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A Cardiovascular Exercise Program for a Paraplegic Amputee

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A CARDIOVASCULAR EXERCISE PROGRAM

FOR A PARAPLEGIC AMPUTEE

(TITLE)

BY

ROGER D. WELLS

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
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A CARDIOVASCULAR EXERCISE PROGRAM FOR A PARAPLEGIC AMPUTEE

A Thesis

Presented to

the Faculty to the Graduate School

Eastern Illinois University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Roger D. Wells

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Abstract

A CARDIOVASCULAR EXERCISE PROGRAM

FOR A PARAPLEGIC AMPUTEE

The intent of the study was to establish a ten week cardiovascular exercise program for a paraplegic amputee and evaluate the effects through a selected battery of physiological tests and measurements. Included were body weight, skinfold thickness, reaction time, grip strength, static and dynamic lung volumes, heart rate, blood pressure, resting $\dot{V}_{O_2}$ and maximum $\dot{V}_{O_2}$. A careful training record was kept and the subject also made observations concerning his feelings about the training.

The subject, D.L.W. was a 37 year old male faculty member at Eastern Illinois University in Charleston, Illinois. He was given a complete physical examination and a stress test before the training program was initiated. Prior to the study, D.L.W. weighed 60 kilograms, was hypertensive and was very motivated to improve his fitness level.

The three day per week training program consisted of arm cranking using a modified bicycle ergometer. The subject was gradually conditioned until he could crank continuously for 15 minutes and a total of 30 minutes of interval work time. During nice weather, the subject would wheel himself in his wheelchair on a predesignated sidewalk course outdoors.

Formal training periods were held from February 28, 1980 to April 25, 1980. The tests were given prior to the start of the program, and every two weeks during the training program. All tests were administered in the Human Performance Laboratory at Eastern Illinois University.

The cardiovascular exercise program as performed in this study was helpful in reducing selected anthropometric measurements and systolic blood pressure. The cardiovascular fitness level improved as evidenced by the increased ability to do aerobic work for extended periods of time.

While it was difficult to assess psychological influences as a result of the physiological changes, the subject did appear to get increased enjoyment through rising early and being involved in the exercise program. Motivation levels were extremely high throughout the investigation. This high motivation seemed to hinder the subjects ability to work at maximal levels during certain testing periods.

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INTRODUCTION

The central nervous system is composed of the brain and spinal cord. Like a complex telephone network, the spinal cord carries the sensory impulses to the brain from both external and internal sensory receptors. The brain is where decisions are made regarding movement and neural impulses are transmitted to the proper muscles. As a result, when an accident or defect causes damage to the central nervous system, movement impulses may be modified or terminated. When impulses have been terminated, feeling and movement messages no longer may be transmitted past the affected area and the muscles would not be able to contract.

The degree to which an individual with spinal cord injury may be successful in accomplishing self sufficiency is determined by several factors including the degree of disability, financial resources, motivation, intelligence, self confidence, survival skills and realistic expectations. In general, lower transection levels cause less disability than those that occur at higher levels because of the smaller area of parases. Other factors that influence successful adjustment of the paraplegic such as psychological stability and the ability to interact socially are not easily observed.

Depending on the source of information, incidence and prevalence of spinal cord injury differ. Incidence rates have been reported from 26.6 to 50.6 spinal cord injuries per million per year. In 1970, it was estimated there were 125,000 to 300,000 paraplegics in the United States (7:469-473).

While incidence rates are gradually increasing, mortality rates for spinal cord injuries have dropped significantly (7:469-473). Prior to World War I, most spinal cord injuries resulted in death within one year. During World War II, antibiotics were available to help sustain life and new rehabilitation techniques were developed (14:51). Because of these advances, many paraplegics can now live a comparatively independent and normal life. The Department of Health Education and Welfare (7:469-473) reported that the mortality rate from spinal injury has dropped to a level that is very similar to that of the normal population, indicating dramatic changes since World War I.

Even though great progress has been made in keeping the paralyzed individual alive, new research must focus on his abilities to function within society. Paraplegia is an involved physical handicap and the individual is left with only two modes of ambulation, the wheelchair and walking straight leg braces. Both methods require more energy than normal walking, leaving the paraplegic with a low incentive to exercise because of his disability, which in turn can lead to a further reduction in physiological capabilities.

Statement of the Problem

The purpose of this study was to establish a cardiovascular exercise program for a paraplegic and to monitor his physiological and perceptual responses during the exercise program.

Limitations of the Study

This investigation was essentially a case study of one subject, therefore a generalization to a populace would not be applicable.

A friction bicycle ergometer was used to administer standardized work loads. Because of the many variables of speed, large differences between friction increments, and the increased resistance as belt temperature rose, extreme attention was maintained to keep error to a minimum while using this scientific instrument.

