ACCUMULATION OF OXYGEN DEBT AND CHANGES IN OTHER SELECTED VARIABLES DURING A STANDARDIZED RUN ON A MOTOR-DRIVEN TREADMILL

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ACCUMULATION OF OXYGEN DEBT AND CHANGES IN OTHER SELECTED VARIABLES DURING A STANDARDIZED RUN ON A MOTOR-DRIVEN TREADMILL

By

Richard D. Bell

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Approval_____

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by Richard B. Bell

The purpose of this study was to determine the pattern of oxygen debt accumulation during a standardized sub-maximal run on a motor-driven treadmill. In addition to oxygen debt accumulation, the pattern of change of other selected variables was studied. These variables included heart rate, oxygen pulse, and oxygen uptake. The standardized run was arbitrarily chosen to be of ten-minutes duration at a speed of ten miles per hour at zero per cent grade.

Six trained subjects were tested on a motor-driven treadmill over an eight-week period. The standardized ten-minute run was divided into ten fifteen-second runs for the first two and one-half minutes, five thirty-second runs for the next two and one-half minutes, and five one-minute runs for the last five minutes. These twenty separate runs were administered in random order to each of the subjects.

A standard fifteen-minute post-exercise recovery period was used with all runs. This recovery period was divided, for purposes of gas collection and analysis, into eight fifteen-second intervals during the first two minutes of recovery, six thirty-second intervals during

the next three minutes, and one ten-minute interval during the remainder of the recovery period.

Data were collected also during three five-minute rest periods and three standard five-minute warm-up runs at six miles per hour and zero per cent grade.

During the rest periods and warm-up runs data were collected at one-minute intervals. Expired air was collected during both the runs and recovery periods and analyzed for oxygen and carbon dioxide content, volume, and temperature. Means and standard deviations were calculated for each interval in the run, recovery, warm-up, and rest periods.

The total mean oxygen debt for the ten-minute standardized run was 3.096 liters. This oxygen debt was accumulated, for the most part, during the initial stages of the run and probably was due to a circulatory lag. Such an oxygen debt is referred to as an alactacid debt. Mean heart rate values reached a value of 186 beats per minute during the tenth minute of exercise. For runs of less than two minutes and thirty-seconds, the heart rate reached near basal levels during the fifteen-minute recovery period. The heart rate remained elevated after fifteen minutes of recovery for runs of longer duration. Oxygen uptake increased with exercise duration due to increased metabolic demands. Oxygen pulse reached a mean value

of 18.82 milliliters per beat during the tenth minute of exercise. These values basically agreed with other values reported in the literature.

Approval: _____

Date: _____

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R. D. B.

DEDICATION

This thesis is respectfully dedicated to my parents Mr. and Mrs. G. Bell. Their constant interest, motivation, and understanding has been gratefully appreciated. It is also dedicated to my wife Caryl for her help in making four years of graduate study an enjoyable experience.

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CHAPTER I

INTRODUCTION

The accumulation of oxygen debt occurs in submaximal exercise as well as in maximal exercise. The amount of oxygen debt accumulated is measured by analyzing a sample of expired air collected during a post-exercise recovery period and by calculating the amount of oxygen used in excess of basic requirements. In short bouts of strenuous exercise, the accumulation of oxygen debt makes it possible to convert stored chemical energy into usable mechanical energy. Anaerobic energy thus supplied is in addition to that supplied via the aerobic metabolic pathways. If work intensity increases beyond the individual's aerobic capacity, the subject must rely on anaerobic chemical processes for much of the energy required to accomplish the work.

The phenomenon of oxygen debt has been well documented in the literature for many years. However, most investigators have been concerned with the total oxygen debt accumulated or with the biochemical nature of oxygen debt. Few, apparently, have been interested in the pattern of accumulation of oxygen debt during a given exercise period, be it maximal or submaximal. The writer hopes this study

will add to the total knowledge of the phenomenon of oxygen debt.

Statement of the Problem

The purpose of this investigation was to determine the pattern of oxygen debt accumulation during a standardized, submaximal run on a motor-driven treadmill. In addition to oxygen debt accumulation, the pattern of change of other selected variables was also studied. These variables included heart rate, respiratory quotient, respiratory frequency, ventilation volume, true oxygen, and oxygen pulse. However only oxygen debt, oxygen uptake, oxygen pulse and heart rate are reported at this time. Raw data for the remaining variables may be obtained from the Human Energy Research Laboratory, Michigan State University.

Scope of the Study

The sample for this study was drawn from individuals who had participated in previous studies involving treadmill running. In addition, individuals participating, or who had previously participated, in intercollegiate athletics were selected for the study. The final sample of six individuals included three with varsity track experience, two with varsity hockey experience, and one individual with extensive treadmill experience. It was hoped that such individuals would minimize the effects of training as the study progressed.

Limitations of the Study

The small sample size and the nonrandom selection of subjects limit the generality of the conclusions.

There was control over the diet or living habits of the six subjects invovled in the study.

Individual motivation during the testing periods was not considered.

Several Douglas Bags were in poor condition throughout the study. This resulted in a slight loss of expired air during some portions of the data collection.

A repeat of the runs was not possible because of the time involved and the laboratory schedule at the time this study was occurring.

Individual variations in height, weight, and body build were not considered.

Definition of Terms Used in This Study

Respiratory Quotient.--Respiratory quotient is the ratio of carbion dioxide exhaled to oxygen extracted. It generally is used for determinations of the amount of fat, carbohydrate, and/or protein utilized during a specific period of muscular work.

Ventilation Volume.--Ventilation volume refers to the corrected volume of air, in liters, expired during a specific time interval.

Oxygen Pulse.--Oxygen pulse is the amount of oxygen removed from the blood per heart beat. It is determined by dividing the oxygen uptake by the heart rate for a specific time interval.

True Oxygen.--True oxygen is the amount of oxygen extracted from the lungs during a specific time interval.

Oxygen Debt.--Oxygen debt is the amount of oxygen required, in the post-exercise period of recovery, to reverse the anaerobic reactions of the exercise period.

Anaerobic Work.--Anaerobic work is that work done by the organism which occurs in the absence of free oxygen.

CHAPTER II

LITERATURE REVIEW

In his book Physiology of Muscular Activity, Karpovich (13, p. 57) states that if work intensity increases beyond a certain optimal point, additional work must depend on anaerobic chemical processes in the muscles for the necessary energy to continue that work. When the concentration of lactic acid in the blood reaches three to four per cent, the muscles cannot continue to contract. After the work period (exercise) is completed, the oxygen consumption remains at a high level until the oxidation of the accumulated products of exercise has been completed or, in other words, until the oxygen debt has been paid.

Taylor (24, p. 151) claims that in submaximal exercise the oxygen debt is a result of a circulatory lag during which time the circulation is increased to the point at which the oxygen requirement of the work is met by the oxygen delivered to the working tissues. An oxygen debt of this type increases in a linear manner with increasing work intensity, but there comes a point when the circulatory system no longer supplies oxygen to the working tissues at a rate which will meet the metabolic requirements of the working muscles. At this point, the oxygen

debt rises rapidly as the metabolic demands of the body are being met by anaerobic chemical processes.

According to Dill and Sacktor (9, p.966), an accumulation of oxygen debt always occurs in maximal exercise of short duration. The accumulation of oxygen debt makes it possible, in short bouts of exercise, to convert stored chemical energy into mechanical energy in excess of the capacity of the respiratory and cardiovascular systems to supply oxygen to the working tissues.

Hill, Long and Upton (11, p.996) say there are two factors involved in repaying the oxygen. The first factor is a rapid component involving the removal of lactic acid from the working tissues. This is designated as the alactacid component. The second factor is a slower component involving the removal of lactic acid from the blood. This is designated as the lactacid component. However, moderate exercise of long duration can produce fatigue without an increase of lactic acid in the blood, and the removal of lactic acid from the system does not run parallel to the repayment of oxygen debt. Moderate exercise of short duration produces no increase of lactic acid in the blood, yet there is an oxygen debt. The evidence for no increase in lactic acid in moderate work is found in the unchanged concentration of lactic acid in the blood and its ready diffusability between the tissues and blood.

In the experiments of Margaria et al. (15), a skilled runner walked or ran for ten minutes at various speeds and grades on a motor-driven treadmill. In exercise not requiring maximal oxygen consumption, the lactic acid in the tissues and blood reached an equilibrium throughout the body. For oxygen debts of three to four liters there was no increase in lactic acid concentration, but beyond six liters of oxygen debt the concentration of lactic acid was a linear function of the extra oxygen consumption. The oxygen consumption curve during recovery was a sum of four functions:

1. The basal oxygen consumption,
2. The oxygen consumption attributable to oxidation of lactic acid,
3. Another exponential function of time occurring at a fast rate,
4. Oxygen consumption decreasing slowly during recovery.

Margaria et al. (15) also concluded that the alactacid oxygen debt was approximately a linear function of the oxygen intake during exercise while the lactacid oxygen debt began only when the work was carried on under anaerobic conditions. In moderate exercise, the oxygen debt could reach a value as high as four liters without evidence of lactic acid accumulation in the blood. In severe exercise, however, the large oxygen debt could not be explained by the accumulation of lactic acid alone.

In a similar manner, the work of Dill et al. (7) showed that the initial rapid payment of the oxygen debt in isolated muscle is not correlated with the removal of lactic acid from the blood as the oxygen debt was produced during the first minutes of recovery. In work such that no lactic acid appears in the blood, the alactacid debt may be as large as three liters. When work is of an anaerobic nature, a debt due to the formation of lactic acid is contracted. The alactacid debt may be paid off during the first five minutes of recovery but subsequent repayment of the lactacid component depends on the rate of lactic acid removal. Although the lactacid and alactacid debts are contracted concurrently, the latter is repaid twenty times more rapidly than the former.

Margaria, Edwards and Dill (15) say there is general agreement that the oxygen debt is due to delayed oxidation of a fraction of the lactic acid produced during anaerobic phases of muscular activity. However, this mechanism does not explain all the processes which occur in the repayment of the oxygen debt. In moderate work the alactacid oxygen debt accounts for most of the lag in oxygen consumption at the beginning of work before a steady state is reached. Lactacid oxygen debt is not appreciable until oxygen intake is equal to or greater than 2.5 l/O_2/minute. The oxygen consumption curve during recovery results from the sum of four functions, two of which are concerned with oxygen

debt. These are, of course, the lactacid and alactacid components of oxygen debt previously discussed.

Probably the most significant study in this area of interest was an unpublished study by Bailey, Orban, and Merriman (19). The purpose of the study was to compare the oxygen consumption, oxygen debt, and oxygen requirement patterns of trained and untrained subjects during a five-minute treadmill run of six miles per hour at a twenty-five per cent grade. Partial results of their data are shown in Figure 1. The oxygen requirement is equal to the total oxygen intake plus the oxygen debt.

The respiratory quotient has been defined previously as the ratio of carbon dioxide exhaled to oxygen extracted. The primary sources of fuel for muscular activity are carbohydrates, fats, and proteins with carbohydrates and fats being the main sources of energy under normal circumstances (13, p. 46). Because of their different chemical structures these sources of muscular energy have different respiratory quotients. The respiratory quotient for carbohydrates is 1.0, since for every molecule of oxygen used a molecule of carbon dioxide is released. The respiratory quotient for fat is 0.7. For protein it is approximately 0.8. However, the amount of protein oxidized during muscular exertion is usually insignificant. During exercise the respiratory quotient rises, providing the exercise is not exhaustive. During recovery, however, the

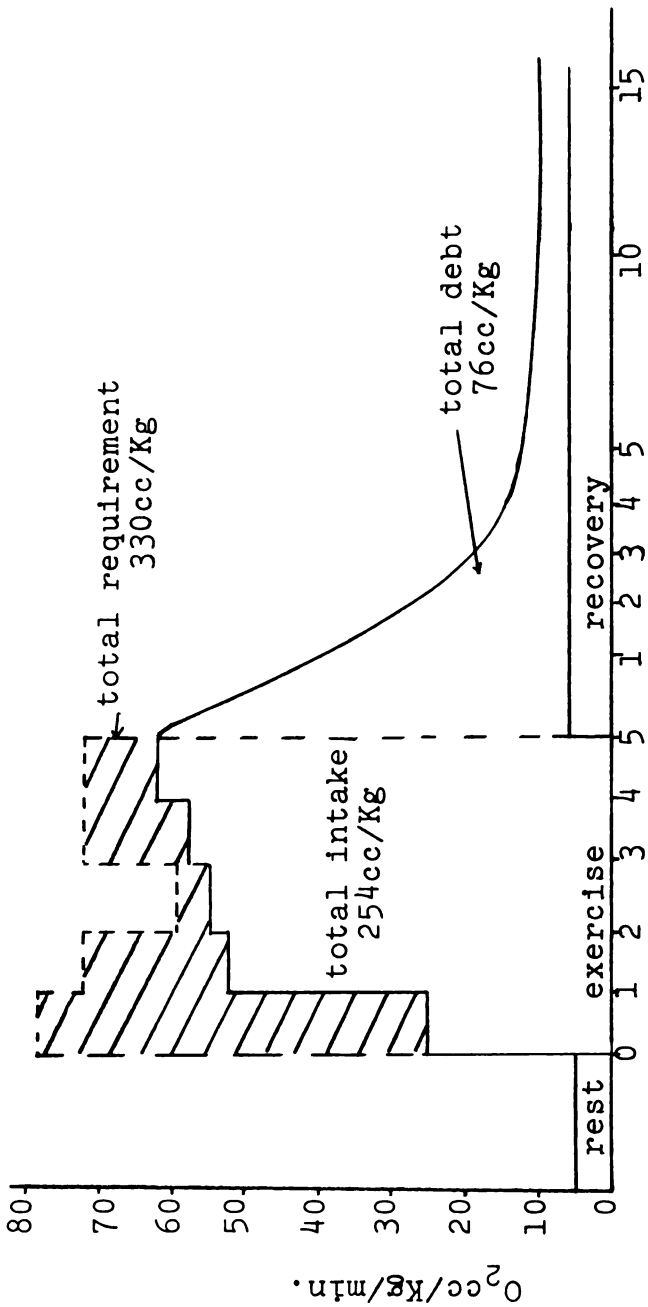

Figure 1.--Study by Bailey, Orban, and Merriman.

respiratory quotient may be over 1.0. This is a spurious respiratory quotient due to over breathing following the cessation of exercise.

Oxygen pulse increases during exercise as the heart rate increases. Values of 11.0 ml to 17.0 ml at heart rates of 130 to 140 beats per minute have been reported (13, p. 135); but with further acceleration of the heart rate, oxygen pulse may, in fact, tend to decrease. Following cessation of exercise, the oxygen pulse value may return to the pre-exercise level faster than the heart rate. This is due to a diminished venous return which reduces the amount of blood passing through the lungs. A smaller amount of oxygen is therefore absorbed from the lungs.

When exercise begins, pulse rate increases rapidly with the largest increase occurring within the first minute. However, pulse rate changes are dependent on the individual (13, p. 167). The time required for the pulse rate to return to normal after exercise depends on two factors: (1) the intensity of the exercise, and (2) the condition of the individual. Post-exercise pulse rates may even fall below the pre-exercise level. However, the pre-exercise pulse rate level is subject to some criticism as it may be easily influenced by several psychological and environmental factors.

CHAPTER III

RESEARCH METHODS

The purpose of this investigation was to determine the pattern of accumulation of oxygen debt and the changes that occur in other selected variables during a standardized run on a motor-driven treadmill. The variables studied were oxygen debt, oxygen pulse, heart rate, and oxygen uptake. Means and standard deviations were caulculated for each part of the ten-minute run. The results were also recorded graphically.

Sampling Procedure

Nine subjects were originally chosen for this experiment. To qualify as a subject, an individual had to be a varsity athlete and/or have had previous treadmill experience, and be in good physical condition. It was necessary to eliminate three of the subjects at the beginning of data collection because of the time required for data collection on each subject. Of the six subjects retained, five were varsity athletes with previous treadmill experience while the sixth had only previous treadmill experience but was judged to be in good physical condition. The ages of the subjects ranged from eighteen to twenty-one years.

Experimental Design

For this experiment, the standard run was arbitrarily chosen to be of ten-minutes duration at a speed of ten miles per hour at zero per cent grade. In order to determine, as accurately as possible, the rate of oxygen debt accumulation during the run, the standardized ten-minute run was divided into ten fifteen-second runs for the first two and one-half minutes, five thirty-second runs for the next two and one-half minutes, and five one-minute runs for the last five minutes. The ten-minute run thus was divided into twenty components. Each component was administered as a separate run and each was followed by a standard fifteen-minute recovery period. In addition, three five-minute sitting rest periods, during which data were collected at one-minute intervals, were included in the testing schedule since base levels for the variables under consideration were required. Three five-minute warm-up runs at six miles per hour, zero per cent grade, followed by a fifteen-minute warm-up recovery period also were included in the testing schedule. Thus each subject had to complete twenty-six test periods, and each testing schedule was randomized for each of the six subjects. The subjects were not aware of their daily assignment until data collection was to begin for that day.

Each fifteen-minute recovery period was divided for purposes of gas collection and analysis. The recovery period consisted of eight fifteen-second intervals during

the first two minutes of recovery, six thirty-second intervals during the next three minutes of recovery, and one ten-minute interval during the remainder of the recovery. Data were collected five days per week over a period of eight weeks. Each subject came to the laboratory at the same time every day he was to be tested in an attempt to reduce the diurnal effects on exercise.

Testing Procedures

Each day, on reporting for testing, each subject first had the recording electrodes attached. Three zinc electrodes were used, two being chest leads and one being a ground lead placed on the lower back. These electrodes were securely attached by adhesive as well as masking tape.

If the subject was to be tested during a five-minute rest period or during the standard five-minute warm-up run (six miles per hour at zero per cent grade) followed by the fifteen-minute warm-up recovery period, he was immediately fitted with an adjustable head gear holding the triple-J, low resistance, valve. If the subject was to be tested during one of the twenty component runs, he completed the standard warm-up and warm-up recovery before being fitted with the head gear. The outlet of the triple-J valve was connected to a Franz Mueller four-way valve via a short section of non-collapsible rubber tubing. The Franz Mueller valve was manually operated and was switched to the next Douglas Bag as close to the completion of a specific time

interval as possible. All switches between Douglas Bags were made at end inspiration to provide for gas collection over a number of respiratory cycles. Expired air was collected in fifty-liter Douglas Bags during each rest period, each run, and during the first five minutes of each recovery period. A three-hundred-liter Douglas Bag was used during the last ten minutes of the recovery period. Expired air was collected only for the first twenty seconds during all one-minute intervals because of the limiting size of the fifty-liter Douglas Bags. (These twenty-second volumes were corrected to one-minute values.) Heart rate was recorded on a Sanborn model 60-1300 recorder. At the completion of each time interval, a Douglas Bag containing expired air was removed from the Franz Mueller valve, stoppered, and immediately analyzed. On completion of a run, the treadmill was stopped, and the subject sat down immediately for the fifteen-minute recovery period.

The expired air was analyzed with a Beckman Model E_2 oxygen analyzer and a Beckman Model 15A L/B infrared carbon dioxide analyzer. Next, each Douglas Bag was evacuated using a Kafranyi volume meter in order to determine both the volume and the temperature of the expired air. A correction factor to account for the air extracted by the oxygen and carbon dioxide analyzers was added to each volume obtained via the Kafranyi meter.

Following data collection, a chart[1] was used to convert the carbon dioxide valves to percentage carbon dioxide. Respiratory quotient and true oxygen values were obtained from a nomogram using percentage carbon dioxide and percentage oxygen as guidelines. A typical data sheet is shown in the Appendix.

For each testing period, percentage carbon dioxide, percentage oxygen, respiratory quotient, true oxygen, corrected ventilation, and oxygen uptake (Oz/liter/minute) were calculated for each time interval of the rest, warm-up, the exercise, and recovery periods. The Bastat Cont/Data 3600 computer program was used to calculate mean values and standard deviations for each time interval for the six subjects. Thus, a mean value for each time interval of the exercise, recovery, warm up, and rest periods was obtained. These mean values were used to plot the data graphically.

Oxygen debt for each component run was calculated by subtracting the resting oxygen uptake value from the recovery oxygen uptake value. (The resting value was multiplied by fifteen as the recovery period was of fifteen minutes duration.)

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[1]Laboratory Conversion Chart.

CHAPTER IV

PRESENTATION AND DISCUSSION OF DATA

The purpose of this investigation was to determine the pattern of oxygen debt accumulation during a standardized sub-maximal run on a motor-driven treadmill. In addition to oxygen debt, the pattern of heart rate, oxygen uptake and oxygen pulse were also studied. The sub-maximal run was arbitrarily selected to be of ten-minutes duration. It was divided into ten fifteen-second intervals, five thirty-second intervals, and five one-minute intervals in order to accurately determine the pattern of change for each variable. Mean values for each time interval of each variable were plotted graphically.

Heart Rate

Mean heart rate values follow the expected pattern during the ten-minute exercise period. From a mean resting value of 64.5 beats per minute (see Fig. 2) the heart rate rises to a mean peak value of 186 beats per minute at the conclusion of the exercise (see Fig. 4). This would indicate that the exercise is of an intense nature although certainly not exhaustive.

