on SGOT levels in well-trained and untrained men is presented in Table I. There was no statistical difference in control levels of SGOT between the 3 groups. Immediately after the Step Test, the untrained group exhibited a significant decrease in SGOT level ($p = 0.004$) whereas the 2 groups of trained men showed no alteration.

TABLE I. Serum Glutamic-Oxalacetic Transaminase Activity in Men before and after Harvard Step Test.

Group	SGOT (μg/ml) Before	After
Untrained	19.9 ± 2.23*(15)†	10.6 ± 1.92 (13)
Athletes		
Freshmen	25.7 ± 2.42 (9)	21.1 ± 2.49 (8)
Varsity	20.8 ± 1.92 (9)	20.75 ± 1.69 (8)

* Values are stand. errors of means.
† No. of men.

The results of the experiment measuring SGOT after a time trial by the same varsity athletes may be seen in Table II. These athletes significantly depleted serum transaminase after a timed track event ($p = 0.003$).

Discussion. The decrease in serum content of this enzyme in untrained men following the Harvard Step Test, and in trained athletes after a time trial, may be the result of: 1) a simple movement from the serum to the active tissue, or 2) hepatic tissue may inactivate serum GOT, with a concomitant increase in rate of synthesis of the enzyme in the active tissue. Recent research in this laboratory, in which untrained rats were exposed to treadmill running or swimming, confirmed the decrease in SGOT with exercise, while GOT was observed to accumulate in heart, liver and skeletal muscle. These experiments did not determine whether transaminase accumulates in tissue due to increased synthesis or due to a movement to the tissue from the serum.

The physiologic mechanisms responsible for the depletion of SGOT in trained and un-

TABLE II. Serum Glutamic-Oxalacetic Transaminase Activity in Varsity Athletes before and after Time Trials.

Group	SGOT (μg/ml) Before	After
Varsity athletes	20.8 ± 1.92*(9)†	12.2 ± 1.66 (10)

* Values are stand. errors of means.
† No. of men.

trained men are not known, but many investigators have reported a close relationship between GOT and adrenocortical activity(21-23). The adrenal cortex could be involved in those instances where psychological stress occurred(24,25), however, a simultaneous measurement of SGOT and adrenal cortex activity was not accomplished. The adrenal cortex hormone(s) would not appear to be implicated in untrained men exposed to a conventional work load with no psychological stress. This is substantiated by the fact that young men on a routine march did not exhibit an increased adrenal cortex activity(26). Connell, Cooper and Redfearn(26) did not include SGOT measurements.

The emotional approach to the work load may be of great importance, but its magnitude could be of similar importance. It is not possible to state which factor is of paramount importance in the GOT response to exercise.

Summary. Serum glutamic-oxalacetic transaminase was determined in trained and untrained men after exposure to exercise through the Harvard Step Test or timed track events. The untrained human subjects exhibited a significant decrease in SGOT. In athletes, competing in timed track events, there was also depletion in serum transaminase titer. However, in well-trained athletes there was no alteration in serum transaminase level following the same exercise as that of the untrained men. The role of the adrenal cortex and its possible interrelationship with transaminase movements, as influenced by exercise and stress, was discussed.

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