Definition of Terms

The following terms are defined as they were employed in this investigation:

Oxygen Consumption ($\dot{V}_{O_2}$)

The ability of the body to consume oxygen for bodily functions has been defined as oxygen consumption. This amount of oxygen is measured in liters per minute (L/min) and/or milliliters per kilogram of body weight per minute (ml/kg/min).

Blood Pressure

Systolic (SBP) and diastolic (DBP) blood pressures indicate, indirectly, the pressure inside the left ventricle during the contraction and relaxation phase of the cardiac cycle. Pressures were expressed in millimeters of mercury (mm Hg).

Vital Capacity (VC)

The maximum amount of air that can be expired following forceful inspirations is defined as vital capacity. This measurement was reported in liters (l).

Timed Vital Capacity (TVC)

The maximum amount of air that can be exhaled in one second following forceful inspirations is termed timed vital capacity, TVC was expressed as a percent of the vital capacity.

Maximum Breathing Capacity (MBC)

The measurement of respiratory muscle strength-endurance and lung surface area is defined as maximum breathing capacity. This maximum amount of air that can be moved by the lungs in 12 seconds is used to predict maximum pulmonary ventilation. MBC was expressed in liters per minute (l/min).

Pulmonary Ventilation ($\dot{V}_E$)

The amount of air that passes through the lungs during a given period of time is termed pulmonary ventilation. The V_E was expressed in liters per minute (l/min).

Reaction Time

Reaction Time is the amount of time that elapsed from the presentation of a stimulus until an initial movement is detected. The reaction time was measured to the nearest 0.01 of a second.

Skinfold Thickness

The thickness of a fold of skin and the underlying subcutaneous fat measured in millimeters (mm) defines skinfold thickness. This measurement was taken with a Lange Skinfold Caliper.

Chapter 2

REVIEW OF RELATED LITERATURE

Since the subject in this investigation was both a paraplegic and a sedentary adult male, the review of related literature concerns itself with these topics and related exercise considerations.

The Paraplegic

Even though research technology has improved significantly during the last few decades, there are few publications concerning the cardiovascular conditioning of paraplegic persons. Zwiren (21:94) stated that prior to 1975, only one study had been published specifically dealing with training the physically handicapped. However, it is generally accepted that many special considerations must be observed when initiating such a program. These considerations include the fitness level, heart rate, blood pressure, circulation, and blood volume.

Fitness Level

Nilsson (14:51) claimed that the paraplegic individual who becomes confined to a wheelchair after an injury will not be involved in sufficient amounts of exercise to prevent atrophy of the arms and trunk. In a study by Stolby (19:223) it was found that free wheelchair driving only increases the heart rate up to 97 beats per minute. For these reasons, paraplegics must continue to train for both cardiovascular fitness and muscle endurance to prevent deconditioning.

Heart Rate

The level of transection of the spinal cord indicates different levels of physical capabilities. Knutson (11:212) stated that a complete transection above the fourth thoracic vertebrae (Th 4) will result in loss of the sympathetic influence upon the heart. He indicated that if this occurs, the heart will not exceed a rate above 100 to 110 beats per minute. Levels of transection below this point may not effect the heart rate, but the amount of conditioning will be limited because of the inability to obtain sufficient stress on circulation due to motor pareses.

Blood Pressure

Pollock (15:421) found that the average blood pressure in eight handicapped subjects with a mean age of 38 years was 138/89 mm Hg compared to 11 sedentary adults of comparable age that had a blood pressure of 122/85 mm Hg. These findings reveal significant difference in the blood pressure of sedentary adults and paraplegics of comparable ages.

Circulation

Hjeltnes (10:111) indicated that the reason for the hypokinetic circulation associated with paraplegia is the loss of vasomotor regulation below the injury level, causing mean circulation pressure to diminish. The lower level of circulation pressure influences a low venous return to the heart resulting in a high heart rate and low stroke volume. During exercise, however, Hjeltnes found a low oxygen content in the venous blood indicating little mixing of the rich oxygenated blood from the paralyzed portion of the body with the deoxygenated blood from the arms.

Blood Volume

Another problem area associated with circulation is the total blood volume. During exercise a circulatory stress is created because the muscles being used need the oxygen the blood is carrying. The conflict arises when exercise is intense and the blood is not available in sufficient amounts. Knutson (11:214) postulated that vascular adaptation obtained with time and training is not dependent upon increases in blood volume. In addition, he suggests that even though blood volume is low in the paraplegic, the increased ability to do work as the result of training is dependent upon vaso-constriction in the unused areas of the body. The effective-ness of this splanic control is lost if transections of the spinal cord are above the Th 4 level. The low physical work capacity of paraplegic individuals with high transection levels is partially due to the inability to control the blood flow.

Clarke (3:427-435) indicated that the physical fitness level of most paraplegics was lower than normal sedentary persons. He stated that lower cardiovascular fitness, higher body weight, greater percent of body fat and lower metabolic rates were characteristics associated with the paraplegic. The etiology of these conditions was associated with the special considerations mentioned previously.