There are two stages in cardiac acceleration during muscular exercise. These are the increase in rate which

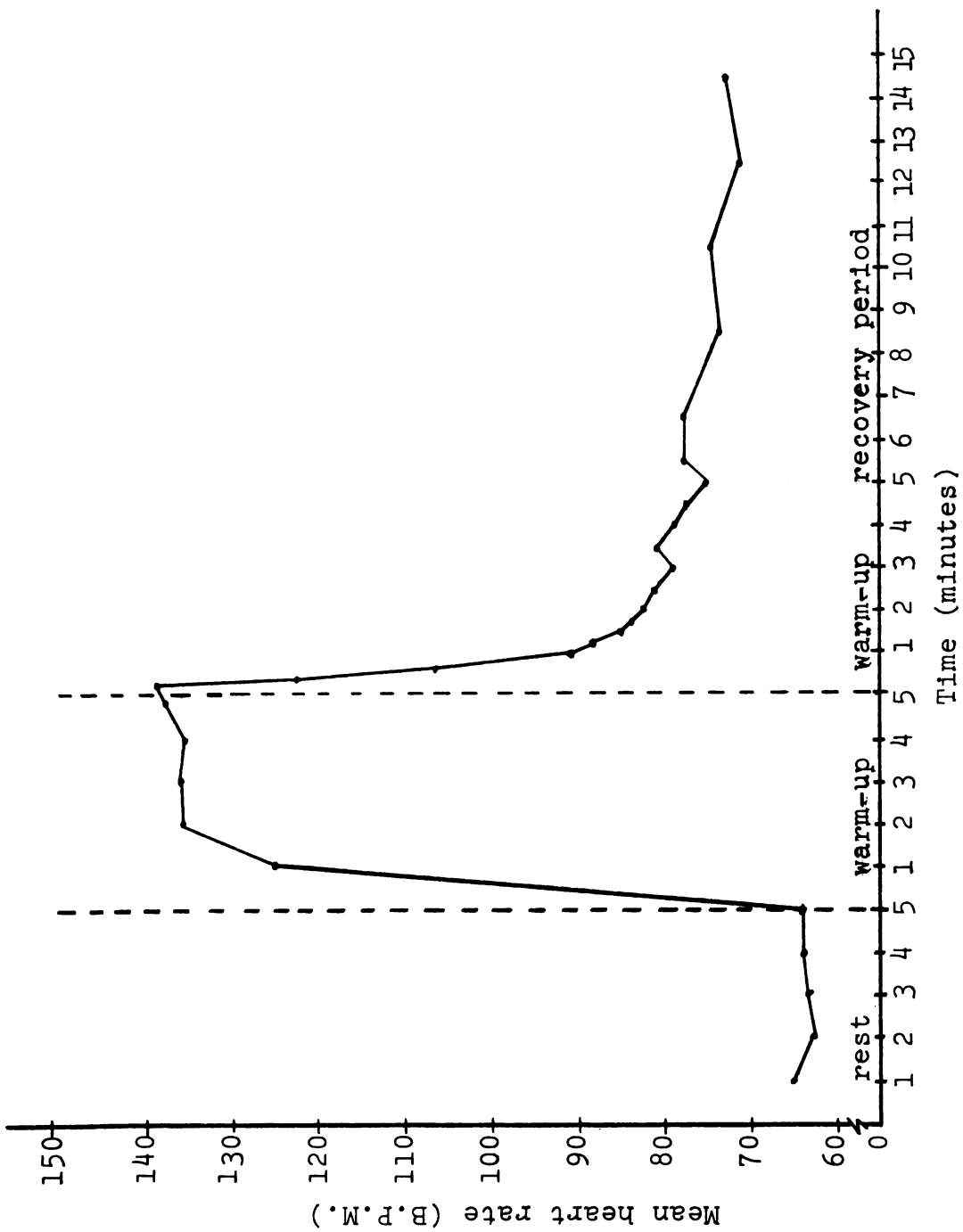

Figure 2.--Mean heart rate values (beats per minute) for a five-minute rest, five-minute warm-up run at six miles per hour zero per cent grade, and a fifteen-minute warm-up recovery period.

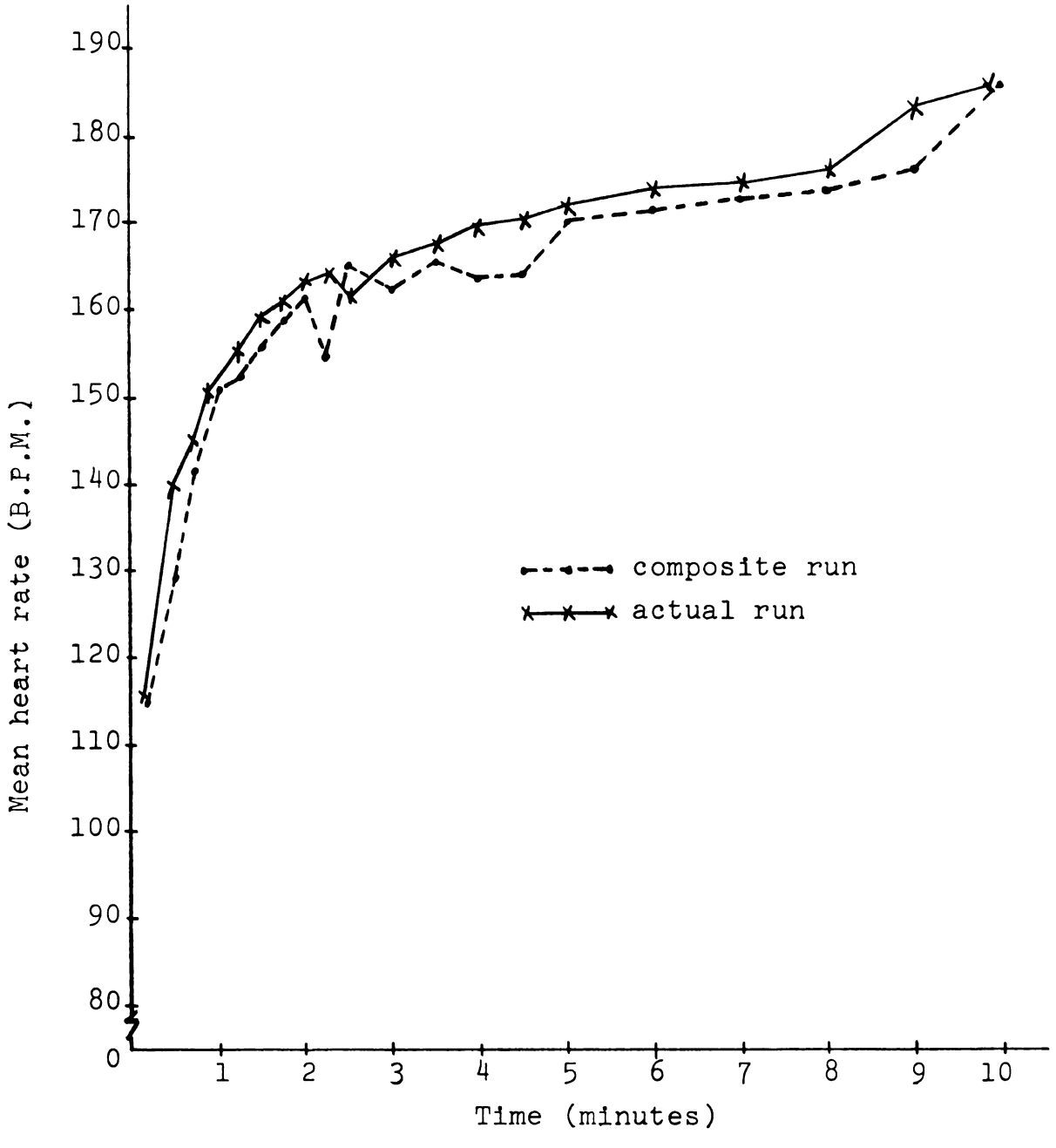

Figure 3.--Mean heart rate values (beats per minute) for the actual ten-minute run and the composite ten-minute run.

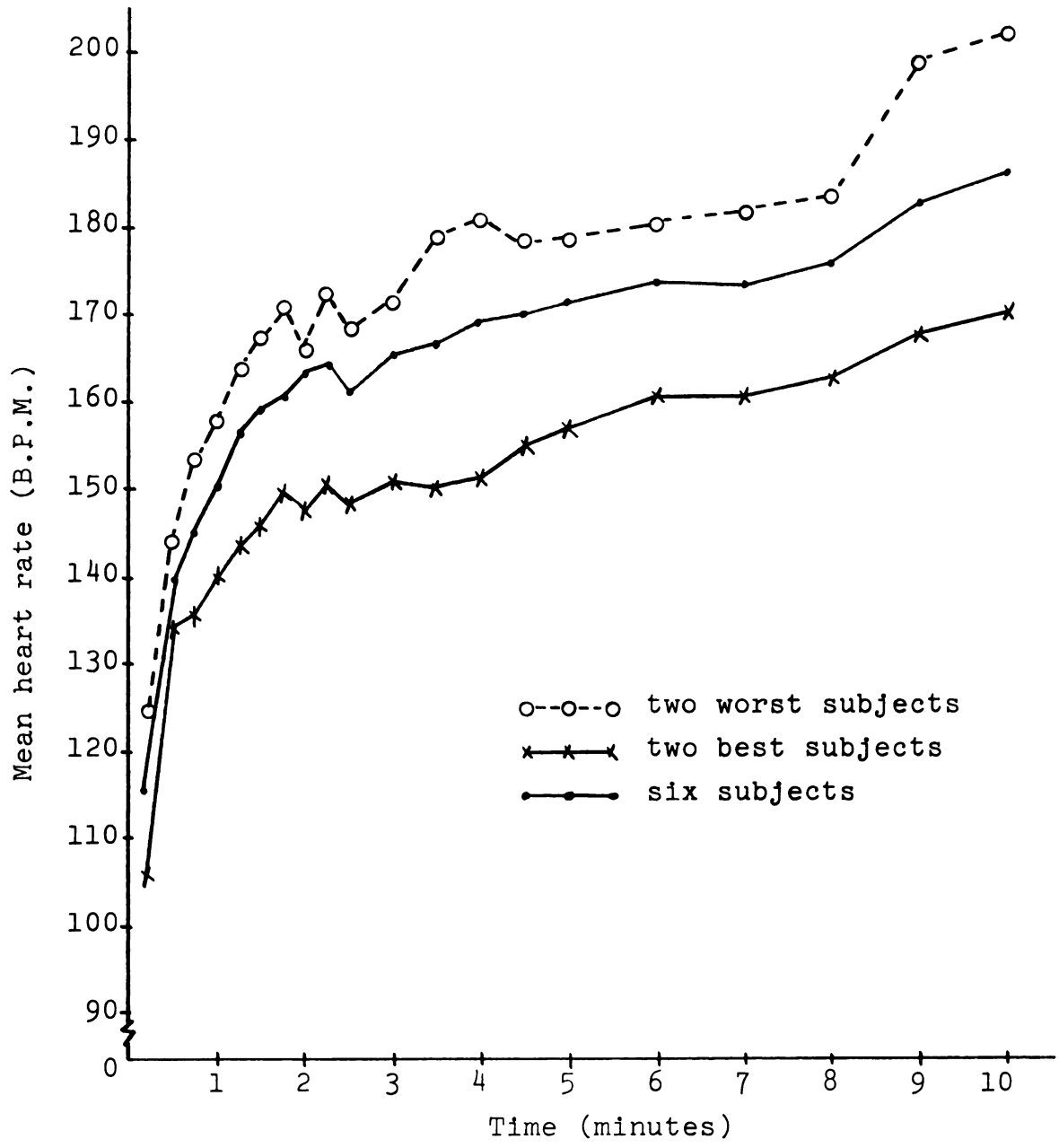

Figure 4.--Mean heart rate values (beats per minute) for an actual ten-minute run for all six subjects, the two worst subjects, and the two best subjects.

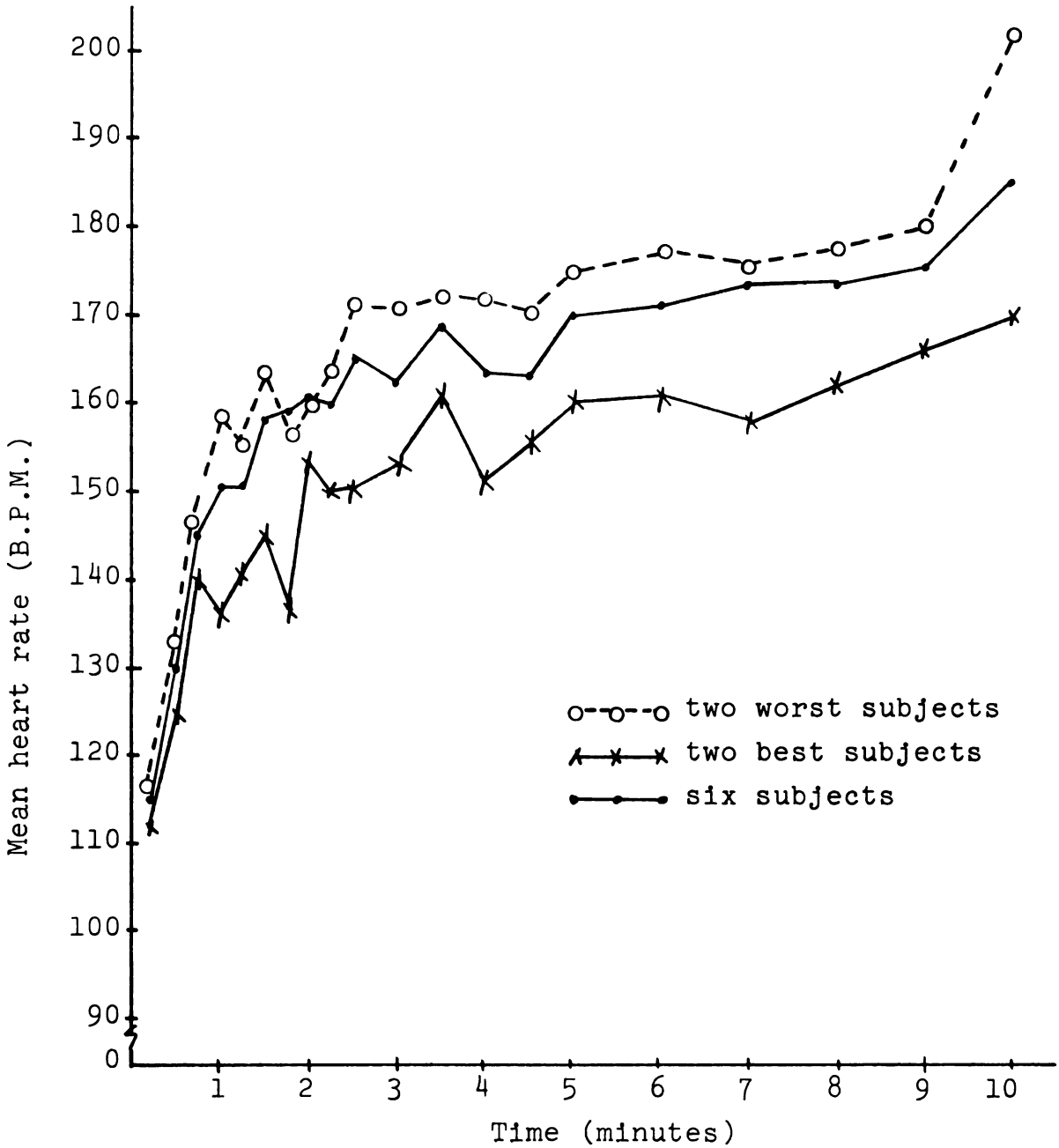

Figure 5.--Mean heart rate values (beats per minute) for the composite ten-minute run for all six subjects, the two worst subjects, and the two best subjects.

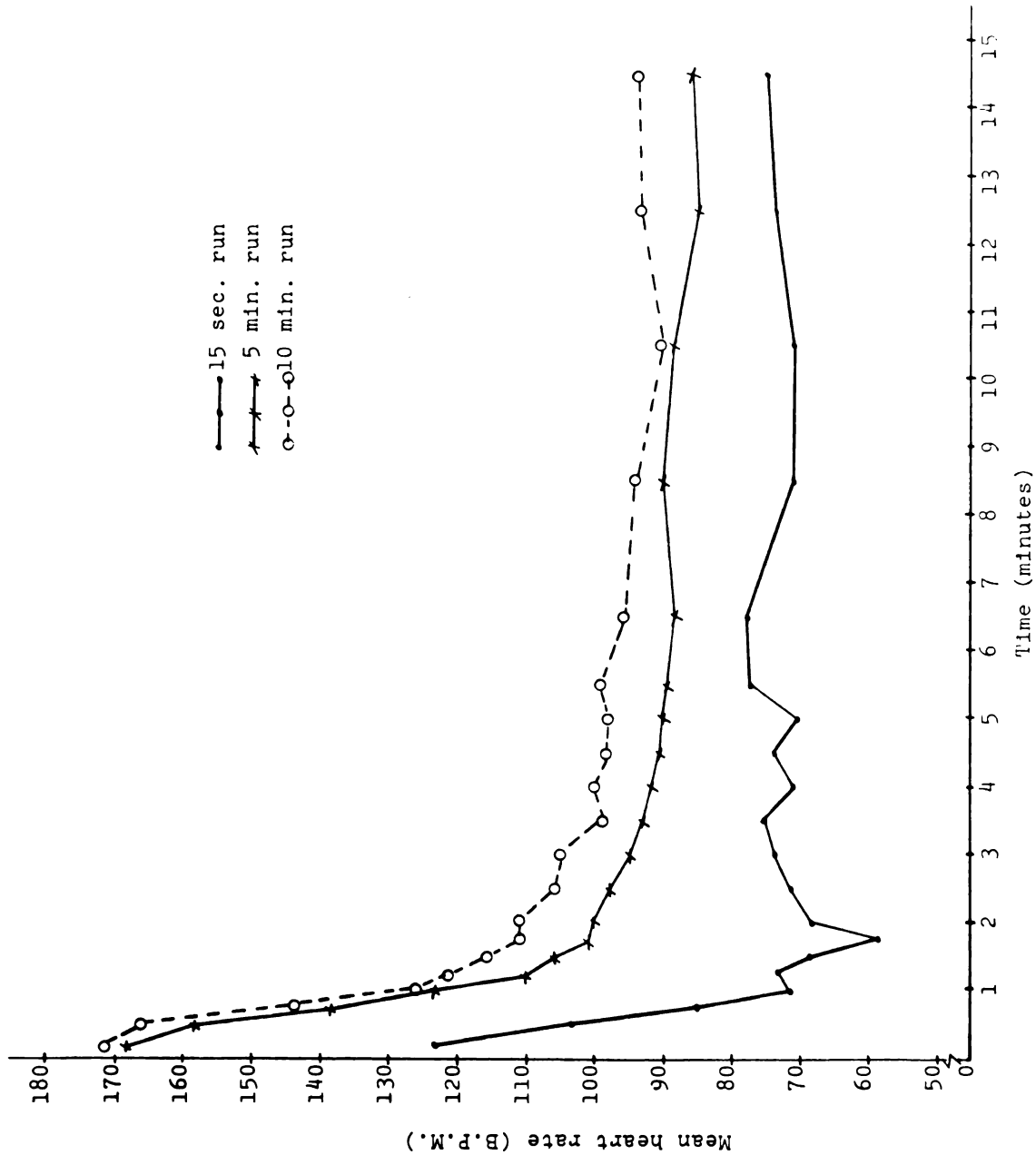

Figure 6.--Mean recovery heart rate values (beats per minute) for the fifteen-second run, the five-minute run, and the ten-minute run.

occurs immediately upon commencement of the exercise and that which develops more gradually. The immediate acceleration of the pulse rate at the onset of exercise occurs too promptly to be a result of the Bainbridge reflex and probably is due to impulses arising in the motor areas of the cortex overflowing to the cardio-inhibitory center (1, p. 247). However, after the initial stages of work the increased acceleratory tone contributes to the increased heart rate. The important factor in the delayed heart rate increase is the rise in venous pressure and the elicitation of the Bainbridge reflex. In the athlete, however, an increased cardiac output is due to an increase in stroke volume and the heart rate increase plays a lesser role.

The recovery of the heart rate also followed a predictable pattern. For runs shorter than two minutes and thirty seconds the heart rate was returned to near basal values during the measured fifteen-minute recovery period. In fact basal levels were reached before two minutes of recovery had passed. Runs of longer duration were characterized by an elevated heart rate at the completion of the recovery period.

Oxygen Uptake

The expected pattern for rate of oxygen consumption during a period of exercise is a steady rise after the onset of exercise followed either by a leveling off if the exercise is of moderate intensity or a secondary rise if the

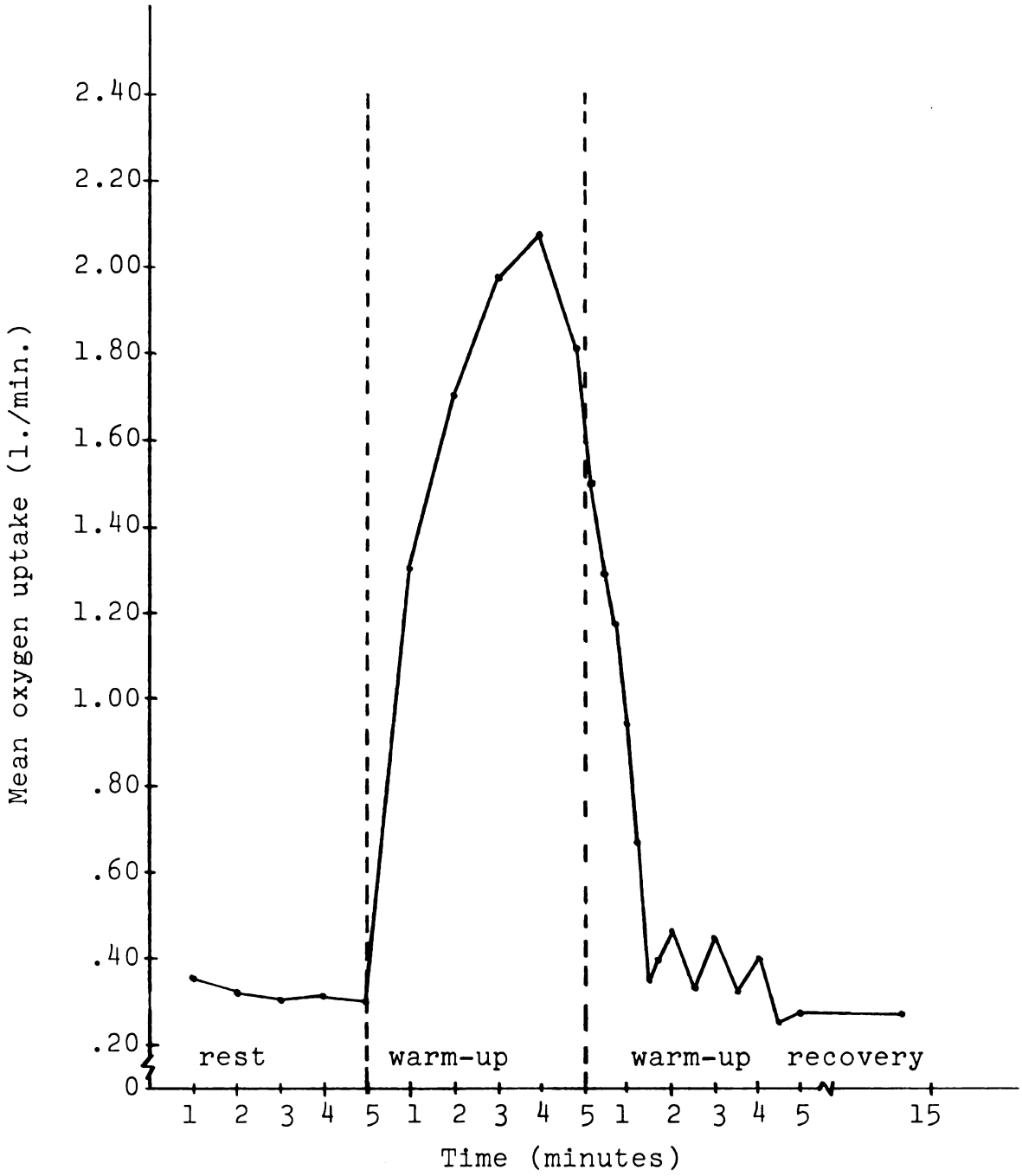

Figure 7.--Mean oxygen uptake values (liters per minute) for the five-minute rest, the five-minute warm-up run at six miles per hour zero per cent grade, and the fifteen-minute warm-up recovery period.

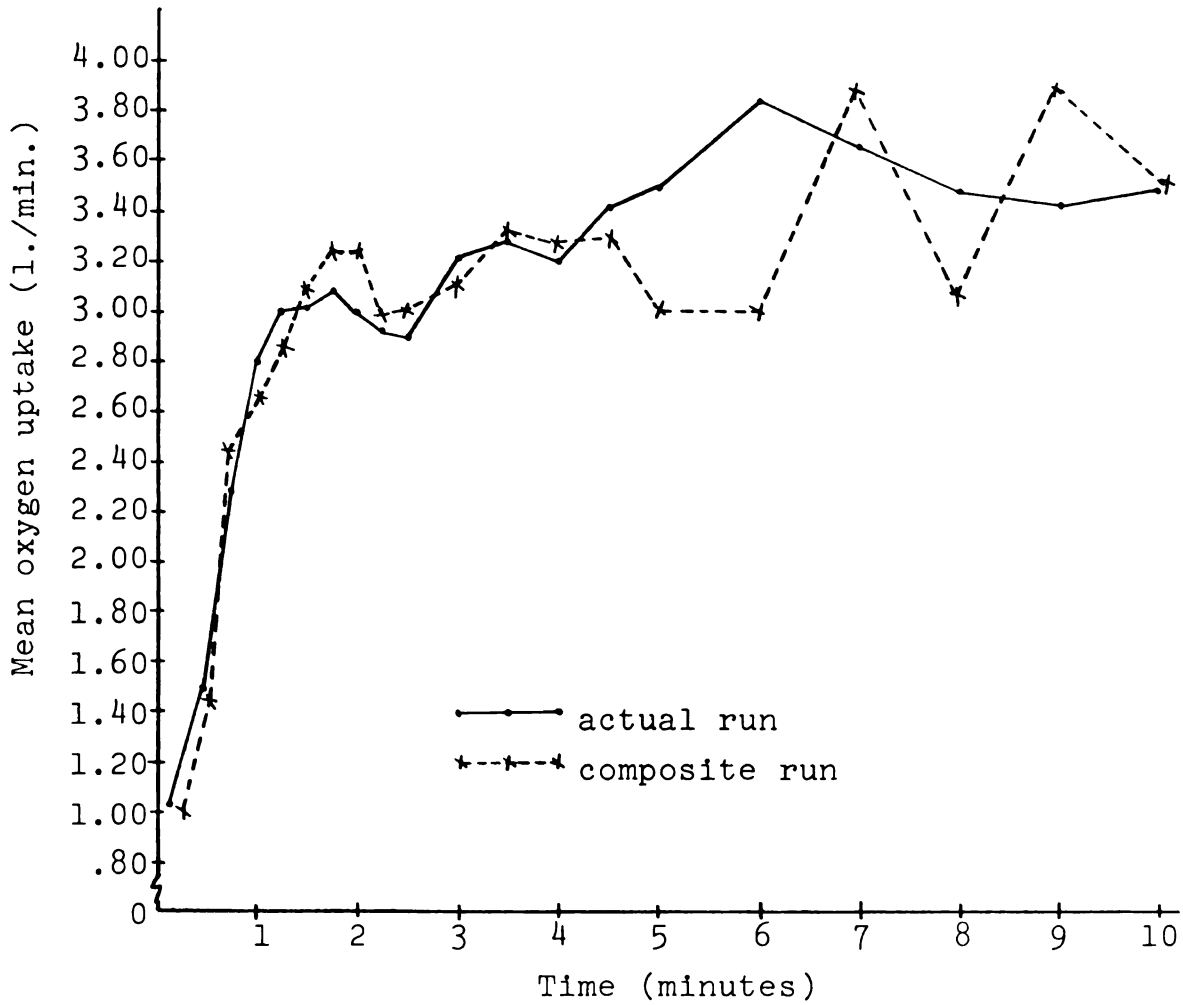

Figure 8.--Mean oxygen uptake values (liters/min.) for the composite ten-minute run and the actual ten-minute run.

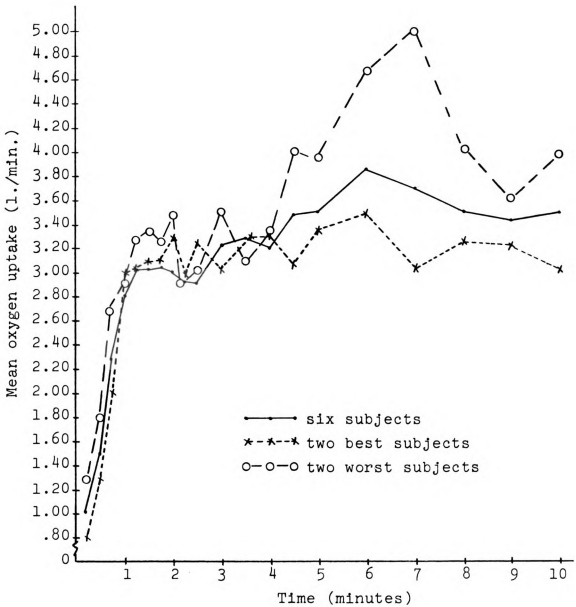

Figure 9.--Mean oxygen uptake values (liters/min.) for all six subjects, the two best subjects, and the two worst subjects for the actual ten-minute run.

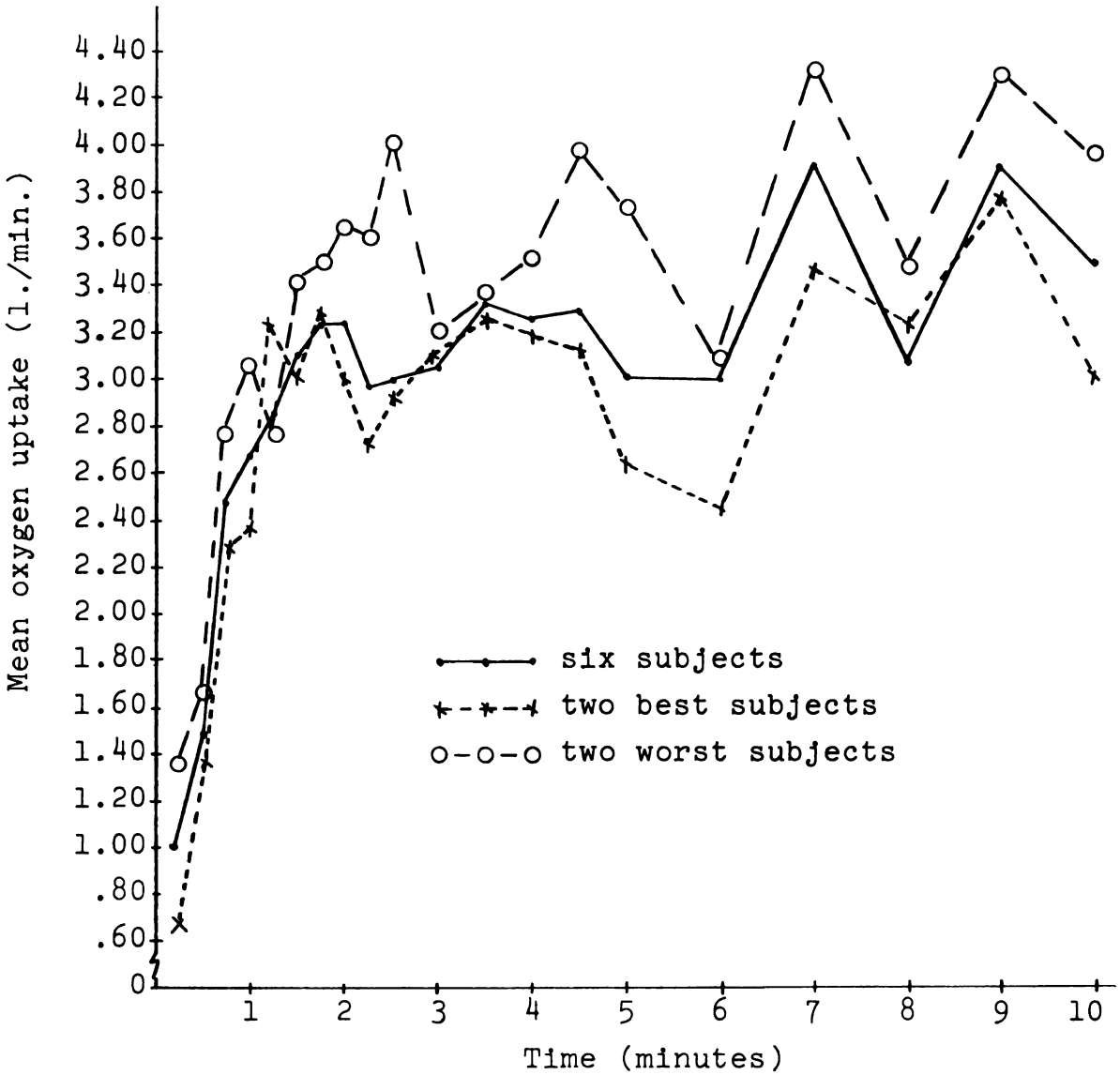

Figure.--Mean oxygen uptake values (liters/min.) for all six subjects, the two best subjects, and the two worst subjects for the composite ten-minute run.

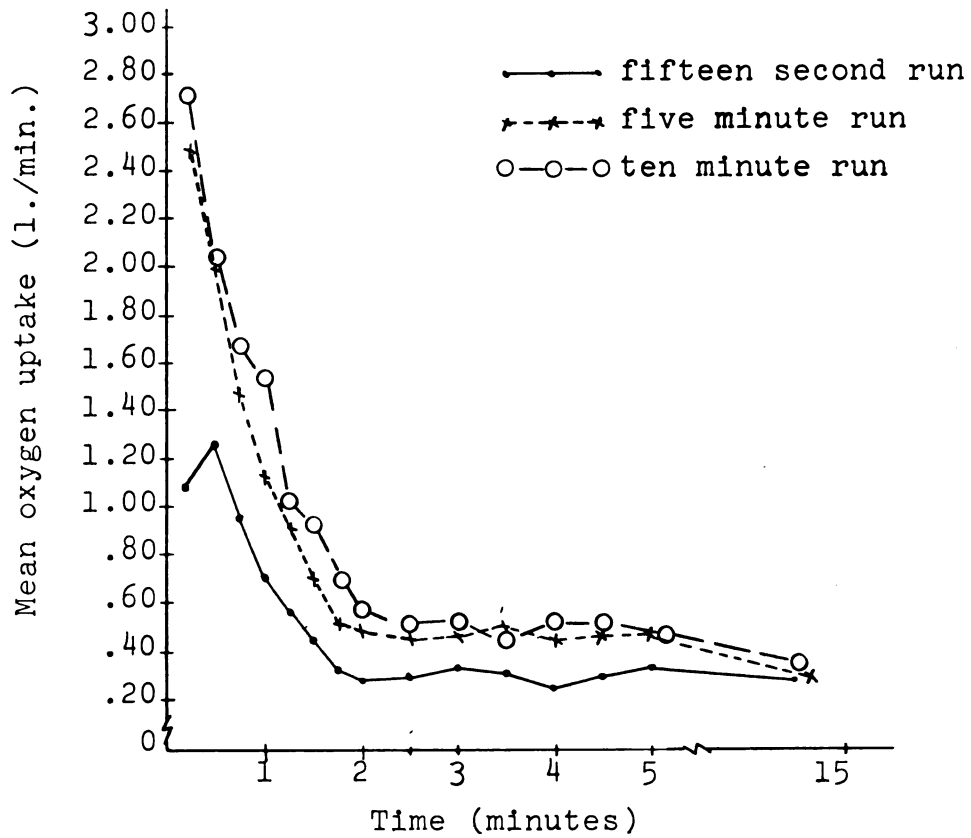

Figure 11.--Mean recovery oxygen uptake values (liters/min.) for the fifteen-second run, the five-minute run, and the ten-minute run.

exercise is moderately severe. The results of this experiment indicated an exercise priod of moderate severity. During muscular exercise oxygen consumption is increased several fold. There are only two ways by which the tissues can be supplied with the extra oxygen they require. These are an increased circulatory rate or a greater coefficient of oxygen extraction (i.e., removal of more oxygen from each unit of blood) (1, p. 246). With moderately severe exercise the coefficient of oxygen utilization is usually doubled while the cardiac output is increased up to four-fold. This would permit an eight-fold increase in oxygen consumption. This rise in oxygen utilization during muscular exercise is attributed to the diversion of a larger proportion of the total blood volume through the contracting muscles. The rate of oxygen consumption is said to represent the physiological cost of the exercise (23, p. 27).

In any given individual there is a linear relationship between oxygen uptake and heart rate during submaximal work. The slope of the line however changes with the state of physical fitness of the individual. Individual differences in oxygen consumption are explained on a basis of greater circulatory reserve. Circulatory reserve depends on the heart rate, the stroke volume, and the arterio-venous oxygen difference. The increase in stroke volume is lowest for non-athletes but it is quite pronounced for competitive athletes.

The pattern of oxygen uptake is somewhat erratic after the five-minute mark of the ten-minute run. This is probably due to the individual differences in physical conditioning of the subjects involved and/or to the small sample size. Two of our subjects were in superior condition (one was competing in cross country) and thus required less oxygen to sustain muscular effort. By way of contrast, the two individuals with varsity hockey experience were in relatively poorer physical condition.

Oxygen Debt

Oxygen debt, as calculated from oxygen uptake values ranged from a mean value of 1.419 liters for the fifteen-second run to a mean value of 3.227 liters for the ten-minute run. The mean rate of net oxygen debt accumulation (Fig. 12) was determined by dividing the mean oxygen debt for each component run by the run time. The results indicated an oxygen debt accumulation which was highest during the initial stages of the run. Such an oxygen debt would be due, primarily, to a circulatory lag which occurred at the beginning of the exercise period. In addition, the oxygen debt thus accumulated would be rapidly repaid during the recovery period and would be defined as the alactacid portion of the total oxygen debt as defined by Hill *et al.* (11). Oxygen debt for work loads below the point at which lactic acid would be detectable in the blood stream is paid off within four minutes after the completion of exercise.

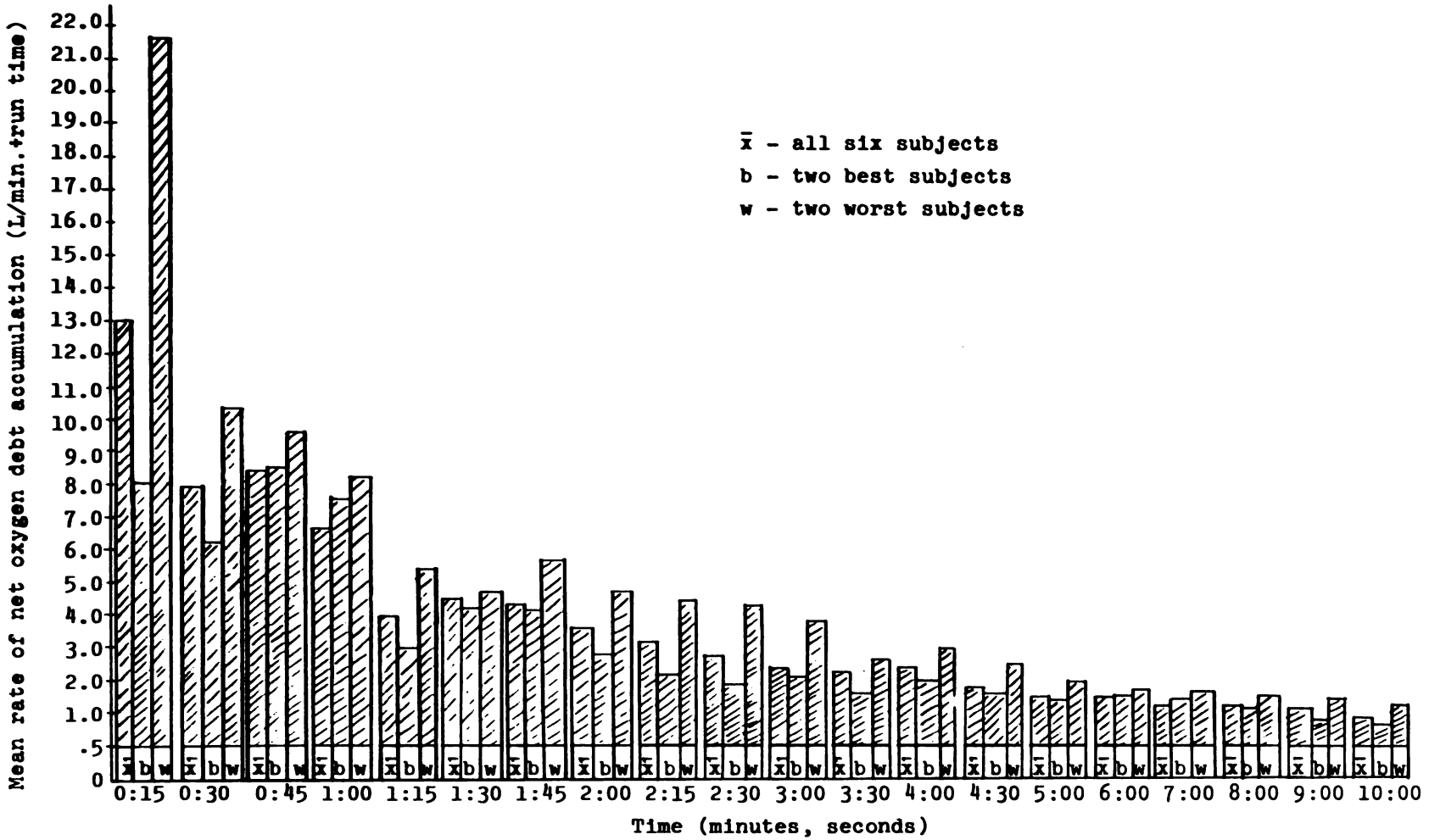

Figure 12.--Mean rate of net oxygen debt accumulation for the ten-minute composite run for all six subjects, the two best subjects, and the two worst subjects.

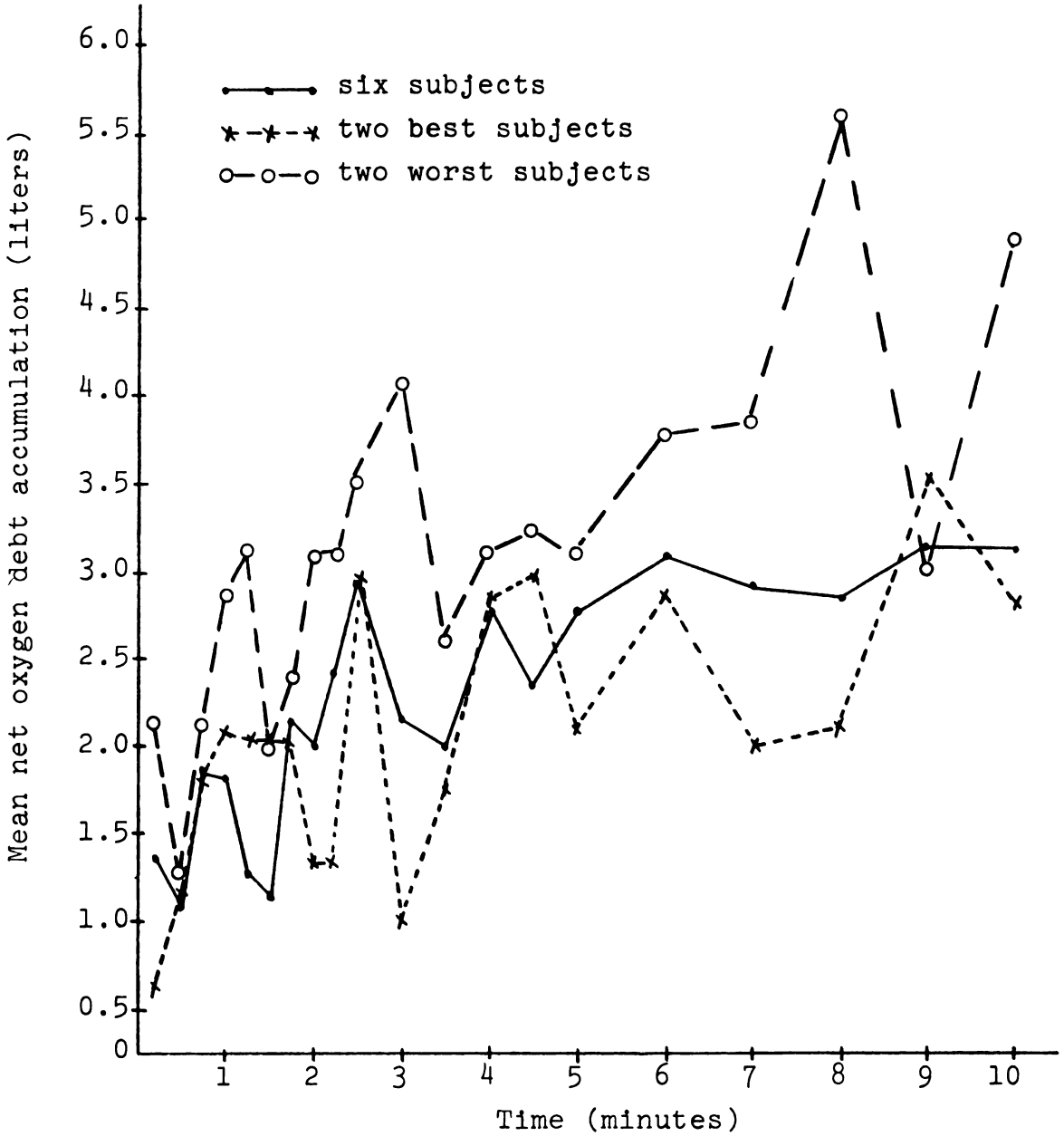

Figure 13.--Mean net oxygen debt accumulation (liters) during the ten-minute composite run for all six subjects, the two best subjects, and the two worst subjects.

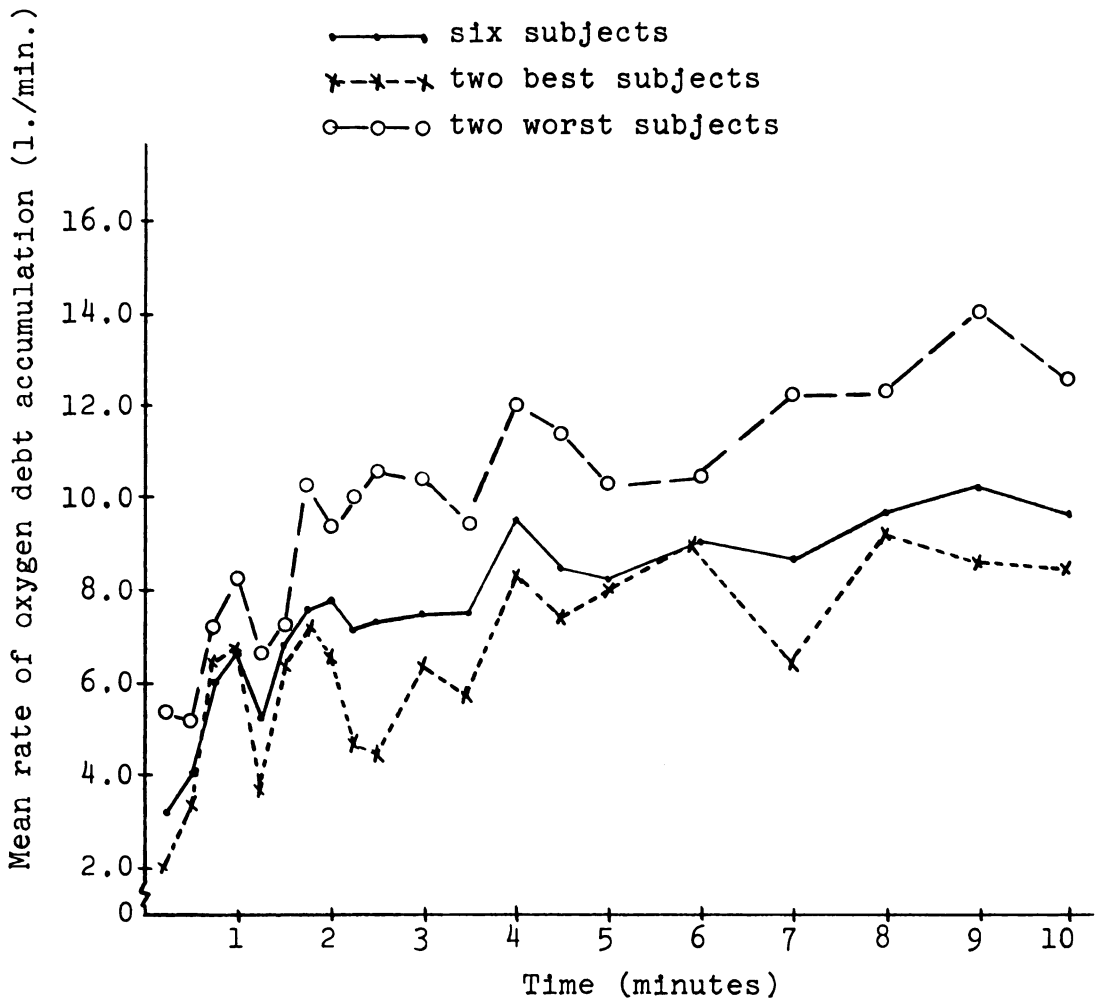

Figure 14.--Mean rate of oxygen debt accumulation (liters/min.) during the ten-minute composite run for all six subjects, the two best subjects, and the two worst subjects.

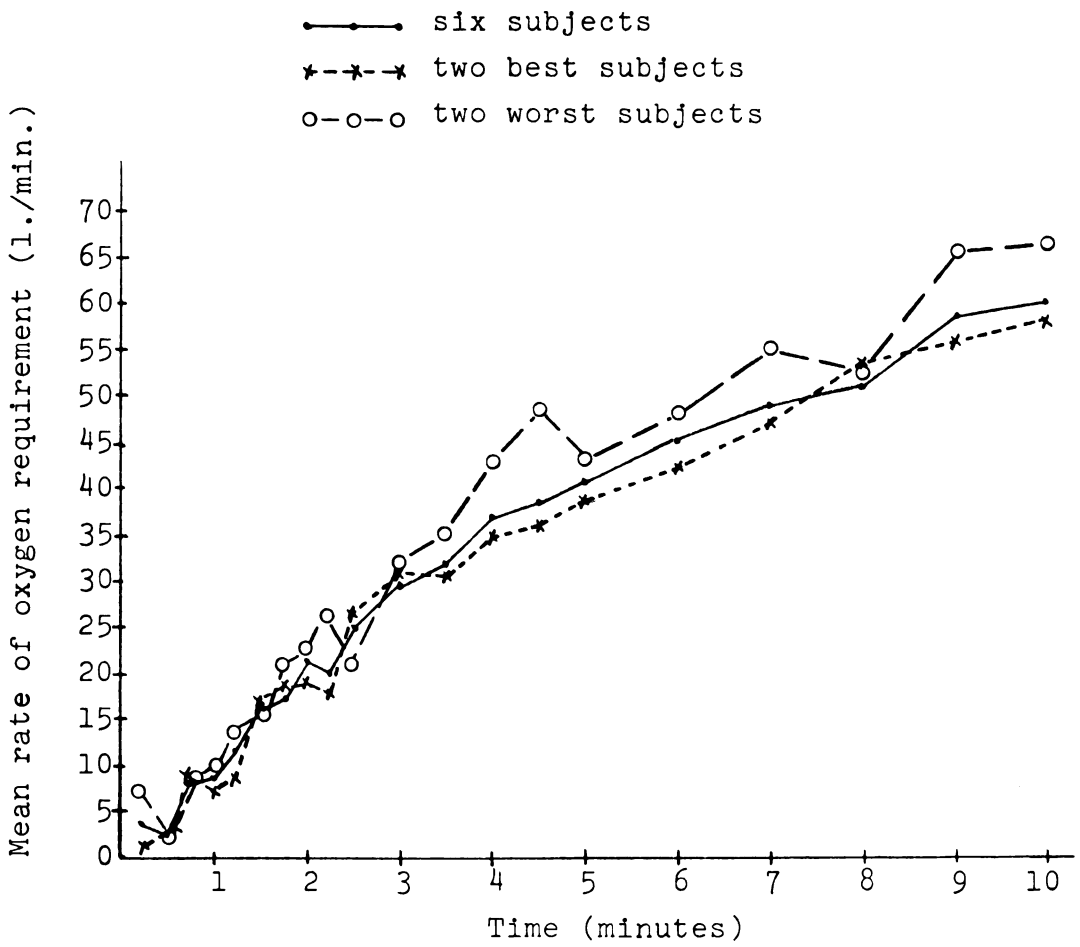

Figure 15.--Mean rate of oxygen requirement during the ten-minute composite run for all six subjects, the two best subjects, and the two worst subjects.

Oxygen consumption during recovery is considered to be a sum of four functions. These functions are a basal oxygen consumption, an oxygen consumption attributable to the oxidation of lactic acid (this is a slow process and is referred to as the lactacid component of oxygen debt), a fast component referred to as the alactacid component of oxygen debt, and lastly an oxygen consumption decreasing very slowly during the recovery period.

The erratic pattern of the oxygen debt graphs may be attributed to differences in physical condition of the subjects and/or to the small number of subjects used in the experiment. This erratic pattern limits the conclusions which could be drawn regarding the possible repayment of oxygen debt during the run.

Oxygen Pulse

Oxygen pulse is defined as the amount of oxygen removed from the blood per heart beat. In this experiment oxygen pulse rose from a mean value of 8.76 milliliters for the fifteen-second run to 18.82 milliliters for the ten-minute run. These figures generally agreed with other values reported in the literature (21, p. 167). The oxygen pulse measured during the five-minute rest averaged 5.042 milliliters which also agreed with values reported in the literature. Oxygen pulse measurements are said to be a good index of the output of the heart. Oxygen pulse values rose rapidly to 20.57 milliliters during the one-minute

thirty-second component of the ten minute run and then leveled off. This was the general pattern of both the mean heart rate and the mean oxygen uptake during the run. An increased heart rate and/or a greater coefficient of oxygen utilization as work intensity is increased are the two factors involved in this increase.

The cardiopulmonary system of a healthy young adult at rest need only supply 250 milliliters of oxygen to the body tissues each minute. At rest the subjects in this experiment required an average of 325.08 milliliters of oxygen each minute. The difference is probably due to some degree of nervous anticipation prior to the exercise period or to the failure of the subjects to be in a fully rested, quiet state before data were collected during the five minute rest period. During vigorous exercise the cardiopulmonary system must supply as much as 5,500 milliliters of oxygen per minute or a twenty-two fold increase. During the tenth minute of exercise the six subjects in this experiment required an average of 3517.26 milliliters of oxygen. This increased supply of oxygen is provided by a great increase in cardiac output per minute and by an increase in alveolar ventilation.

Increased activity of skeletal muscles lowers tissue PO_2, raises tissue PCO_2, increases tissue temperature, and lowers tissue pH. This favors dissociation of HbO_2 and the delivery of oxygen to the working tissue. During moderate

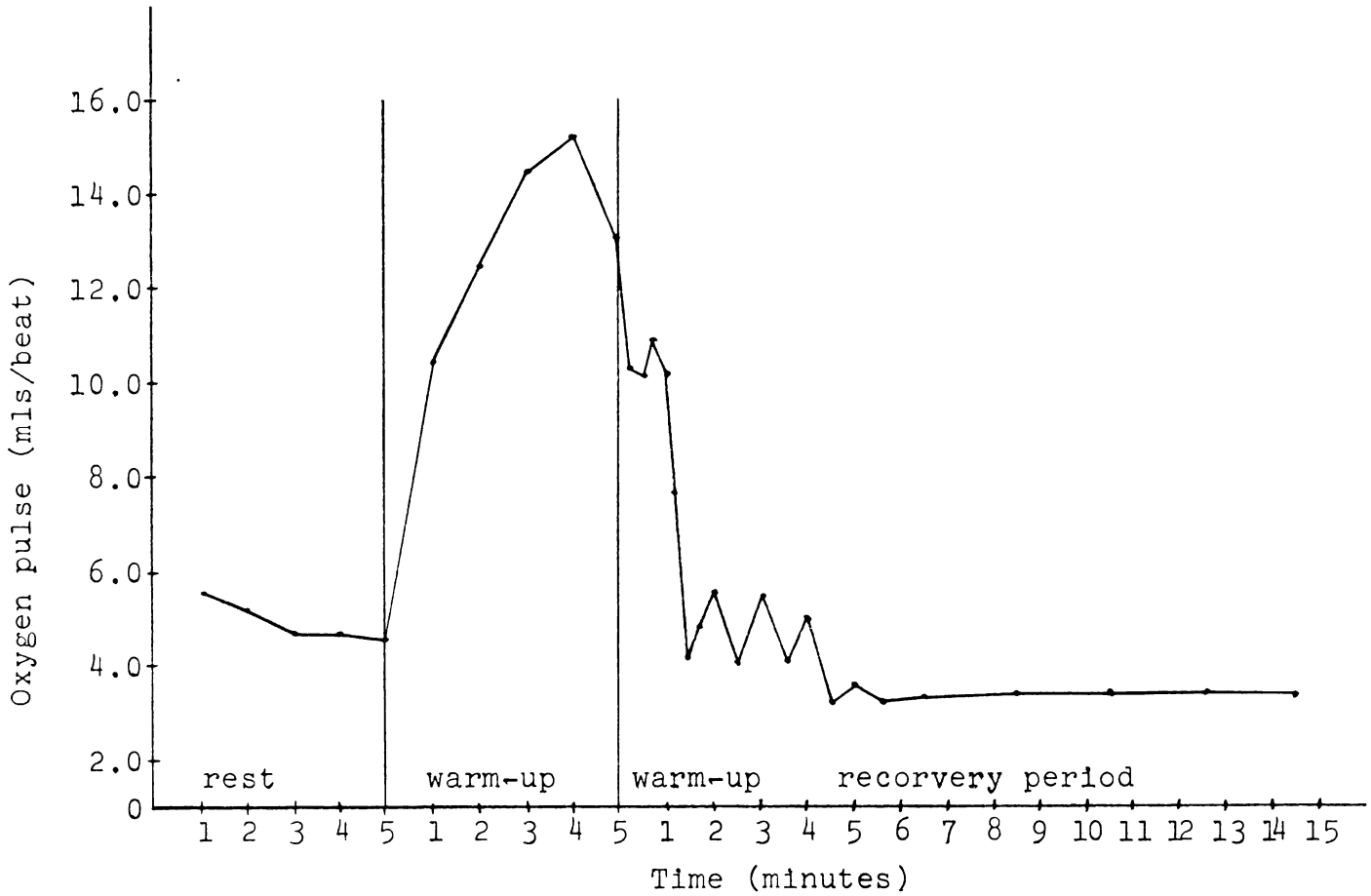

Figure 16.--Mean oxygen pulse values (mls. per heart beat) for the five-minute rest, the five-minute warm-up run at six miles per hour zero per cent grade, and the fifteen-minute warm-up recovery period.

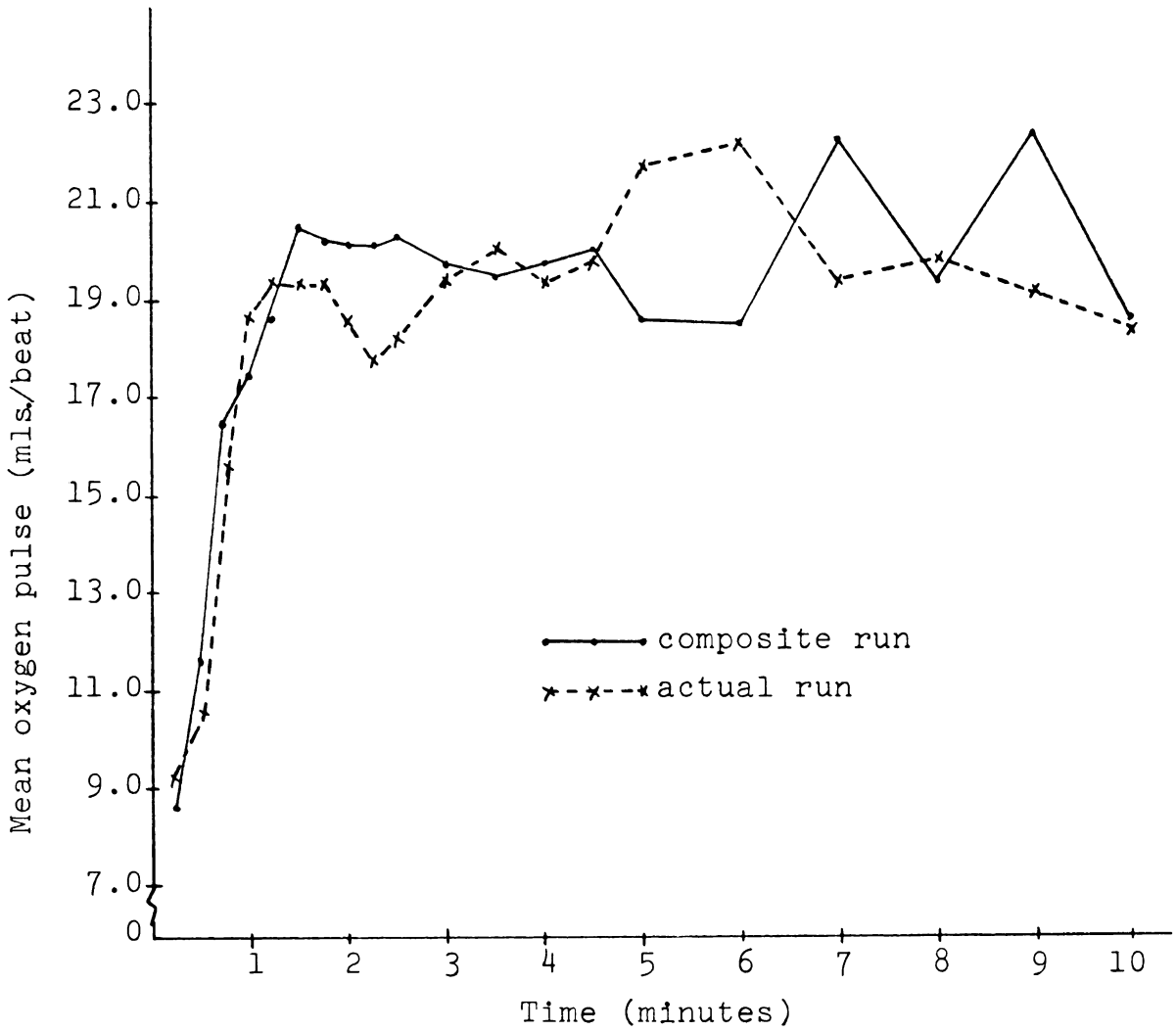

Figure 17.--Mean oxygen pulse values (mls. per heart beat) for the actual ten-minute run and the ten-minute composite run.

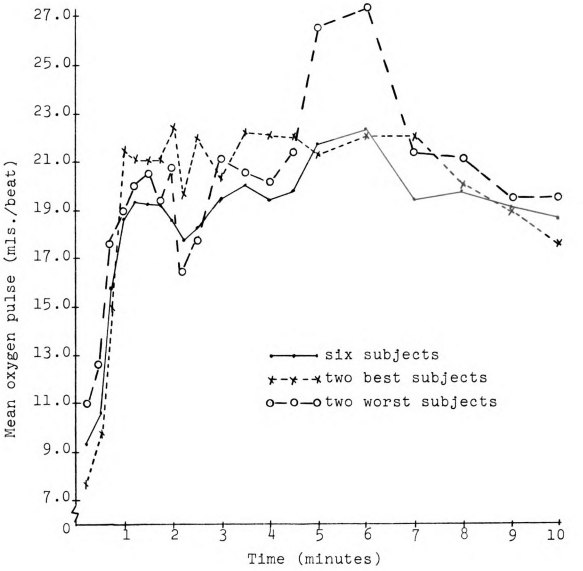

Figure 18.--Mean oxygen pulse values (mls. per heart beat) during the actual ten-minute run for all six subjects, the two best subjects, and the two worst subjects.

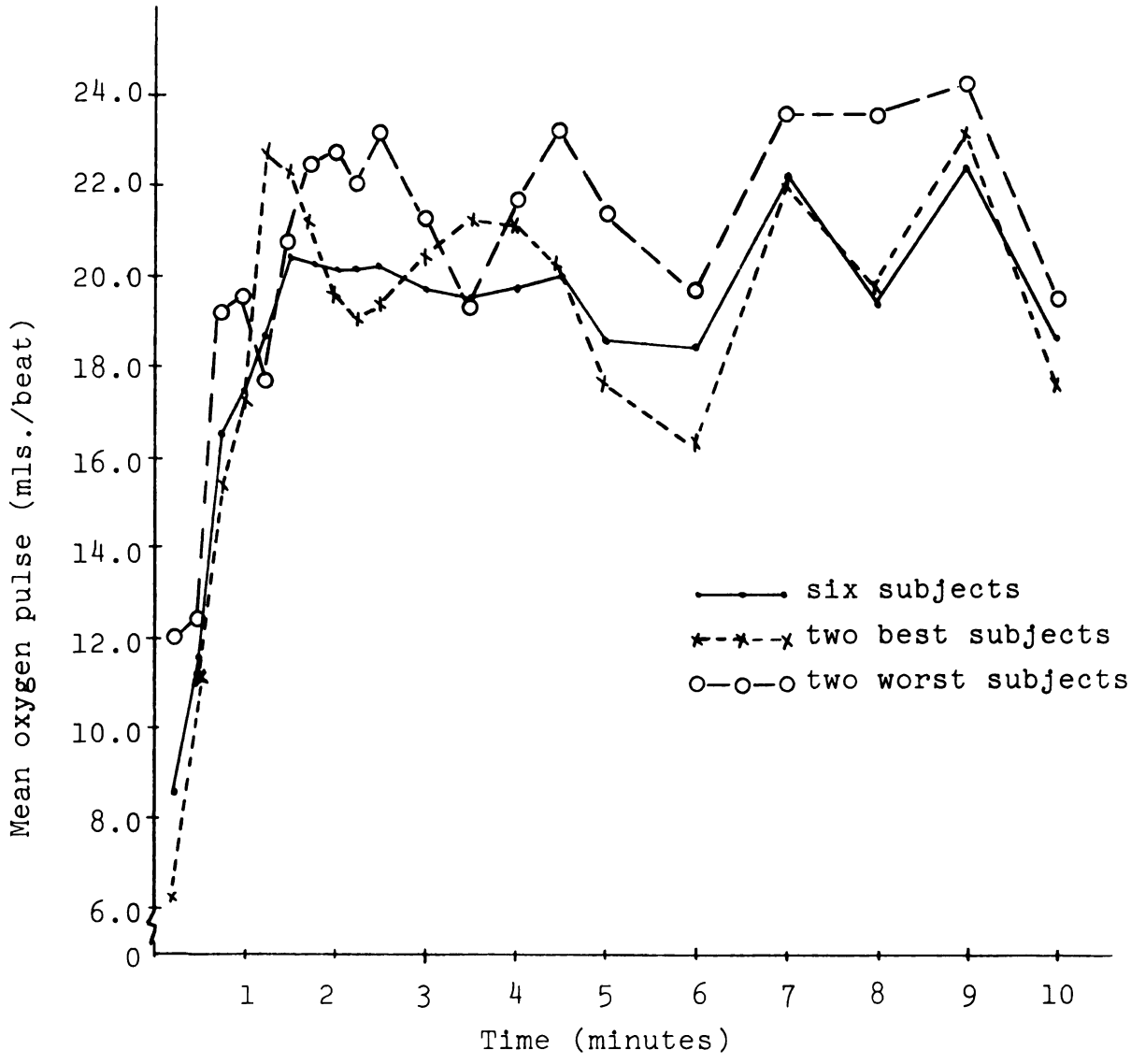

Figure 19.--Mean oxygen pulse values (mls. per heart beat) during the ten-minute composite run for all six subjects, the two best subjects, and the two worst subjects.

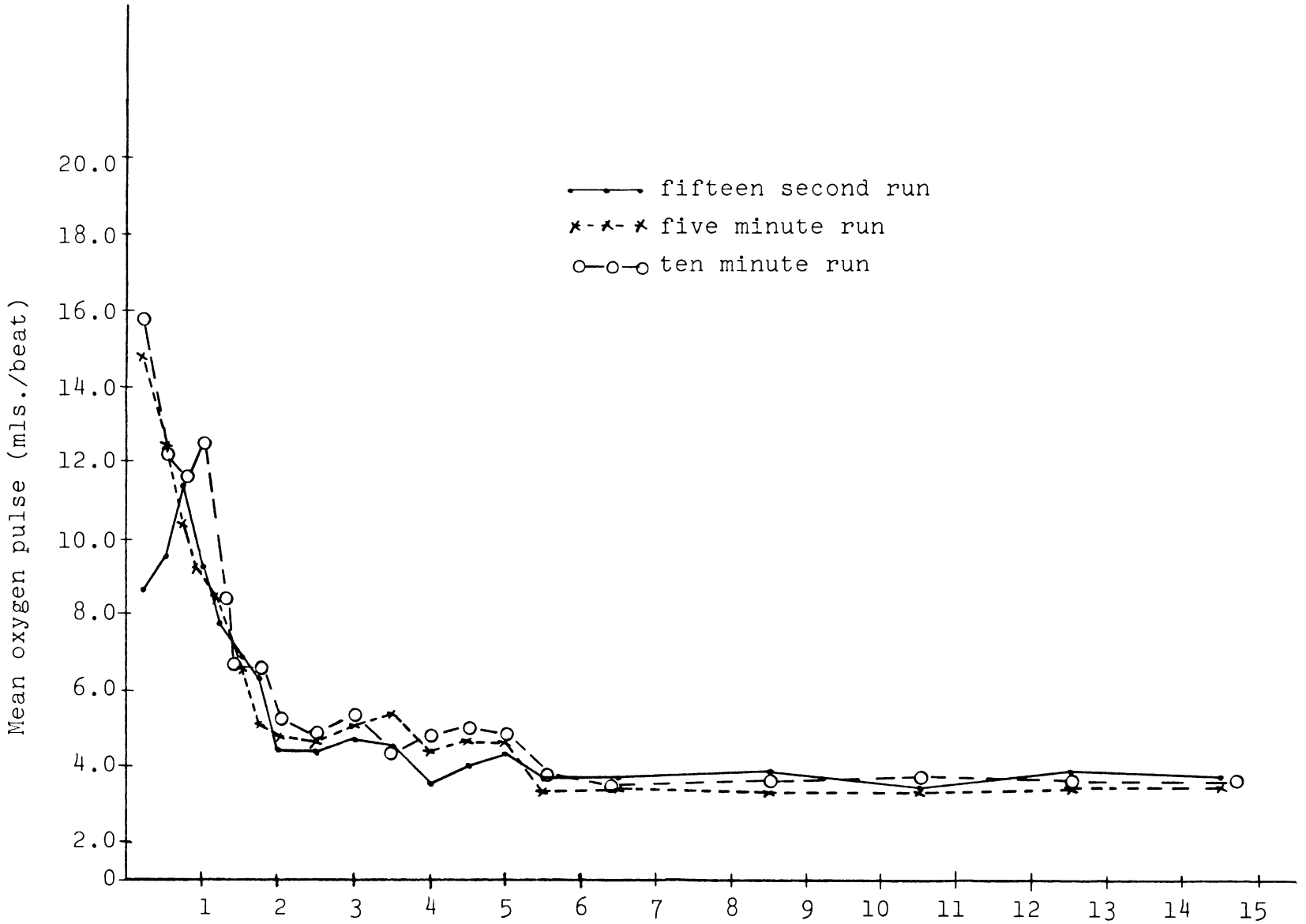

Figure 20.--Mean recovery oxygen pulse values (mls. per heart beat) for the fifteen-second run, the five-minute run, and the ten-minute run.

exercise there is no significant change in arterial PO_2, PCO_2, or pH. The factors responsible for an increase in ventilation during moderate exercise are not known but it is likely that multiple factors are involved.

Rest and Warm-Up Data

Three five-minute rest periods and three five-minute warm-up runs at six miles per hour and zero per cent grade were included in the experimental design. Both the rest period and the warm-up run were divided into five one-minute intervals and samples of expired air were taken during the first twenty seconds of each minute. The data indicate that no basal trend was established for heart rate, oxygen uptake, and oxygen pulse during the five-minute rest. It would seem that either a longer resting period is necessary or the subjects be in a completely rested state before data are collected in order to achieve values as close to a basal level as possible. Oxygen pulse and oxygen uptake values returned to apparent basal values during the fifteen-minute recovery period following the five-minute warm-up run. Heart rate, however, remained slightly elevated although close to basal levels as measured by the five-minute rest.

Because of an inconsistent pattern during the five-minute rest, basal values for all variables were determined by taking the mean of only the last three minutes of the

five-minute rest period. Rest and warm-up graphs are included with graphs of each parameter studied in order to make the total picture of each parameter more meaningful.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to determine the pattern of oxygen-debt accumulation during a standardized, sub-maximal run on a motor-driven treadmill. In addition to oxygen debt, the pattern of other selected variables also was studied. These variables included heart rate, oxygen pulse, and oxygen uptake (liters/minute).

Six subjects were tested five days per week on a motor-driven treadmill for a period of eight weeks. A standardized run of ten miles per hour at zero per cent grade was divided into ten fifteen-second runs for the first two and one-half minutes, five thirty-second runs for the next two and one-half minutes, and five one-minute runs for the remaining five minutes. A fifteen-minute recovery period was also divided into eight fifteen-second intervals for the first two minutes, six thirty-second intervals for the next three minutes and one ten-minute interval for the remaining ten minutes of recovery. In addition, three five-minute rest periods, during which data were collected at one-minute intervals, were included in the testing schedule since basal levels for the variables under consideration were required. Three five-minute warm-up runs at six miles per hour, zero per cent grade, followed by the standard fifteen-minute

recovery period, were also included in the testing schedule. Thus each subject had to complete twenty-six test periods. Each testing schedule was completely randomized for each of the six subjects. Data were collected on heart rate, oxygen pulse, oxygen debt, and oxygen uptake (liters/minute). Means and standard deviations for each interval of each variable were calculated and plotted graphically.

Conclusions

1. The mean total oxygen debt for a ten-minute standard run at ten miles per hour and zero per cent grade was 3.096 liters. The largest portion of this debt was accumulated during the initial stages of the run and may be referred to as the alactacid portion of the oxygen debt. The large initial debt was due to a circulatory lag at the beginning of the exercise period.

2. During this experiment, oxygen debt was not accumulated to a greater degree as the duration of work increased. Mean net oxygen debt accumulation appeared to level off after the two-minute and thirty-second run (Fig. 14).

3. Heart rate increased with work duration to a mean maximal value of 186 beats per minute during the tenth minute of exercise. This would seem to indicate the work was of an intense nature although certainly not exhaustive.

4. Oxygen consumption increased with work duration up to an optimal point. After this point, anaerobic mechanisms supplied the energy and an oxygen debt was accumulated. Oxygen requirement (Fig.15) increased with the duration of work through the ten-minute run.

5. Oxygen pulse values increased with work duration only during the initial stages of work (Fig. 17). Following the initial stages of exercise, oxygen pulse values tended to level off as work duration increased indicating, further, an increasing dependence on the anaerobic mechanisms for the needed energy requirements.

6. A five-minute rest period was not of sufficient length to establish accurate basal levels of any of the parameters considered in this experiment. The final three minutes of the five-minute rest period appeared to yield a truer indication of basal levels and was used to calculate the resting levels of all of the parameters.

Recommendations

1. This study should be repeated with several modifications in the experimental design. Repeats of each run should be conducted in order to make use of more sophisticated methods of statistical analysis. This would result in better interpretations of the results.

2. Larger Douglas Bags should be used to collect expired air during the thirty-second and one-minute runs.

3. A larger, more random sample should be used.

4. Collection of blood samples during each run should be considered in order to determine blood lactate concentrations during both the run and the recovery periods.

5. A slower treadmill speed should be considered in order to clearly differentiate between an exhaustive and a sub-maximal run.

6. A longer rest period is needed in order to achieve more nearly basal levels.

7. Body temperature should be taken during the exercise periods.

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APPENDIX

TABLE 1.-- Name of Study Oxygen Debt Accumulation

Date 4-29-65 Laboratory Room Temperature 71° Subject (name) Fulcher
Time of Day 11:35am B. Pressure 745.0

Kagr. Temp.	Bag	Finial Kafronyi	Initial Kafronyi	Samp. Gas	Kafr. Diff.	X Kafronyi Cf. 1.07	X STPC Corr.	CO_2 Read.	% CO_2	O_2 Read.	% O_2	RQ	True O_2	Corr. Vent.	True O_2 X Corr. Vent.	X Time	= O_2 l/min.
23.0	1	95.6	89.6	.3	6.3	6.741	.880	44.0	3.17	2.80	17.40	.85	3.65	5.932	.2165	3.8	.8228
	2	99.1	95.6	.2	3.7	3.959	.880	45.0	3.28	1.90	16.95	.79	4.15	3.484	.446	4.3	.6217
	3	102.6	99.1	.2	3.7	3.959	.880	50.0	3.70	0.12	16.06	.71	5.20	3.484	.1812	4.3	.7790
	4	4.8	2.6	.2	2.4	2.568	.880	45.0	3.28	0.92	16.46	.67	4.80	2.259	.1085	3.3	.3579
	5	7.0	4.8	.2	2.4	2.568	.880	47.5	3.49	0.26	16.13	.66	5.15	2.259	.1164	5	.5819
	6	10.2	7.0	.2	3.4	3.638	.880	42.5	3.05	1.68	16.84	.69	4.38	3.201	.1402	4	.5608
	7	13.3	10.2	.2	3.3	3.531	.880	39.5	2.79	3.02	17.51	.75	3.60	2.107	.1119	3.8	.4251
	8	14.9	13.3	.2	1.8	1.926	.880	42.0	3.00	2.42	17.21	.75	3.90	1.695	.0061	4	.2644[.387]
	9	17.1	14.9	.2	2.4	2.568	.880	38.0	2.66	3.08	17.54	.72	3.60	2.259	.0814	4.3	.3496
	10	20.8	17.1	.2	3.9	4.173	.880	39.5	2.79	3.04	17.52	.76	2.60	3.672	.1322	1.9	.2512
	11	26.3	20.8	.2	5.7	6.099	.880	40.0	2.84	3.06	17.53	.78	3.55	5.267	.1905	2.2	.4191
	12	31.9	26.3	.2	5.8	6.206	.880	39.0	2.74	3.86	17.93	.86	3.10	5.461	.1693	1.8	.3047
	13	34.9	31.9	.2	3.2	3.424	.880	35.0	2.40	4.30	18.15	.80	2.90	3.013	.0874	2.2	.1922
	14	38.3	34.9	.2	3.6	3.852	.880	36.5	2.54	3.82	17.91	.78	3.15	3.389	.1068	2	.2136
	15	42.0	38.3	.2	3.9	4.173	.880	37.5	2.23	4.66	18.33	.80	2.70	3.672	.0992	2.1	.2082
	16	134.1	042.0	.2	92.3	98.761	.880	39.0	2.74	3.38	17.69	.79	3.40	86.909	2.955	÷10	.2955

TABLE 2.--Heart rate values for five-minute rest.

	Mean	Standard Deviation
1'00"	65.911	10.598
2'00"	73.241	10.170
3'00"	63.952	9.265
4'00"	74.476	8.394
5'00"	64.447	9.052

TABLE 3.--Heart rate values for five-minute warm up.

	Mean	Standard Deviation
1'00"	125.275	13.653
2'00"	136.166	14.186
3'00"	137.466	16.280
4'00"	136.975	12,386
5'00"	138.383	13.667
15"	139.883	22.083
30"	123.350	18.229
45"	107.125	14.615
1'00"	91.775	13.714
1'15"	87.050	12.960
1'30"	85.258	13.198
1'45"	84.475	15.552
2'00"	83.916	12.807
2'30"	81.991	13.651
3'00"	79.033	11.711
3'30"	81.508	12.352
4'00"	79.950	11.214
4'30"	77.916	9.727
5'00"	75.725	9.595
5'30"	78.791	11.627
6'30"	77.291	13.260
8'30"	74.050	9.091
10'30"	75.891	11.756
12'30"	72.933	9.023
14'30"	73.183	9.713

TABLE 4.--Heart rate values for a fifteen-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	690.00000	115.0000000	79778.00000	9.25203
0:15	749.00000	124.8333333	94443.00000	13.73196
0:30	625.00000	104.1666667	67377.00000	21.32057
0:45	513.00000	85.5000000	45843.00000	19.90729
1:00	434.00000	72.3333333	32346.00000	13.80821
1:15	439.00000	73.1666667	33257.00000	15.07868
1:30	416.00000	69.3333333	29766.00000	13.58921
1:45	347.00000	57.8333333	23821.00000	27.39647
2:00	416.00000	69.3333333	29480.00000	11.29011
2:30	431.00000	71.8333333	31813.00000	13.06012
3:00	445.00000	74.1666667	33829.00000	12.84394
3:30	451.00000	75.1666667	34749.00000	13.02945
4:00	436.00000	72.6666667	32314.00000	11.23684
4:30	449.00000	74.8333333	34461.00000	13.12123
5:00	429.00000	71,5000000	31373.00000	11.82793
5:30	270.00000	78.3333333	37236.00000	9.15787
6:30	471.00000	78,5000000	37709.00000	12.12848
8:30	435.00000	72,5000000	32077.00000	10.38749
10:30	435.00000	72.5000000	32179.00000	11.32696
12:30	444.00000	74.0000000	33222.00000	8.55570
14:30	453.00000	75.5000000	35121.00000	13.56097

TABLE 5.--Heart rate values for a thirty-second run.

Var	Sum	Mean	Sum Squares	Standard Deviation
0:15	662.00000	110.3333333	73656.00000	11.09354
0:30	779.00000	129.8333333	101263.00000	4.05648
0:15	805.00000	134.1666667	109689.00000	18.35665
0:30	733.00000	122.1666667	91585.00000	20.18333
0:45	633.00000	105.5000000	69477.00000	23.21853
1:00	499.00000	83.1666667	42519.00000	14.27469
1:15	454.00000	75.6666667	35356.00000	14.16569
1:30	416.00000	69.3333333	29802.00000	13.85189
1:45	444.00000	74.0000000	33362.00000	10.05982
2:00	447.00000	74.5000000	34021.00000	11.99583
2:30	456.00000	76.0000000	36066.00000	16.79286
3:00	438.00000	73.0000000	32998.00000	14.31084
3:30	459.00000	76.5000000	36085.00000	13.93915
4:00	457.00000	76.1666667	35695.00000	12.62405
5:30	449.00000	74.8333333	34381.00000	12.49667
5:00	464.00000	77,3333333	36576.00000	11.77568
5:30	495.00000	82.5000000	41409.00000	10.69112
6:30	455.00000	75,8333333	35253.00000	12.23792
8:30	446.00000	74.3333333	33942.00000	12.56450
10:30	457.00000	76.1666667	35417.00000	11.03479
12:30	470.00000	78.3333333	37180.00000	8.52447
14:30	468.00000	78.0000000	37114.00000	11.04536

TABLE 6.--Heart rate values for a forty-five second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	681.00000	113.5000000	77647.00000	8.40833
0:30	803.00000	133.8333333	107851.00000	8.75024
0:45	863.00000	143.8333333	124645.00000	10.16694
0:15	859.00000	143.1666667	124165.00000	15.39372
0:30	762.00000	127.0000000	99258.00000	22.28901
0:45	635.00000	105.8333333	69511.00000	21.47945
1:00	524.00000	87.3333333	46792.00000	14.34805
1:15	493.00000	82.1666667	41169.00000	11.49638
1:30	401.00000	66.8333333	32013.00000	32.38880
1:45	394.00000	65.6666667	31050.00000	32.17867
2:00	464.00000	77.3333333	36536.00000	11.51810
2:30	480.00000	80.0000000	38784.00000	8.76356
3:00	494.00000	82.3333333	41052.00000	8.71015
3:30	497.00000	82.8333333	41393.00000	6.70572
4:00	298.00000	83.0000000	42490.00000	15.20526
4:30	486.00000	81.0000000	39724.00000	8.46168
5:00	490.00000	81.6666667	40358.00000	8.26236
5:30	487.00000	81.1666667	40377.00000	13.02945
6:30	498.00000	83.0000000	42084.00000	12.24745
8:30	463.00000	77.1666667	35973.00000	6.99762
10:30	461.00000	76.8333333	35825.00000	8.99815
12:30	466.00000	77.6666667	36716.00000	10.23067
14:30	422.00000	70.3333333	33372.00000	27.17106

TABLE 7.--Heart rate values for a one-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	691.00000	115.1666667	82061.00000	22.27480
0:30	821.00000	136.8333333	113635.00000	16.09244
0:45	881.00000	146.8333333	130065.00000	11.87294
1:00	910.00000	151.6666667	139604.00000	17.81759
0:15	890.00000	148.3333333	132484.00000	9.66782
0:30	808.00000	134.6666667	109952.00000	15.10850
0:45	583.00000	97.1666667	62033.00000	32.81717
1:00	520.00000	86.6666667	47114.00000	20.23528
1:15	470.00000	78.3333333	37796.00000	13.99524
1:30	439.00000	73.1666667	33077.00000	13.83353
1:45	460.00000	76.6666667	36080.00000	12.75408
2:00	462.00000	77.0000000	36554.00000	14.00000
2:30	477.00000	79.5000000	38485.00000	10.61603
3:00	462.00000	77.0000000	36082.00000	10.07968
3:30	433.00000	72.1666667	31869.00000	11.14301
4:00	465.00000	77.5000000	36557.00000	10.19313
4:30	458.00000	76.3333333	35220.00000	7.20185
5:00	451.00000	75.1666667	34209.00000	7.85918
5:30	474.00000	79.0000000	37788.00000	8.27043
6:30	488.00000	81.3333333	40232.00000	10.40513
8:30	461.00000	76.8333333	36073.00000	11.42658
10:30	489.00000	81.5000000	40565.00000	11.92896
12:30	472.00000	78.6666667	37934.00000	12.67544
14:30	459.00000	76.5000000	35831.00000	11.97915

TABLE 8.--Heart rate values for a one-minute fifteen-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	641.00000	106.8333333	68823.00000	8.28050
0:30	800.00000	133.3333333	107482.00000	12.76976
0:45	825.00000	137.5000000	114161.00000	12.02913
1:00	883.00000	147.1666667	130681.00000	12.10647
1:15	914.00000	152.3333333	139780.00000	10.46263
0:15	893.00000	148.8333333	133569.00000	11.49638
0:30	778.00000	129.6666667	193220.00000	21.63023
0:45	606.00000	101.0000000	63422.00000	21.05232
1:00	486.00000	81.0000000	42586.00000	25.37716
1:15	447.00000	74.5000000	35345.00000	20.21633
1:30	427.00000	71.1666667	32941.00000	22.59572
1:45	433.00000	72.1666667	33709.00000	22.18483
2:00	430.00000	71.6666667	32986.00000	20.82947
2:30	454.00000	75.6666667	35938.00000	17.80637
3:00	460.00000	76.6666667	36970.00000	18.45716
3:30	441.00000	73.5000000	32769.00000	8.43208
4:00	440.00000	73.3333333	33110.00000	12.98717
4:30	456.00000	76.0000000	35456.00000	12.64911
5:00	420.00000	70.0000000	30960.00000	17.66352
5:30	442.00000	73.6666667	34986.00000	22.02423
6:30	470.00000	78.3333333	38414.00000	17.87363
8:30	428.00000	71.3333333	31650.00000	14.96217
10:30	433.00000	72.1666667	32485.00000	15.72789
12:30	424.00000	70.6666667	31110.00000	15.14816
14:30	459.00000	76.5000000	36757.00000	18.13009

TABLE 9.--Heart rate values for a one-minute thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	669.00000	111.5000000	75237.00000	11.34460
0:30	772.00000	128.6666667	99910.00000	10.76414
0:45	851.00000	141.8333333	121493.00000	12.59233
1:00	874.00000	145.6666667	128346.00000	14.37591
1:15	921.00000	153.5000000	142121.00000	12.22702
1:30	941.00000	156.8333333	148533.00000	13.80459
0:15	929.00000	154.8333333	144841.00000	14.14803
0:30	859.00000	143.1666667	125081.00000	20.49797
0:45	700.00000	116.6666667	83310.00000	18.12917
1:00	565.00000	94.1666667	56585.00000	26.00320
1:15	502.00000	83.6666667	44462.00000	22.18708
1:30	479.00000	79.8333333	40781.00000	22.54255
1:45	456.00000	76.0000000	37246.00000	22.75961
2:00	456.00000	76.0000000	36378.00000	18.55802
2:30	450.00000	75.0000000	35930.00000	20.88061
3:00	446.00000	74.3333333	34666.00000	17.39732
3:30	471.00000	78.5000000	38065.00000	14.77498
4:00	463.00000	77.1666667	36819.00000	14.77047
4:30	451.00000	75.1666667	35241.00000	16.37580
5:00	448.00000	74.6666667	34562.00000	14.90861
5:30	472.00000	78.6666667	38040.00000	13.48580
6:30	462.00000	77.0000000	36420.00000	13.00769
8:30	458.00000	76.3333333	35660.00000	11.82652
10:30	436.00000	72.6666667	32590.00000	13.47096
12:30	429.00000	71.5000000	31635.00000	13.86723
14:30	442.00000	73.6666667	33428.00000	13.17067

TABLE 10.--Heart rate values for a one-minute forty-five second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	668.00000	111.3333333	74810.00000	9.37372
0:30	802.00000	133.6666667	107650.00000	9.47980
0:45	842.00000	140.3333333	118532.00000	8.61781
1:00	888.00000	148.0000000	131584.00000	5.65685
1:15	912.00000	152.0000000	138848.00000	6.69328
1:30	926.00000	154.3333333	143396.00000	9.83192
1:45	952.00000	158.6666667	151168.00000	4.84424
0:15	895.00000	149.1666667	134433.00000	13.62962
0:30	841.00000	140.1666667	119359.00000	17.19787
0:45	701.00000	116.8333333	83893.00000	19.96413
1:00	574.00000	95.6666667	56494.00000	17.78389
1:15	498.00000	83.0000000	42918.00000	17.79888
1:30	482.00000	80.3333333	39590.00000	13.18585
1:45	478.00000	79.6666667	38930.00000	13.03329
2:00	498.00000	83.0000000	41958.00000	11.17139
2:30	492.00000	82.0000000	40944.00000	10.95445
3:00	511.00000	85.1666667	44325.00000	12.68726
3:30	486.00000	81.0000000	39820.00000	9.52890
4:00	488.00000	81.3333333	40280.00000	10.85664
4:30	500.00000	83.3333333	41922.00000	8.06639
5:00	488.00000	81.3333333	39968.00000	7.44759
5:30	496.00000	82.6666667	41208.00000	6.40833
6:30	450.00000	75.0000000	33836.00000	4.14729
8:30	459.00000	76.5000000	35297.00000	6.05805
10:30	476.00000	79.3333333	38154.00000	8.84685
12:30	488.00000	81.3333333	40086.00000	8.89194
14:30	474.00000	79.0000000	37836.00000	8.83176

TABLE 11.--Heart rate values for a two-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	666.00000	111.0000000	74058.00000	8.13809
0:30	779.00000	129.8333333	101339.00000	6.30608
0:45	855.00000	142.5000000	122365.00000	10.27132
1:00	863.00000	143.8333333	124991.00000	13.13646
1:15	926.00000	154.3333333	143348.00000	9.33095
1:30	959.00000	159.8333333	153913.00000	11.25019
1:45	960.00000	160.0000000	155066.00000	17.12308
2:00	967.00000	161.1666667	157241.00000	16.69032
0:15	937.00000	156.1666667	147385.00000	14.53845
0:30	869.00000	146.5000000	130033.00000	15.87136
0:45	751.00000	125.1666667	96717.00000	23.31023
1:00	598.00000	99.6666667	61092.00000	17.27040
1:15	520.00000	86.6666667	46274.00000	15.53920
1:30	506.00000	84.3333333	43598.00000	13.60392
1:45	486.00000	81.0000000	40204.00000	12.94604
2:00	485.00000	80.8333333	40061.00000	13.09071
2:30	489.00000	81.5000000	40979.00000	15.00333
3:00	498.00000	83.0000000	41846.00000	10.11929
3:30	494.00000	82.3333333	41228.00000	10.53882
4:00	487.00000	81.1666667	40069.00000	10.40032
4:30	480.00000	80.0000000	38720.00000	8.00000
5:00	484.00000	80.6666667	39232.00000	6.15359
5:30	493.00000	82.1666667	40925.00000	9.13053
6:30	470.00000	78.3333333	36956.00000	5.27889
8:30	450.00000	75.0000000	33900.00000	5.47723
10:30	446.00000	74.3333333	33372.00000	6.62319
12:30	481.00000	80.1666667	38733.00000	5.87934
14:30	462.00000	77.0000000	35796.00000	6.66333

TABLE 12.--Heart rate values for a two-minute fifteen second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	688.00000	114.6666667	78968.00000	3.93277
0:30	830.00000	138.3333333	114936.00000	4.88535
0:45	860.00000	143.3333333	124044.00000	12.46863
1:00	900.00000	150.0000000	135464.00000	9.63328
1:15	929.00000	154.8333333	144101.00000	7.22265
1:30	957.00000	159.5000000	152965.00000	8.04363
1:45	969.00000	161.5000000	157193.00000	11.82793
2:00	958.00000	159.6666667	153572.00000	11.05743
2:15	924.00000	154.0000000	144088.00000	18.93146
0:15	940.00000	156.6666667	149242.00000	19.87628
0:30	865.00000	144.1666667	126281.00000	17.75857
0:45	715.00000	119.1666667	86379.00000	15.32862
1:00	597.00000	99.5000000	60021.00000	11.13104
1:15	538.00000	89.6666667	49338.00000	14.81441
1:30	477.00000	79.5000000	38775.00000	13.06522
1:45	504.00000	85.0000000	43328.00000	14.08545
2:00	492.00000	82.0000000	40914.00000	10.67708
2:30	488.00000	81.3333333	40412.00000	12.01111
3:00	494.00000	82.3333333	41014.00000	8.26236
3:30	479.00000	79.8333333	38481.00000	6.79461
4:00	475.00000	79.1666667	37921.00000	7.96032
4:30	476.00000	79.3333333	38040.00000	7.44759
5:00	469.00000	78.1666667	36913.00000	7.11102
5:30	476.00000	79.3333333	37928.00000	5.75036
6:30	471.00000	78.5000000	37405.00000	9.28978
8:30	469.00000	78.1666667	37401.00000	12.17237
10:30	462.00000	77.0000000	35710.00000	5.21536
12:30	465.00000	77.5000000	36361.00000	8.04363
14:30	473.00000	78.8333333	37693.00000	8.99815

TABLE 13.--Heart rate values for a two-minute thirty-second run.

Var	Sum	Mean	Sum	Standard Deviation
0:15	669.00000	111.5000000	75033.00000	9.37550
0:30	797.00000	132.8333333	106293.00000	9.21774
0:45	872.00000	145.3333333	127442.00000	11.93756
1:00	900.00000	150.0000000	135760.00000	12.32883
1:15	930.00000	155.0000000	144586.00000	9.33809
1:30	940.00000	156.6666667	147838.00000	10.68956
1:45	960.00000	160.0000000	153888.00000	7.58947
2:00	978.00000	163.0000000	160164.00000	12.24745
2:15	980.00000	163.3333333	160528.00000	9.60555
2:30	991.00000	165.1666667	164601.00000	13.57080
0:15	960.00000	160.0000000	154486.00000	13.31165
9:30	875.00000	145.8333333	129817.00000	21.03727
9:45	709.00000	118.1666667	85209.00000	16.90463
1:00	566.00000	94.3333333	55382.00000	19.94660
1:15	499.00000	83.1666667	43047.00000	17.58882
1:30	449.00000	74.8333333	34977.00000	16.59418
1:45	477.00000	79.5000000	39317.00000	16.70629
2:00	457.00000	76.1666667	36417.00000	17.93786
2:30	480.00000	80.0000000	39110.00000	11.91638
3:00	493.00000	82.1666667	41245.00000	12.13947
3:30	484.00000	80.6666667	39590.00000	10.46263
4:00	492.00000	82.0000000	40816.00000	9.71597
4:30	487.00000	81.1666667	39973.00000	9.43221
5:00	464.00000	77.3333333	36086.00000	6.37704
5:30	472.00000	78.6666667	37234.00000	4.54606
6:30	495.00000	82.5000000	41201.00000	8.52643
8:30	472.00000	78.6666667	37272.00000	5.31664
10:30	467.00000	77.8333333	36585.00000	6.88234
12:30	463.00000	77.1666667	36139.00000	9.06458
14:30	450.00000	75.0000000	34014.00000	7.26636

TABLE 14.--Heart rate values for a three-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	685.00000	114.1666667	78585.00000	8.72735
0:30	799.00000	133.1666667	107227.00000	12.85950
0:45	851.00000	141.8333333	121463.00000	12.35179
1:00	908.00000	151.3333333	137968.00000	10.55778
1:15	935.00000	155.8333333	146585.00000	13.27278
1:30	948.00000	158.0000000	150640.00000	13.08434
1:45	954.00000	159.0000000	152228.00000	10.41153
2:00	963.00000	160.5000000	155369.00000	12.70827
2:15	974.00000	162.3333333	158884.00000	12.42041
2:30	987.00000	164.5000000	163201.00000	12.95762
3:00	982.00000	163.6666667	161394.00000	11.60460
0:15	951.00000	158.5000000	151745.00000	14.22322
0:30	861.00000	143.5000000	124997.00000	16.99117
0:45	737.00000	122.8333333	91813.00000	16.03018
1:00	618.00000	103.0000000	65610.00000	19.77878
1:15	566.00000	94.3333333	55642.00000	21.21006
1:30	528.00000	88.0000000	48594.00000	20.63977
1:45	522.00000	87.0000000	47022.00000	17.93321
2:00	530.00000	88.3333333	48838.00000	20.10638
2:30	511.00000	85.1666667	45177.00000	18.20348
3:00	519.00000	86.5000000	46883.00000	19194743
3:30	507.00000	84.5000000	44561.00000	18.54454
4:00	517.00000	86.1666667	46117 00000	17.71346
4:30	513.00000	85.5000000	45325.00000	17.10848
5:00	597.00000	84.5000000	44325.00000	17.22498
5:30	522.00000	87.0000000	46694.00000	16.00000
6:30	496.00000	82.6666667	42264.00000	15.88290
8:30	465.00000	77.5000000	37429.00000	16.68233
10:30	486.00000	81.0000000	40172.00000	12.69646
12:30	490.00000	81.6666667	41006 00000	14.06651
14:30	487.00000	81.1666667	40113.00000	10.81511

TABLE 15.--Heart rate values for a three-minute thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	672.00000	112.0000000	75782.00000	10.17841
0:30	770.00000	128.3333333	100410.00000	17.8512
0:45	845.00000	140.8333333	120561.00000	17.64558
1:00	882.00000	147.0000000	130724.00000	14.628;4
1:15	918.00000	153.0000000	141268.00000	12.86931
1:30	942.00000	157.0000000	148596.00000	11.84905
2:00	966.00000	161.0000000	155972.00000	9.44458
2:15	973.00000	162.1666667	158309.00000	10.20621
2:30	986.00000	164.3333333	162260.00000	6.74290
3:00	965.00000	160.8333333	155869.00000	11.53112
3:30	997.00000	166.1666667	166353.00000	11.70328
0:15	973.00000	162.1666667	158877.00000	14.75692
0:30	903.00000	150.5000000	136533.00000	11.23833
0:45	768.00000	128.0000000	99690.00000	16.64932
1:00	657.00000	109.5000000	73029.00000	14.74788
1:15	602.00000	100.3333333	61302.00000	13.42634
1:30	570.00000	95.0000000	55236.00000	14.73771
1:45	525.00000	87.5000000	47225.00000	16.04681
2:00	523.00000	87.1666667	47217.00000	18.04901
2:30	520.00000	86.6666667	47026.00000	19.79562
3:00	497.00000	82.8333333	42293.00000	14.99889
3:30	520.00000	86.6666667	45976.00000	13.48579
4:00	597.00000	84.5000000	43553.00000	11.92896
4:30	503.00000	83.8333333	42585.00000	9.13053
5:00	499.00000	83.1666667	42279.00000	12.48065
5:30	510.00000	85.0000000	44234.00000	13.29662
6:30	497.00000	82.8333333	41529.00000	8.49510
8:30	494.00000	83.3333333	41068.00000	8.89194
10:30	499.00000	83.1666667	42135.00000	11.26795
12:30	469.00000	78.1666667	37469.00000	12.71875
14:30	488.00000	81.3333333	40126.00000	9.33095

TABLE 16.--Heart rate values for a four-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	796.00000	117.6666667	86682.00000	26.86758
0:30	841.00000	140.1666667	118581.00000	11.83920
0:45	879.00000	146.5000000	129577.00000	12.67675
1:15	928.00000	154.6666667	143936.00000	9.00370
1:30	948.00000	158.0000000	150448.00000	11.52389
1:45	906.00000	151.0000000	139906.00000	24.89980
2:00	960.00000	160.0000000	154144.00000	10.43072
2:15	963.00000	160.5000000	155297.00000	12.12848
2:30	973.00000	162.0000000	158000.00000	10.35374
3:00	970.00000	161.6666667	157516.00000	11.82652
3:30	986.00000	164.3333333	162564.00000	10.30857
4:00	984.00000	164.0000000	162088.00000	11.93315
0:15	962.00000	160.3333333	155250.00000	14.20798
0:30	876.00000	145.3333333	128800.00000	20.34371
0:45	745.00000	124.1666667	94539.00000	20.17341
1:00	645.00000	107.5000000	70865.00000	17.47856
1:15	607.00000	101.1666667	62857.00000	17.02253
1:30	582.00000	97.0000000	57892.00000	16.95877
1:45	538.00000	89.6666667	49516.00000	15.97081
2:00	550.00000	91.6666667	51412.00000	14.10910
2:30	539.00000	89.8333333	49573.00000	15.18442
3:00	527.00000	87.8333333	46901.00000	11.07098
3:30	552.00000	92.0000000	51368.00000	10.80740
4:00	516.00000	86.0000000	45160.00000	12.52198
4:30	516.00000	86.0000000	44920.00000	10.43072
5:00	525.00000	87.5000000	46393.00000	9.54463
5:30	438.00000	73.0000000	37996.00000	34.70447
6:30	512.00000	85.3333333	44200.00000	10.09290
8:30	507.00000	84.5000000	43585.00000	12.19426
10:30	483.00000	80.5000000	39325.00000	9.41807
12:30	492.00000	82.0000000	40696.00000	8.39047
14:30	484.00000	80.6666667	39512.00000	9.68848

TABLE 17.--Heart rate values for a four-minute thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	735.00000	122.5000000	93491.00000	26.28117
0:30	810.00000	135.0000000	111314.00000	19.81918
0:45	869.00000	144.8333333	126953.00000	14.78400
1:00	897.00000	149.5000000	135093.00000	14.08190
1:15	932.00000	155.3333333	146288.00000	17.42029
1:30	940.00000	156.6666667	148176.00000	13.48580
1:45	951.00000	158.5000000	151617.00000	13.29286
2:00	950.00000	158.3333333	151204.00000	12.54857
2:15	976.00000	162.6666667	159264.00000	10.01332
2:30	946.00000	157.6666667	150548.00000	16.70529
3:00	953.00000	158.8333333	152561.00000	15.44560
3:30	964.00000	160.6666667	156360.00000	17.18914
4:00	976.00000	162.6666667	159528.00000	12.47201
4:30	986.00000	164.3333333	162476.00000	9.41630
0:15	990.00000	165.0000000	164018.00000	11.55855
0:30	889.00000	148.1666667	132933.00000	15.57455
0:45	736.00000	122.6666667	91618.00000	16.94304
1:00	636.00000	106.0000000	69176.00000	18.76166
1:15	603.00000	100.5000000	62421.00000	19.07616
1:30	561.00000	93.5000000	53991.00000	17.53568
1:45	543.00000	90.5000000	50383.00000	15.75754
2:00	552.00000	92.0000000	51392.00000	11.02724
2:30	548.00000	91.3333333	51446.00000	16.70529
3:00	526.00000	87.6666667	46894.00000	12.50067
3:30	519.00000	86.5000000	45885.00000	14.08190
4:00	506.00000	84.3333333	43236.00000	10.61446
4:30	510.00000	85.0000000	43996.00000	11.36662
5:00	513.00000	85.5000000	44533.00000	11.58879
5:30	515.00000	85.8333333	44395.00000	6.17792
6:30	494.00000	82.3333333	41004.00000	8.14043
8:30	499.00000	83.1666667	41761.00000	7.22265
10:30	522.00000	87.0000000	45746.00000	8.14862
12:30	467.00000	77.8333333	36641.00000	7.65289
14:30	494.00000	82.3333333	40796.00000	4.96655

TABLE 18.--Heart rate values for a five-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	788.00000	131.3333333	106250.00000	23.49184
0:30	879.00000	146.5000000	130253.00000	17.20174
0:45	907.00000	151.1666667	138005.00000	13.39278
1:00	912.00000	152.0000000	139240.00000	11.09955
1:15	940.00000	156.6666667	147664.00000	8.91441
1:30	935.00000	155.8333333	146137.00000	9.30412
1:45	988.00000	164.6666667	163376.00000	11.70755
2:00	967.00000	161.1666667	156257.00000	9.04249
2:15	1001.00000	166.8333333	167469.00000	9.68332
2:30	993.00000	165.5000000	165161.00000	12.80234
3:00	1000.00000	166.6666667	167192.00000	10.25020
3:30	1005.00000	167.5000000	168723.00000	8.78066
4:00	1013.00000	168.8333333	171317.00000	7.60044
4:30	1011.00000	168.5000000	170837.00000	9.83362
5:00	1022.00000	170.3333333	174412.00000	8.14043
0:15	1016.00000	169.3333333	172754.00000	11.92756
0:30	956.00000	159.3333333	153584.00000	15.88290
0:45	839.00000	139.8333333	118515.00000	15.45855
1:00	744.00000	124.0000000	93508.00000	15.82403
1:15	667.00000	110.8333333	74541.00000	12.93703
1:30	637.00000	106.1666667	68607.00000	13.99166
1:45	617.00000	102.8333333	64133.00000	11.70328
2:00	609.00000	101.5000000	63139.00000	16.28189
2:30	588.00000	98.0000000	58934.00000	16.18641
3:00	572.00000	95.3333333	55678.00000	15.14816
3:30	564.00000	94.0000000	53974.00000	13.84197
4:00	559.00000	93.1666667	52925.00000	12.99872
4:30	553.00000	92.1666667	51401.00000	9.30412
5:00	554.00000	92.3333333	52028.00000	13.23128
5:30	545.00000	90.8333333	50059.00000	10.53407
6:30	535.00000	89.1666667	48107.00000	8.97589
8:30	547.00000	91.1666667	50497.00000	11.21457
10:30	529.00000	88.1666667	47273.00000	11.25019
12:30	519.00000	86.5000000	45561.00000	11.55422
14:30	522.00000	87.0000000	45742.00000	8.09938

TABLE 19.--Heart rate values for a six-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	712.00000	118.6666667	84998.00000	10.07307
0:30	830.00000	138.3333333	115348.00000	10.30857
1:45	862.00000	143.6666667	124276.00000	9.33095
1:00	905.00000	150.8333333	136777.00000	7.38693
1:15	930.00000	155.0000000	144516.00000	8.55570
1:30	934.00000	155.6666667	146020.00000	11.20119
1:45	983.00000	163.8333333	161889.00000	12.96791
2:00	966.00000	161.0000000	156228.00000	11.84905
2:15	962.00000	160.3333333	155460.00000	15.61623
2:30	1006.00000	167.6666667	168884.00000	6.50128
3:00	997.00000	166.1666667	166393.00000	12.04021
3:30	996.00000	166.0000000	166326.00000	14.07125
4:00	1009.00000	168.1666667	170133.00000	9.51660
4:30	1004.00000	167.3333333	168670.00000	11.55278
5:00	1029.00000	171.5000000	177121.00000	11.37981
6:00	1036.00000	172.6666667	179406.00000	10.23067
0:15	1004.00000	167.3333333	170266.00000	21.27596
0:30	920.00000	153.3333333	144424.00000	25.91267
0:45	839.00000	139.8333333	119005.00000	18.35665
1:00	739.00000	123.1666667	92687.00000	18.25833
1:15	682.00000	113.6666667	79072.00000	17.61439
1:30	639.00000	106.5000000	68943.00000	13.33792
1:45	617.00000	102.8333333	64745.00000	16.10486
2:00	612.00000	102.0000000	62998.00000	10.71448
2:30	594.00000	99.0000000	59270.00000	9.63328
3:00	578.00000	96.3333333	56220.00000	10.38589
3:30	561.00000	93.5000000	53043.00000	10.85818
4:00	553.00000	92.1666667	51545.00000	10.74089
4:30	563.00000	93.8333333	53525.00000	11.80537
5:00	552.00000	92.0000000	51170.00000	8.78635
5:30	527.00000	87.8333333	46731.00000	9.41099
6:30	515.00000	85.8333333	44791.00000	10.83359
8:30	526.00000	87.6666667	46394.00000	7.50111
10:30	517.00000	86.1666667	45003.00000	9.53764
12:30	520.00000	86.6666667	45384.00000	7.96660
14:30	522.00000	87.0000000	45628.00000	6.54217

TABLE 20.--Heart rate values for a seven-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	731.00000	121.8333333	91147.00000	20.42955
0:30	851.00000	141.8333333	121901.00000	15.49731
0:45	877.00000	146.1666667	129505.00000	16.22858
1:00	946.00000	157.6666667	150286.00000	15.05545
1:15	931.00000	155.1666667	145539.00000	14.68900
1:30	954.00000	159.0000000	152068.00000	8.74071
1:45	991.00000	165.1666667	164377.00000	11.80537
2:00	1014.00000	169.0000000	174386.00000	24.57641
2:15	1013.00000	168.8333333	172801.00000	18.82994
2:30	997.00000	166.1666667	166937.00000	15.93006
3:00	993.00000	165.5000000	165097.00000	12.29227
3:30	984.00000	164.0000000	162184.00000	12.71220
4:00	1006.00000	167.6666667	169964.00000	16.07068
4:30	981.00000	163.5000000	160925.00000	10.31019
5:00	1015.00000	169.1666667	172525.00000	12.81275
6:00	1034.00000	172.3333333	179032.00000	12.95634
7:00	1040.00000	173.3333333	181552.00000	16.03330
0:15	1012.00000	168.6666667	171642.00000	13.79372
0:30	920.00000	153.3333333	141970.00000	13.44123
0:45	807.00000	134.5000000	110429.00000	19.42936
1:00	708.00000	118.0000000	84984.00000	16.97056
1:15	634.00000	105.6666667	68294.00000	16.13278
1:30	619.00000	103.1666667	65171.00000	16.19156
1:45	585.00000	97.5000000	57623.00000	10.82128
2:00	595.00000	99.1666667	59689.00000	11.70328
2:30	590.00000	98.3333333	58926.00000	13.48579
3:00	560.00000	93.3333333	58926.00000	13.48579
3:30	537.00000	89.5000000	49205.00000	15.12283
4:00	534.00000	89.0000000	48732.00000	15.53061
4:30	532.00000	88.6666667	48160.00000	14.06651
5:00	533.00000	88.8333333	38165.00000	12.78150
5:30	532.00000	88.6666667	47940.00000	12.40430
6:30	507.00000	84.5000000	43769.00000	13.61984
8:30	523.00000	87.1666667	46141.00000	10.51507
10:30	515.00000	85.8333333	44961.00000	12.30312
12:30	498.00000	83.0000000	42122.00000	12.55388
14:30	501.00000	83.5000000	42329.00000	9.95490

TABLE 21.--Heart rate values for an eight-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	741.00000	123.5000000	94445.00000	24.21363
0:30	818.00000	136.3333333	112130.00000	11.03932
0:45	840.00000	140.0000000	117990.00000	8.83176
1:00	915.00000	152.5000000	140313.00000	12.45392
1:15	932.00000	155.3333333	145552.00000	12.50067
1:30	936.00000	156.0000000	146880.00000	13.14534
1:45	916.00000	152.6666667	149336.00000	9.93311
2:00	962.00000	160.3333333	155282.00000	14.43145
2:15	933.00000	155.5000000	145833.00000	12.25969
2:30	955.00000	159.1666667	153381.00000	16.59418
3:00	986.00000	164.3333333	163788.00000	18.73677
3:30	967.00000	161.1666667	156685.00000	12.93703
4:00	997.00000	166.1666667	167009.00000	16.37580
4:30	1032.00000	172.0000000	178424.00000	13.56466
5:00	1010.00000	168.3333333	170686.00000	11.57008
6:00	1019.00000	169.8333333	173805.00000	12.20519
7:00	1044.00000	174.0000000	182414.00000	12.31260
8:00	1042.00000	173.6666667	181534.00000	10.70825
0:15	1033.00000	172.1666667	178321.00000	9.72454
0:30	943.00000	157.1666667	149837.00000	18.04901
0:45	845.00000	140.8333333	120629.00000	18.02683
1:00	721.00000	120.1666667	88179.00000	17.54328
1:15	669.00000	111.5000000	75797.00000	15.51451
1:30	645.00000	196,5000000	70145.00000	12.70827
1:45	613.00000	102.1666667	63581.00000	13.80459
2:00	609.00000	101.5000000	62813.00000	14.13860
2:30	584.00000	97.3333333	47768.00000	13.60392
3:00	587.00000	97.8333333	58201.00000	12.43248
3:30	579.00000	96.5000000	57041.00000	15.28071
4:00	567.00000	94.5000000	54597.00000	14.25132
4:30	562.00000	93.6666667	53886.00000	15.78185
5:00	533.00000	88.8333333	48473.00000	14.99889
6:30	510.00000	85.0000000	43772.00000	9.18695
6:30	539.00000	89.8333333	49757.00000	16.35135
8:30	496.00000	82.6666667	41432.00000	9.26643
10:30	519.00000	86.5000000	45769.00000	13.23254
12:30	508.00000	84.6666667	44280.00000	15.93319
14:30	500.00000	83.3333333	42360.00000	11.77568

TABLE 22.--Heart rate values for a nine-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	640.00000	106.6666667	78808.00000	10.40513
0:30	814.00000	135.6666667	111042.00000	11.03932
0:45	879.00000	146.5000000	129417.00000	11.34460
1:00	913.00000	152.1666667	139691.00000	12.35179
1:30	962.00000	160.3333333	154898.00000	11.46589
1:45	959.00000	159.8333333	153945.00000	11.53112
2:00	976.00000	162.6666667	159296.00000	10.32796
2:15	986.00000	164.3333333	163002.00000	13.92360
2:30	1012.00000	168.6666667	171906.00000	15.59060
3:00	986.00000	164.3333333	162988.00000	13.82269
3:30	1009.00000	168.1666667	170401.00000	12.00694
4:00	1011.00000	168.5000000	170953.00000	10.94989
4:30	1031.00000	171.8333333	177757.00000	10.92551
5:00	1036.00000	172.6666667	179422.00000	10.38589
6:00	1036.00000	172.6666667	179578.00000	11.79265
7:00	1049.00000	174.8333333	183871.00000	9.70395
8:00	1066.00000	177.6666667	190000.00000	11.02119
9:00	1058.00000	176.3333333	187300.00000	12.16004
0:15	1011.00000	168.5000000	172403.00000	20.24599
0:30	986.00000	164.3333333	163554.00000	17.44324
0:45	878.00000	146.3333333	130996.00000	22.42915
1:00	793.00000	132.1666667	86619.00000	19.98416
1:15	715.00000	119.1666667	86619.00000	16.82161
1:30	705.00000	117.5000000	84411.00000	17.73979
1:45	661.00000	110.1666667	74131.00000	16.19156
2:00	617.00000	102.8333333	64175.00000	12.05681.
2:30	617.00000	102.8333333	64297.00000	13.02945
3:00	584.00000	97.3333333	57432.00000	10.85664
3:30	599.00000	99.8333333	60477.00000	11.63472
4:00	595.00000	99.1666667	59797.00000	12.59233
4:30	580.00000	96.6666667	57006.00000	13.70645
5:00	568.00000	94.6666667	54718.00000	13.76469
5:30	589.00000	98.1666667	58273.00000	9.51665
6:30	583.00000	97.1666667	57723.00000	14.66174
8:30	563.00000	93.8333333	53497.00000	11.56575
10:30	552.00000	92.0000000	51688.00000	13.44619
12:30	536.00000	89.3333333	48566.00000	11.69045
14:30	536.00000	89.3333333	48672.00000	12.56450

TABLE 23.--Heart rate values for a ten-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	593.00000	115.5000000	80719.00000	11.64045
0:30	837.00000	139.5000000	117123.00000	8.50294
0:45	871.00000	145.1666667	126969.00000	10.28429
1:00	903.00000	150.5000000	136567.00000	11.53690
1:15	940.00000	156.6666667	148048.00000	12.50067
1:30	952.00000	158.6666667	151520.00000	9.68848
1:45	966.00000	161.0000000	156356.00000	12.88410
2:00	978.00000	163.0000000	160356.00000	13.72589
2:15	983.00000	163.8333333	161649.00000	10.96206
2:30	972.00000	162.0000000	158128.00000	11.52389
3:00	995.00000	165.8333333	165773.00000	12.40027
3:30	1000.00000	166.6666667	167688.00000	14.29219
4:00	1016.00000	169.3333333	173086.00000	14.44530
4:30	1018.00000	169.6666667	173452.00000	13.09408
5:00	1034.00000	172.3333333	179002.00000	12.72268
6:00	1042.00000	173.6666667	181578.00000	11.11156
7:00	1043.00000	173.8333333	186077.00000	10.70358
8:00	1055.00000	175.8333333	186077.00000	10.70358
9:00	1101.00000	183.5000000	203627.00000	17.85217
10:00	1116.00000	186.0000000	209606.00000	20.14944
0:15	1035.00000	172.5000000	179681.00000	15.12283
0:30	996.00000	166.0000000	166498.00000	15.24467
0:45	867.00000	144.5000000	127181.00000	19.49102
1:00	760.00000	126.6666667	97156.00000	13.33667
1:15	734.00000	122.3333333	90662.00000	13.18585
1:30	697.00000	116.1666667	81921.00000	13.80459
1:45	672.00000	112.0000000	75744.00000	9.79796
2:00	666.00000	111.0000000	74558.00000	11.24278
2:30	638.00000	106.3333333	68174.00000	8.16497
3:00	634.00000	105.6666667	67406.00000	9.09212
3:30	599.00000	99.8333333	60711.00000	13.49691
4:00	602.00000	100.3333333	61158.00000	12.30718
4:30	598.00000	99.6666667	60380.00000	12.48466
5:00	587.00000	97.8333333	58289.00000	13.12123
5:30	591.00000	98.5000000	58961.00000	12.22702
6:30	581.00000	96.8333333	57087.00000	12.85950
8:30	565.00000	94.1666667	54019.00000	12.76584
10:30	543.00000	90.5000000	49805.00000	11.51955
12:30	566.00000	94.3333333	53898.00000	10.05319
14:30	567.00000	94.5000000	54441.00000	13.11106

TABLE 24.---Oxygen pulse values for five-minute rest.

	Five-minute rest---Mean oxygen pulse-mls.
1:00	5.57
2:00	5.25
3:00	4.83
4:00	4.82
5:00	4.74

TABLE 25.--Oxygen pulse values for a five-minute warm up and fifteen-minute recovery period.

	Five-minute warm up--Mean oxygen pulse-mls.
1:00	10.53
2:00	12.51
3:00	14.44
4:00	15.30
5:00	13.16
0:15	10.79
0:30	10.44
0:45	10.99
1:00	10.47
1:15	7.74
1:30	4.20
1:45	4.78
2:00	5.67
2:30	4.00
3:00	5.62
3:30	4.01
4:00	5.06
4:30	3.39
5:00	3:61
5:30	3:24
6:30	3.30
8:30	3.44
10:30	3.36
12:30	3.50
14:30	3.48

		Recovery																			
Run		0:15	0:30	0:45	1:00	1:15	1:30	1:45	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5:30	6:30	8:30	10:30	12:30	14:30
0:15	8.77	8.79	9.80	11.53	9.28	7.88	6.94	6.31	4.40	4.35	4.78	4.65	3.67	4.04	4.38	3.69	3.68	3.99	3.49	3.91	3.83
0:30	11.76	11.274	12.55	11.04	7.10	8.15	7.81	5.72	5.15	3.07	3.84	4.04	3.50	3.90	3.91	2.76	3.01	3.06	2.99	2.91	2.92
0:45	16.66	15.03	13.82	13.70	11.75	9.04	7.51	7.58	5.21	5.16	4.28	4.34	4.54	3.90	4.15	3.94	3.86	4.15	4.17	4.12	4.55
1:00	17.68	15.44	13.85	14.25	11.88	8.63	6.66	5.38	5.22	4.69	4.43	4.63	4.22	4.93	4.11	3.66	3.55	3.76	3.55	3.67	3.78
1:15	18.88	16.01	13.10	12.38	9.21	7.63	5.69	5.14	4.96	3.95	3.94	4.46	4.04	3.50	3.41	2.94	2.77	3.04	3.01	3.07	2.84
1:30	20.57	16.32	14.32	9.19	8.80	8.67	7.64	5.99	5.01	5.92	4.70	5.21	4.42	4.39	3.52	3.41	3.48	3.51	3.69	3.75	3.64
1:45	20.33	17.65	14.65	14.68	9.32	8.93	7.25	5.21	4.67	5.76	5.38	4.49	4.22	4.53	4.96	3.17	3.49	3.42	3.30	3.22	3.32
2:00	20.23	14.80	13.60	12.52	11.34	9.10	8.20	6.95	5.87	5.15	5.35	4.28	4.53	3.78	4.47	2.69	3.87	4.04	4.08	3.78	3.94
2:15	20.23	13.66	12.89	14.31	10.17	9.09	7.79	5.68	6.41	5.06	4.58	4.79	4.85	4.89	4.82	4.26	4.31	4.32	4.39	4.36	4.29
2:30	20.33	13.91	13.20	12.06	10.77	10.26	9.67	7.33	6.44	5.38	4.95	5.15	4.66	4.33	4.36	4.59	4.38	4.59	4.64	4.68	4.81
3:00	19.93	15.03	13.39	11.09	10.81	9.87	8.24	7.10	5.15	5.21	4.54	4.32	4.97	4.37	4.08	3.23	3.40	3.63	3.47	3.44	3.46
3:30	19.79	15.68	12.58	11.92	9.76	7.95	5.86	6.00	6.15	5.03	4.32	4.46	4.73	4.72	4.42	3.62	3.72	3.72	3.70	3.94	3.79
4:00	19.97	16.77	15.75	13.13	11.11	10.85	8.31	8.03	6.27	5.59	5.15	4.86	5.07	4.43	4.54	3.99	3.41	3.44	3.61	3.55	3.61
4:30	20.08	17.40	16.48	13.07	10.10	8.37	7.00	6.89	5.86	4.84	4.22	5.53	4.27	4.35	4.40	3.45	3.60	3.56	3.40	3.80	3.60
5:00	18.79	14.84	12.69	10.55	9.23	8.61	6.79	5.18	4.94	4.88	5.10	5.48	4.69	4.82	4.81	3.55	3.61	3.53	3.65	3.72	3.70
6:00	18.66	16.15	14.13	.2138	9.50	7.82	7.16	8.04	5.85	6.64	5.19	4.50	4.47	3.69	3.97	3.23	3.31	3.24	3.29	3.28	3.26
7:00	22.34	14.64	14.59	11.43	10.90	8.75	7.20	6.85	6.80	5.67	4.60	4.49	4.64	4.27	4.25	2.94	3.09	2.88	3.04	3.14	3.13
8:00	19.47	15.90	15.38	14.10	10.20	8.02	6.68	6.92	5.05	5.11	5.31	5.66	5.12	4.42	4.01	3.99	3.78	4.10	3.92	4.00	4.07
9:00	22.34	15.06	13.15	11.50	12.19	13.05	7.93	6.62	5.84	5.59	5.79	4.89	4.69	4.74	4.63	3.13	3.16	3.29	3.36	3.46	3.46
10:00	18.82	15.95	12.22	11.62	12.51	8.38	6.81	6.59	5.27	4.91	5.21	4.52	4.90	4.59	4.44	3.61	3.68	3.78	3.93	3.78	3.77

TABLE 27.--Oxygen uptake values (L/Min) for five minute rest.

	Mean	Standard Deviation
1'00"	0.367	0.135
2'00"	0.332	0.097
3'00"	0.309	0.046
4'00"	0.311	0.035
5'00"	0.305	0.043

TABLE 28.--Oxygen uptake (L/Min) values for a five minute warm-up.

	Mean	Standard Deviation
1'00"	1.319	0.514
2'00"	1.704	0.577
3'00"	1.985	0.467
4'00"	2.094	0.613
5'00"	1.821	0.748
15"	1.510	0.668
30"	1.288	0.647
45"	1.178	0.697
1'00"	0.961	0.625
1'15"	0.674	0.597
1'30"	0.358	0.147
1'45"	0.404	0.208
2'00"	0.476	0.505
2'30"	0.328	0.129
3'00"	0.444	0.440
3'30"	0.327	0.150
4'00"	0.405	0.272
4'30"	0.264	0.146
5'00"	0.273	0.124

TABLE 29.--Oxygen uptake (L/Min) values for a fifteen second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.03700	1.0061667	6.68770	0.35028
0:15	6.53800	1.0895556	7.98857	0.41577
0:30	7.39700	1.2328333	9.62818	0.31904
0:45	5.91700	0.9861667	6.55030	0.37819
1:00	4.02800	0.6713333	3.04767	0.26212
1:15	3.45900	1.5765000	2.15448	0.17909
1:30	2.88600	0.4810000	1.42861	0.08994
1:45	2.19000	0.3650000	1.42861	0.05784
2:00	1.82900	0.3048333	0.59411	0.08553
2:30	1.87300	0.3121667	0.68557	0.14205
3:00	2.13200	0.3553333	0.82679	0.11766
3:30	2.09900	0.3498333	0.77683	0.09223
4:00	1.59900	0.2665000	0.44894	0.06754
4:30	1.81100	0.3018333	0.58623	0.08901
5:00	2.05900	0.3431667	0.63923	0.08081
5:30	1.73400	0.2890000	0.55248	0.10134

TABLE 30.--Oxygen uptake (L/Min) values for a thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.21400	1.0356667	6.59876	0.18062
0:30	9.16100	1.5268333	14.19961	0.20605
0:15	9.07500	1.5125000	14.41667	0.37168
0:30	9.20400	1.5340000	14.38968	0.23270
0:45	6.98900	1.1648333	8.65673	0.32116
1:00	3.54800	0.5913333	2.15685	0.10844
1:15	3.70000	0.6166667	2.39471	0.15036
1:30	3.24700	0.5411667	1.81784	0.11016
1:45	2.53700	0.4228333	1.12585	0.10308
2:00	2.30100	0.3835000	0.90055	0.06020
2:30	1.39800	0.2330000	0.34550	0.06287
3:00	1.67900	0.2798333	0.48606	0.05696
3:30	1.85500	0.3091667	0.59301	0.06247
4:00	1.60100	0.2668333	0.43680	0.04383
4:30	1.75300	0.2921667	0.52656	0.05366
5:00	1.81400	0.3023333	0.56380	0.05543
5:30	1.36500	0.2275000	0.37895	0.11698

TABLE 29.--Oxygen uptake (L/Min) values for a fifteen second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.03700	1.0061667	6.68770	0.35028
0:15	6.53800	1.0895556	7.98857	0.41577
0:30	7.39700	1.2328333	9.62818	0.31904
0:45	5.91700	0.9861667	6.55030	0.37819
1:00	4.02800	0.6713333	3.04767	0.26212
1:15	3.45900	1.5765000	2.15448	0.17909
1:30	2.88600	0.4810000	1.42861	0.08994
1:45	2.19000	0.3650000	1.42861	0.05784
2:00	1.82900	0.3048333	0.59411	0.08553
2:30	1.87300	0.3121667	0.68557	0.14205
3:00	2.13200	0.3553333	0.82679	0.11766
3:30	2.09900	0.3498333	0.77683	0.09223
4:00	1.59900	0.2665000	0.44894	0.06754
4:30	1.81100	0.3018333	0.58623	0.08901
5:00	2.05900	0.3431667	0.63923	0.08081
5:30	1.73400	0.2890000	0.55248	0.10134

TABLE 30.--Oxygen uptake (L/Min) values for a thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.21400	1.0356667	6.59876	0.18062
0:30	9.16100	1.5268333	14.19961	0.20605
0:15	9.07500	1.5125000	14.41667	0.37168
0:30	9.20400	1.5340000	14.38968	0.23270
0:45	6.98900	1.1648333	8.65673	0.32116
1:00	3.54800	0.5913333	2.15685	0.10844
1:15	3.70000	0.6166667	2.39471	0.15036
1:30	3.24700	0.5411667	1.81784	0.11016
1:45	2.53700	0.4228333	1.12585	0.10308
2:00	2.30100	0.3835000	0.90055	0.06020
2:30	1.39800	0.2330000	0.34550	0.06287
3:00	1.67900	0.2798333	0.48606	0.05696
3:30	1.85500	0.3091667	0.59301	0.06247
4:00	1.60100	0.2668333	0.43680	0.04383
4:30	1.75300	0.2921667	0.52656	0.05366
5:00	1.81400	0.3023333	0.56380	0.05543
5:30	1.36500	0.2275000	0.37895	0.11698

TABLE 31.--Oxygen uptake values (L/Min) for a firty-five second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	5.22000	0.8700000	4.96768	0.29199
0:30	10.72700	1.7878333	19.45178	0.23396
0:45	14.74000	2.4566667	36.67765	0.30541
0:15	12.92000	2.1533333	27.91537	0.13734
0:30	10.53200	1.7553333	19.19764	0.37695
0:45	8.69500	1.4491667	13.38002	0.39485
1:00	6.15700	1.0261667	6.65795	0.26071
1:15	4.45600	0.7426667	3.33803	0.07578
1:30	3.01000	0.5016667	1.57435	0.11343
1:45	2.99000	0.4983333	1.67510	0.19240
2:00	2.41600	0.4026667	1.00771	0.08351
2:30	2.47600	0.4126667	1.03986	0.06016
3:00	2.10900	0.3515000	0.75815	0.05803
3:30	2.15300	0.3588333	0.78052	0.03989
4:00	2.26300	0.3771667	0.88245	0.07605
4:30	1.89700	0.3161667	0.61586	0.05673
5:00	2.03300	0.3388333	0.70048	0.04823
5:30	1.91900	0.3198333	0.62625	0.04998

TABLE 32.--Oxygen uptake (L/Min) values for a one-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	5.62500	0.9375000	5.71494	0.29715
0:30	8.96300	1.4938333	14.11901	0.38204
0:45	14.29100	2.3818333	34.53282	0.31434
1:00	16.14400	2.6906667	44.52791	0.46886
0:15	13.74000	2.2900000	32.38745	0.42962
0:30	11.19300	1.8655000	21.19858	0.24221
0:45	8.31000	1.3850000	12.15479	0.35929
1:00	6.18000	1.0300000	6.74565	0.27577
1:15	4.05600	0.6760000	2.92201	0.18982
1:30	3.41200	1.5686667	1.99612	0.10566
1:45	2.47600	0.4126667	1.11952	0.13983
2:00	2.41500	0.4025000	1.03591	0.11302
2:30	2.23800	0.3730000	0.93369	0.14065
3:00	2.40600	0.3410000	0.72014	0.06701
3:30	2.00400	0.3340000	0.71911	0.09977
4:00	1.96100	0.3268333	0.74313	0.14298
4:30	2.25300	0.3755000	0.89726	0.10125
5:00	1.85400	0.3090000	0.61596	0.09282
5:30	1.73600	0.2893333	0.54328	0.09055

TABLE 33.--Oxygen uptake values (L/Min) for a one-minute fifteen-secong run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.03100	1.0051667	6.93349	0.41745
0:30	10.13600	1.6893333	17.44838	0.25507
0:45	14.35600	2.3926667	35.15729	0.40204
1:00	16.79400	2.7990000	47.70688	0.37429
1:15	17.13000	2.8550000	49.68568	0.39485
0:15	14.29400	2.3823333	34.90245	0.41216
0:30	10.19700	1.6995000	17.96867	0.35746
0:45	7.50100	1.2501667	9.90846	0.32587
1:00	4.47400	0.7456667	4.15448	0.40456
1:15	3.41000	0.5683333	2.19030	0.22463
1:30	2.42800	0.4046667	1.18466	0.20106
1:45	2.22400	0.3706667	0.92689	0.14320
2:00	2.13700	0.3561667	0.86835	0.14644
2:30	1.79600	0.2993333	0.63764	0.14145
3:00	1.81200	0.3020000	0.60714	0.10947
3:30	1.97000	0.3283333	0.71496	0.11674
4:00	1.77300	0.2955000	0.68182	0.17771
4:30	1.59500	0.2658333	0.48866	0.11372
5:00	1.43400	0.2390000	0.43269	0.13414
5:30	1.30000	0.2166667	0.37026	0.13311

TABLE 34.--Oxygen uptake values (L/Min) for a one-minute thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	7.26800	9.2113333	8.94438	0.16758
0:30	9.85000	1.6416667	16.57229	0.28350
0:45	15.22300	2.5371667	39.02251	0.28257
1:00	17.26500	2.8775000	50.24879	0.33727
1:15	18.32100	3.0535000	56.15702	0.20681
1:30	18.68200	3.1136667	58.60376	0.29470
0:15	15.16200	2.5270000	38.61995	0.24722
0:30	12.30300	2.0505000	25.62839	0.28323
0:45	6.43300	1.0721667	7.73838	0.41015
1:00	4.97100	0.8285000	4.30411	0.19268
1:15	4.35300	0.7255000	3.31050	0.17459
1:30	3.65800	0.6096667	2.43339	0.20161
1:45	2.73000	0.4550000	1.30105	0.10854
2:00	2.28700	0.3811667	0.92445	0.10269
2:30	2.66200	0.4436667	1.22850	0.09743
3:00	2.09200	0.3486667	0.74831	0.06148
3:30	2.44700	0.4078333	1.06716	0.11764
4:00	2.04800	0.3413333	0.72441	0.07121
4:30	1.97800	0.3296667	0.68182	0.07712
5:00	1.57900	0.2631667	0.45820	0.09237
5:30	1.60500	0.2675000	0.46652	0.08624

TABLE 35.--Oxygen uptake values (L/Min) for a one-minute forty-five second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.93300	1.1555000	8.43390	0.29080
0:30	9.51700	1.5861667	15.42949	0.25843
0:45	14.32900	2.3881667	34.45169	0.21525
1:00	17.13900	2.8565000	49.59848	9.35803
1:15	16.68300	2.7805000	46.82346	0.29542
1:30	18.59600	3.0993333	58.20690	0.33814
1:45	19.39100	3.2318333	63.17629	0.31869
0:15	15.80000	2.6333333	42.89321	0.50726
0:30	12.32200	2.0536667	26.45270	0.47905
0:45	10.29000	1.7150000	18.50576	0.41435
1:00	5.35200	0.8920000	5.41899	0.35917
1:15	4.44500	0.7408333	3.46123	0.18342
1:30	3.49200	0.5820000	2.18979	0.17745
1:45	2.49100	0.4151667	1.14549	0.14921
2:00	2.33000	0.3883333	0.97395	0.11758
2:30	2.83300	0.4721667	1.41432	0.12383
3:00	2.74800	0.4580000	1.33973	0.12740
3:30	2.18500	0.3641667	0.82307	0.07398
4:00	2.05800	0.3430000	0.74932	0.09319
4:30	2.26000	0.3766667	0.89110	0.08926
5:00	2.41700	0.4028333	1.03704	0.11260
5:30	1.57100	0.2618333	0.44654	0.08391

TABLE 36.--Oxygen uptake values (L/Min) for a two-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	5.31400	0.8856667	5.45928	0.38803
0:30	8.86200	1.4770000	13.95670	0.41654
0:45	13.00000	2.1666667	29.00843	0.41031
1:00	16.33400	2.7223333	45.23100	0.39100
1:15	17.19900	2.8665000	49.79203	0.31340
1:30	18.30400	3.0506667	56.45194	0.35001
1:45	19.87300	3.3121667	66.67494	0.41286
2:00	19.37300	3.2288333	63.13073	0.34016
0:15	13.87300	2.3121667	33.85159	0.59580
0:30	11.95100	1.9918333	25.62391	0.60324
0:45	9.41000	1.5683333	15.45596	0.37362
1:00	6.78700	1.1311667	7.96997	0.24197
1:15	4.73100	0.7885000	4.05448	0.25459
1:30	4.14700	0.6911667	3.94889	0.19111
1:45	3.37500	0.5625000	1.97615	0.12467
2:00	2.84400	0.4740000	1.39395	0.09580
2:30	2.51800	0.4196667	1.14719	0.13451
3:00	2.66400	0.4440000	1.29224	0.14794
3:30	2.11300	0.3521667	0.76703	0.06768
4:00	2.21000	0.3683333	0.85207	0.08724
4:30	1.81300	0.3021667	0.57160	0.06895
5:00	2.16800	0.3613333	0.80082	0.05907
5:30	1.81800	0.3030000	0.56579	0.05465

TABLE 36.--Oxygen uptake values (L/min) for a two-minute run.

TABLE 37.--Oxygen uptake values (L/Min) for a two-minute fifteen-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.06500	1.0108333	6.58686	0.30205
0:30	7.55900	1.2598333	9.97499	0.30063
0:45	11.72700	1.9545000	24.74247	0.60366
1:00	14.56400	2.4273333	38.06435	0.73657
1:15	17.21900	2.8698333	50.63399	0.49363
1:30	15.80200	2.6336667	45.04189	0.82761
1:45	17.54800	2.9246667	55.40828	0.90402
2:00	17.40300	2.9005000	54.06122	0.84662
2:15	17.94400	2.9906667	55.17836	0.55024
0:15	12.84100	2.1401667	30.02752	0.71353
0:30	11.15400	1.8590000	22.24261	0.54906
0:45	10.23600	1.6070000	19.68271	0.66635
1:00	6.07400	1.0123333	6.55418	0.28470
1:15	4.89200	0.8153333	4.26114	0.23347
1:30	3.71500	0.6191667	2.31570	0.05566
1:45	2.86100	0.4768333	1.42877	0.11362
2:00	3.15500	0.5258333	1.80451	0.17059
2:30	2.46500	0.4108333	1.16405	0.17398
3:00	2.25900	0.3765000	0.90533	0.10471
3:30	2.29400	0.3823333	0.91499	0.08709
4:00	2.30100	0.3835000	0.94042	0.10769
4:30	2.33000	0.3883333	0.94869	0.09368
5:00	2.26200	0.3770000	0.88594	0.08144
5:30	2.02600	0.3376667	0.69216	0.04012

TABLE 38.--Oxygen uptake values (L/Min) for a two-minute thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	5.51200	0.9186667	5.85123	0.39687
0:30	8.72200	1.4536667	14.12028	0.53692
0:45	13.16100	2.1935000	31.29498	0.69661
1:00	15.62100	2.6035000	43.69704	0.77817
1:15	16.29.00	2.7151667	47.03789	0.74901
1:30	16.38800	2.7313333	47.92454	0.79542
1:45	17.20200	2.8670000	52.40811	0.78613
2:00	19.37700	3.2295000	64.25189	0.57860
2:15	19.47500	3.2458333	65.30315	0.64661
2:30	18.00100	3.0001667	58.88461	0.98779
0:15	13.35000	2.2250000	31.97911	0.67459
0:30	11.54600	1.9243333	23.01797	0.39990
0:45	8.55300	1.4255000	13.77125	0.56195
1:00	6.09500	1.0158333	6.66918	0.30909
1:15	5.12600	0.8543333	5.02112	0.35828
1:30	4.33600	0.7226667	3.90368	0.38992
1:45	3.49700	0.5828333	2.14223	0.14427
2:00	2.94300	0.4905000	1.53540	0.13554
2:30	2.58100	0.4301667	1.18044	0.11847
3:00	2.44000	0.4066667	1.09065	0.14028
3:30	2.49500	0.4158333	1.08547	0.09794
4:00	2.29000	0.3816667	0.96883	0.13770
4:30	2.11300	0.3521667	0.78890	0.09463
5:00	2.02300	0.3371667	0.72544	0.09311
5:30	2.16400	0.3606667	0.88596	0.14525

TABLE 39.--Oxygen uptake values (L/Min) for a three-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	5.95000	0.9916667	6.10216	0.20087
0:30	10.26400	1.7106667	17.75482	0.19826
0:45	14.61900	2.4365000	36.19400	0.33906
1:00	16.41500	2.7358333	45.77235	0.41561
1:15	17.85200	2.9753333	54.31778	0.49033
1:30	18.69300	3.1155000	58.78503	0.33075
1:45	19.49200	3.2486667	63.72179	0.28241
2:00	17.84800	2.9746667	53.73543	0.35877
2:15	18.08300	3.0138333	56.25715	0.59296
2:30	18.71100	3.1185000	60.20436	0.60912
3:00	18.69200	3.1153333	58.33950	0.14676
0:15	14.29400	2.3823333	35.59385	0.55512
0:30	11.53200	1.9220000	23.34548	0.48600
0:45	8.16900	1.3615000	11.21794	0.13846
1:00	6.67900	1.1131667	8.07725	0.35844
1:15	5.58400	0.9306667	5.59653	0.28273
1:30	4.34700	0.7245000	3.44747	0.24416
1:45	3.70800	0.6180000	2.51519	0.21149
2:00	2.73200	0.4553333	1.32583	0.12795
2:30	2.66100	0.4435000	1.29977	0.15467
3:00	2.32500	0.3875000	1.03528	0.16392
3:30	2.18800	0.3646667	0.90826	0.14858
4:00	2.10400	0.3506667	0.79021	0.10238
4:30	2.24200	0.3736667	0.90216	0.11349
5:00	2.06300	0.3438333	0.74224	0.08114
5:30	1.68400	0.2806667	0.54782	0.12262

TABLE 40.--Oxygen uptake values (L/Min) for a three-minute thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.78300	1.1305000	7.77560	0.14658
0:30	11.07300	1.8455000	20.93609	0.31650
0:45	15.20400	2.5340000	39.04180	0.32089
1:00	17.78700	2.9645000	52.8955;	0.18218
1:15	17.43600	2.9060000	50.86540	0.19818
1:30	17.91300	2.9855000	54.49218	0.45009
1:45	19.89000	3.3150000	66.38470	0.29978
2:00	19.41400	3.2356667	63.11432	0.24376
2:15	17.73600	2.9560000	52.72310	0.24310
2:30	18.42200	3.0703333	57.65147	0.46686
3:00	19.89200	3.3153333	66.84908	0.42437
3:30	19.14700	2.1911667	61.94471	0.41072
0:15	15.26000	2.5433333	40.61959	0.60139
0:30	11.36100	1.8935000	22.34208	0.40744
0:45	9.15400	1.5256667	14.61812	0.36115
1:00	6.41300	1.0688333	7.01683	0.18022
1:15	4.78300	0.7971667	4.03828	0.21234
1:30	3.34400	0.5573333	2.09227	0.21380
1:45	3.14800	0.5246667	1.77959	0.15996
2:00	3.21700	0.5361667	1.85553	0.16167
2:30	2.61500	0.4358333	1.25667	0.15295
3:00	2.14500	0.3575000	0.80940	0.09226
3:30	2.32400	0.3873333	9.03627	0.08498
4:00	2.40200	0.4003333	1.00354	0.09159
4:30	2.35500	0.3925000	0.94651	0.06659
5:00	2.21000	0.3683333	0.84760	0.08196
5:30	1.85000	0.3083333	0.57733	0.03719

TABLE 40.--Oxygen uptake values (l. N/m) for a 3-hour 3-speed-minute [illegible]

Val.	Sum	Mean	[illegible]

TABLE 41.--Oxygen uptake values (L/Min) for a four-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.63300	1.1036667	7.95569	0.35978
0:30	9.82500	1.6375000	16.88306	0.39865
0:45	13.42400	2.2373333	31.71363	0.57960
1:00	16.98100	2.8301667	48.95245	0.42270
1:15	16.61100	2.7685000	46.94093	0.43666
1:30	18.97100	3.1618333	60.58609	0.34726
1:45	18.78000	3.1300000	59.41927	0.35717
2:00	19.33900	3.2231667	63.37456	0.45645
2:15	18.88800	3.1480000	60.63403	0.48469
2:30	18.02600	3.0043333	55.56203	0.53027
3:00	17.51300	2.9188333	52.86296	0.59084
3:30	19.57800	3.2630000	64.55317	0.36610
4:00	19.62400	3.2706667	65.06739	0.42044
0:15	16.13400	2.6890000	45.12018	0.58921
0:30	13.73300	2.2888333	32.95853	0.55245
0:45	9.78400	1.6306667	17.15398	0.48980
1:00	7.16500	1.1941667	8.85783	0.24561
1:15	6.58700	1.0978333	7.78768	0.33354
1:30	4.83300	0.8055000	4.27058	0.27481
1:45	4.31800	0.7196667	3.73021	0.35290
2:00	3.45200	0.5753333	2.04112	0.10495
2:30	3.01000	0.5016667	1.66868	0.17814
3:00	2.69700	0.4495000	1.26622	0.10384
3:30	2.68400	0.4473333	1.27483	0.12181
4:00	2.61400	0.4356667	1.16620	0.07398
4:30	2.28500	0.3808333	0.95017	0.12646
5:00	2.37900	0.3965000	0.96499	0.06590
5:30	1.74700	0.2911667	0.57059	0.11128

TABLE 42.--Oxygen uptake values (L/Min) for a four-minute thirty-second run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.96200	1.1603333	8.59040	0.32005
0:30	10.18000	1.6966667	21.05246	0.86953
0:45	13.58600	2.2643333	33.47178	0.73601
1:00	15.80700	2.6345000	42.97357	0.51576
1:15	17.04100	2.8401667	49.50849	0.47100
1:30	17.93300	2.9888333	55.32276	0.58720
1:45	20.15500	3.3591667	69.04056	0.51702
2:00	20.43000	3.4050000	71.86775	0.67876
2:15	19.87500	3.3125000	68.91945	0.78530
2:30	20.58900	3.4315000	72.95126	0.67825
3:00	17.46100	2.9101667	53.97447	0.79499
3:30	20.36600	3.3943333	73.10697	0.89196
4:00	20.32700	3.3878333	70.55852	0.58207
4:30	19.83600	3.3060000	67.35989	0.59701
0:15	17.22400	2.8706667	54.44806	1.00037
0:30	14.66000	2.4433333	40.07324	0.92239
0:45	9.62500	1.6041667	17.02512	0.56303
1:00	6.42700	1.0711667	7.72779	0.41071
1:15	5.32200	0.8870000	5.30217	0.34104
1:30	4.22300	0.7038333	3.65985	0.37083
1:45	3.86500	0.6441667	2.60979	0.15498
2:00	3.18200	0.5303333	1.82315	0.16470
2:30	2.64900	0.4415000	1.30011	0.16160
3:00	2.21900	0.3698333	0.92714	0.14593
3:30	2.86800	0.4780000	1.49411	0.15698
4:00	2.16200	0.3603333	0.81850	0.08884
4:30	2.22100	0.3701667	0.84315	0.06483
5:00	2.25300	0.3755000	0.88551	0.08889
5:30	1.77800	0.2963333	0.53995	0.05113

TABLE 43.--Oxygen uptake values (L/Min) for a five-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.82400	1.1373333	8.12537	0.26989
0:30	10.34200	1.7236667	17.93336	0.14642
0:45	14.41900	2.4031667	35.08428	0.29429
1:00	15.64800	2.6080000	41.17050	0.26852
1:15	16.83600	2.8060000	47.87025	0.35452
1:30	17.62700	2.9378333	52.39234	0.34847
1:45	17.75500	2.9591667	53.25207	0.37738
2:00	18.41300	3.0688333	57.02489	0.32201
2:15	17.88900	2.9815000	54.94585	0.56742
2:30	18.82900	3.1381667	59.90979	0.40528
3:00	17.99600	2.9993333	54.75029	0.39352
3:30	17.14400	2.8573333	50.81556	0.60489
4:00	19.10500	3.1841667	61.69773	0.41575
4:30	18.36500	3.0608333	57.00350	0.39782
5:00	18.74800	3.1246667	59.89094	0.51180
0:15	15.07600	2.5126667	39.25227	0.52370
0:30	12.13300	2.0221667	25.41304	0.41907
0:45	8.84800	1.4746667	14.29202	0.49883
1:00	6.86400	1.1440000	8.49751	0.35919
1:15	5.72400	0.9540000	5.85693	0.28151
1:30	4.32500	0.7208333	3.29246	0.18701
1:45	3.19000	0.5316667	1.90216	0.20305
2:00	3.00500	0.5008333	1.70036	0.19767
2:30	2.87000	0.4783333	1.49216	0.15449
3:00	2.91400	0.4856667	1.43935	0.96945
3:30	3.09200	0.5153333	1.83191	0.21840
4:00	2.62400	0.4373333	1.22578	0.12508
4:30	2.66600	0.4443333	1.31231	0.15982
5:00	2.66400	0.4440000	1.27921	0.13885
5:30	1.93100	0.3218333	0.65318	0.08966

TABLE 44.--Oxygen uptake values (L/Min) for a six-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.39400	1.0658333	6.93349	0.15329
0:30	10.14800	1.6913333	17.40000	0.21741
0:45	13.37400	2.2290000	30.80753	0.44652
1:00	16.05900	2.6765000	43.10705	0.15820
1:15	15.71500	2.6191667	42.91391	0.59223
1:30	17.04600	2.8410000	49.94119	0.55018
1:45	18.57500	3.0958333	57.83696	0.25763
2:00	19.15400	3.1923333	61.80307	0.36252
2:15	15.30800	2.5513333	41.49480	0.69843
2:30	18.25700	3.9428333	56.58666	0.45468
3:00	18.64200	3.1070000	58.11737	0.19833
3:30	19.75500	3.2925000	65.81944	0.39398
4:00	19.24400	3.2073333	63.28080	0.55837
4:30	19.38400	3.2306667	63.43517	0.40297
5:00	20.40800	3.4013333	70.28793	0.41797
6:00	18.16600	3.0276667	56.26385	0.50264
0:15	16.21000	2.7016667	44.92591	0.47579
0:30	12.99400	2.1656667	29.28172	0.47771
0:45	10.38700	1.7311667	18.68928	0.37620
1:00	7.02400	1.1706667	9.28269	0.46042
1:15	5.33400	0.8890000	5.22629	0.31124
1:30	4.57700	0.7628333	3.72382	0.21556
1:45	4.95500	0.8258333	4.76211	0.36609
2:00	3.58300	0.5971167	2.85006	0.37694
2:30	3.93900	0.6565000	2.86009	0.23415
3:00	2.99700	0.4995000	1.57474	0.12469
3:30	2.52400	0.4206667	1.11465	0.10285
4:00	2.47000	0.4116667	1.11538	0.14040
4:30	2.07600	0.3460000	0.85096	0.16289
5:00	2.19100	0.3651667	0.83841	0.08755
5:30	1.70100	0.2835000	0.55357	0.11944

TABLE 45.--Oxygen uptake values (L/Min) for a seven-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.63600	1.1060000	7.43836	0.14067
0:30	9.10500	1.5175000	14.22651	0.28624
0:45	14.87000	2.4783333	37.20593	0.26575
1:00	15.35600	2.5593333	41.79319	0.70598
1:15	15.82500	2.6375000	43.10532	0.52285
1:30	18.43500	3.0725000	56.82339	0.19071
1:45	18.17200	3.0286667	55.94613	0.42643
2:00	18.99600	3.1660000	60.81772	0.36780
2:15	16.25900	2.7098333	46.21251	0.65625
2:30	17.43900	2.9065000	52.89975	0.66533
3:00	19.34500	3.2241667	62.79244	0.29015
3:30	20.08500	3.3475000	67.72632	0.31362
4:00	18.02500	3.0041667	55.35018	0.48991
4:30	19.67100	3.2785000	64.85536	0.26981
5:00	20.89000	3.4816667	73.19218	0.30337
6:00	19.35800	3.2263333	63.00988	0.33302
7:00	23.49200	3.9153333	92.82905	0.41232
0:15	14.81500	2.4691667	37.40203	0.40530
0:30	13.42300	2.2371667	30.86893	0.40974
0:45	9.22600	1.5376667	15.85892	0.57834
1:00	7.71400	1.2856667	11.27346	0.52074
1:15	5.54900	0.9248333	5.55502	0.29090
1:30	4.45500	0.7425000	3.54371	0.21720
1:45	4.01000	0.6683333	3.92635	0.26319
2:00	4.05100	0.6751667	3.10016	0.27021
2:30	3.34000	0.5566667	1.90793	0.09866
3:00	2.57500	0.4291667	1.26017	0.17610
3:30	2.41000	0.4016667	1.04749	0.12608
4:00	2.48000	0.4133333	1.13151	0.14591
4:30	2.27400	0.3791667	0.89553	0.08115
5:00	2.26000	0.3766667	0.94225	0.13490
5:30	1.56300	0.2605000	0.49678	0.13388

TABLE 46.--Oxygen uptake values (L/Min) for an eight-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.49800	1.0830000	7.19407	0.17705
0:30	9.29600	1.5493333	15.13385	0.38243
0:45	13.88200	2.3136667	32.52983	0.28688
1:00	16.54700	2.7578333	45.94295	0.24863
1:15	18.97600	3.0126667	54.93875	0.31041
1:30	18.00800	3.0013333	54.79253	0.38588
1:45	18.53300	3.9888333	57.76513	0.32242
2:00	17.97600	2.9960000	54.90443	0.45570
2:15	16.88900	2.8148333	48.33608	0.39909
2:30	18.06000	3.0100000	55.37210	0.44978
3:00	18.09900	3.0165000	55.49122	0.42322
3:30	18.77400	3.1290000	59.72726	0.44349
4:00	19173800	3.2896667	65.95094	0.45155
4:30	18.99000	3.1650000	61.05285	0.43578
5:00	18.80700	3.1345000	60.16141	0.49211
6:00	21.09500	3.5158333	75.01973	0.41309
7:00	22.16700	3.6945000	83.94735	0.64053
8:00	18.87900	3.1465000	61.58573	0.66075
0:15	16.43000	2.7383333	46.68309	0.58177
0:30	14.50400	2.4173333	38.67229	0.84986
0:45	11.91100	1.9851667	25.20570	0.55864
1:00	7.35800	1.2263333	10.40480	0.52563
1:15	5.36300	0.8938333	5.35798	0.33596
1:30	4.30600	0.7176667	3.25000	0.17873
1:45	4.24100	0.7068333	3.17993	0.19092
2:00	3.97600	0.5126667	1.83957	0.22918
2:30	2.81800	0.4696667	1.51275	0.19454
3:30	3.27400	0.5456667	1.84909	0.11187
4:00	2.90200	0.4836667	1.55842	0.17596
4:30	2.48400	0.4140000	1.20775	0.18941
5:00	2.13800	0.3563333	0.91548	0.17529
5:30	2.03200	0.3386667	0.79627	0.14704

TABLE 47.--Oxygen uptake values (L/Min) for a nine-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.35500	1.0573333	6.85034	0.16889
0:30	10.41600	1.7360000	18.75075	0.36567
0:45	14.83100	2.4718333	37.09209	0.29405
1:00	17.22600	2.8710000	49.98496	0.32530
1:15	17.51700	2.9195000	51.64851	0.31876
1:30	19.55000	3.2583333	64.60908	0.42630
1:45	19.42800	3.2380000	63.47031	0.33539
2:00	20.15400	3.3590000	67.81257	0.15185
2:15	17.71700	2.9528333	52.63443	0.25262
2:30	18.43900	3.9731667	56.80071	0.16407
3:00	19.37100	3.2285000	64.69892	0.65721
3:30	21.45200	3.5753333	77.23087	0.32644
4:00	20.04100	3.3401667	67.05126	0.14899
4:30	19.69000	3.2816667	66.17928	0.56094
5:00	21.65000	3.6083333	79.37591	0.50110
6:00	20.53100	3.4218333	70.68911	0.29511
7:00	22.13900	3.6898333	83.28445	0.56484
8:00	21.96600	3.6610000	81.95145	0.55388
0:15	15.22000	2.5366667	39.51432	0.42573
0:30	12.96200	2.1603333	31.56381	0.84399
0:45	10.09300	1.6821667	19.18395	0.66421
1:00	9.67200	1.6120000	18.81088	0.80245
1:15	9.32900	1.5548333	17.50839	0.77503
1:30	5.59000	0.9316667	5.54625	0.26009
1:45	4.38100	0.7301667	3.48486	0.23916
2:00	3.59900	0.5998333	2.31171	0.17488
2:30	3.45200	0.5753333	2.10514	0.15433
3:00	3.38000	0.5633333	2.97318	0.18391
3:30	2.92600	0.4876667	1.62676	0.19992
4:00	2.78900	0.4648333	1.47241	0.18761
4:30	2.74800	0.4580000	1.37841	0.15480
5:00	2.62800	0.4380000	1.21215	0.11053
5:30	1.84100	0.3068333	0.67509	0.14846

TABLE 48.--Oxygen uptake values (L/Min) for a ten-minute run.

Var	Sum	Mean	Sum of Squares	Standard Deviation
0:15	6.41800	1.0696667	7.29259	0.25979
0:30	9.00500	1.5008333	14.21323	0.37369
0:45	13.87600	2.3126667	32.74742	0.36245
1:00	16.93600	2.8226667	48.19195	0.27830
1:15	18.15900	3.0265000	55.46723	0.31907
1:30	18.35200	3.0586667	57.09686	0.43914
1:45	18.65100	3.1085000	58.33965	0.26945
2:00	18.16900	3.0281667	57.65961	0.72675
2:15	17.71200	2.9520000	53.53936	0.50071
2:30	17.68800	2.9480000	53.42032	0.50519
3:00	19.38200	3.2303333	62.96255	0.26542
3:30	19.85000	3.3083333	66.17207	0.31675
4:00	19.22600	3.2043333	62.78572	0.48563
4:30	20.64800	3.4413333	62.45814	0.52943
5:00	21.94200	3.5070000	74.56983	0.39384
6:00	23.17700	3.8628333	94.69397	1.01637
7:00	22.46000	3.7433333	93.32242	1.35994
8:00	21.37400	3.5623333	77.10554	0.43914
9:00	20.63500	3.4391667	72.10159	0.47632
10:00	21.10300	3.5171667	66.02728	0.60075
0:15	16.51300	2.7521667	46.27642	0.40741
0:30	12.16600	2.0287778	26.82679	0.65699
0:45	10.08000	1.7800000	17.51088	0.33955
1:00	9.50700	1.5845000	16.60616	0.55539
1:15	6.15000	1.0250000	6.76146	0.30256
1:30	4.74500	0.7908333	4.28458	0.32621
1:45	4.42700	0.7378333	4.75849	0.54628
2:00	3.50900	0.5848333	2.10134	0.09916
2:30	3.13400	0.5223333	1.67938	0.09208
3:00	3.30400	0.5506667	1.87345	0.10397
3:30	2.70600	0.4510000	1.27996	0.10914
4:00	2.94500	0.4908333	1.64455	0.19952
4:30	2.74700	0.4578333	1.32289	0.11421
5:00	2.60200	0.4336667	1.20544	0.12413
5:30	2.13300	0.3555000	0.80387	0.09549