The Sedentary Adult and Exercise

Since very little research was found concerning the paraplegic and exercise, it was felt that a portion of this review of related literature should deal with the immediate and long range adjustments that have been documented for sedentary adults. One may assume that many of the exercise adaptations would also be found for the paraplegic.

Body Weight and Percent of Body Fat

Many persons exercise in an attempt to lose weight. The initial weight loss is usually caused by a decrease in body fluids with long range losses attributed to reduced body fat content. Pollock (15:423) claimed that the frequency, duration, and intensity of the exercise routine were the major factors contributing to the degree of body weight or fat loss.

In a study conducted with blind subjects by Siegel (18:27), total body weight did not change in a group of 46 year old men following a program of six minute submaximal workouts three days a week for 15 weeks. In another group of men, it was found that endurance training four days per week significantly decreased body fat and body weight.

Pollock (16:195) reported that arm ergometry training two times per week at 85 percent of maximal heart rate had no significant effect on the body composition of 19 sedentary men and paraplegics. In a follow up study published three years later it was stated that the percent of body fat could be reduced if exercise bouts were performed from three to five days per week and each bout contained an energy expenditure of 300 to 500 kilocalories (15:423).

The loss in total body weight over a given length of time was from the diminishing stores of body fat. Wilson (20:444-450) claimed that the long range body fat losses occurred when the energy output during training was greater than the energy input from food over the same period of time.

Blood Pressure

According to Mathews (13:292), blood pressure can be reduced by continuous steady state exercise. These reductions were reported to be found at rest and during exercise, particularly in older men and women.

However, Pollock (15:420) did not find any significant changes in blood pressure following a 20 week exercise program with sedentary adults and paraplegic subjects using arm ergometry as a training device. This discrepancy may be due to the lack of systemic vaso-motor control in the paralyzed area as mentioned earlier. No other blood pressure studies could be located, therefore no clear hypothesis can be formulated relative to the effect of exercise on the blood pressure of a paraplegic.

Lung Volumes

According to Hjeltnes (10:109), vital capacity and timed vital capacity remained relatively unimproved in most paraplegics despite physical training. Improvement was found only in high level transections which caused other physical problems as well.

Zwiren (21:96), in a study using normal sedentary subjects and wheelchair athletes, found that normal athletes were the only group to have significantly larger vital capacities. No significant differences were found between groups in timed vital capacity or maximal breathing capacity. These studies indicated that lung volumes can be used as an accurate measure of both dynamic and static capacities.

Pollock (17:470) found that in 14 sedentary men between the ages of 30 to 40 years, there were no significant changes in vital capacity when they trained three days per week for 20 weeks.

Cardiorespiratory Changes

According to Consolazio (5) and Cureton (6), heart rate, pulmonary ventilation and oxygen consumption at rest and during exercise are indicators of mans cardiorespiratory fitness.

Heart Rate. Many conflicting findings have been reported concerning the maximal heart rate attainable when using arm cranking. Pollock's (17:471) study of 14 sedentary men from 30 to 40 years of age found a mean maximum heart rate of 195 beats per minute. Following a 20 week conditioning program, the mean maximum heart rate was reported to be 187 beats per minute.

Nilsson (14:55) found that after seven weeks of training involving 12 rehabilitated paraplegic subjects with a mean age of 36 years, maximal heart rates dropped from two to 15 beats per minute during maximal exercise.

Grimby (9:6), however, found the maximal heart rate to be unchanged following a six week training program. Siegel (18:27), using a 15 week exercise program found no significant difference in heart rates of men 32 to 59 years old. Grimby (9:6) found no significant drop in heart rate during maximal exercise although along with Siegel (18:26) he did find a significant drop in heart rate during submaximal work loads.

According to Nilsson (14:55), heart rates can be assumed to be near normal for the paraplegic if the spinal lesion is below the fourth thoracic vertebrae (Th 4). Åstrand (1:530) and Nilsson (14:55) concluded that heart rates during arm ergometry in paraplegics were higher than normal subjects using treadmill ergometry.

Oxygen Consumption ($\dot{V}_{O_2}$) and Pulmonary Ventilation ($\dot{V}_E$). The body's ability to consume oxygen was reported by Hjeltness (10:110) to be uneffected by paraplegia. He found the average oxygen consumption of 0.95 l/m at 40 watts of work per minute using arm ergometry, the same as the $\dot{V}_{O_2}$ found in other studies with healthy young males and paraplegics. Pollock (17:471), using maximal work loads, found paraplegics to be approximately 17 percent below their normal sedentary male counter parts in maximal oxygen consumption tests ($\dot{V}_{O_2}$ max).

In either maximal or submaximal situations, oxygen consumption and pulmonary ventilation can be increased with training. Siegel (18:28) reported increases in $\dot{V}_{O_2}$ max up to 7 ml/kg/min in arm ergometry. This increase from 1.63 to 1.73 l/min was found following a 15 week interval training routine. Pollock (17:469) found increases in $\dot{V}_{O_2}$ max of 7.3 ml/kg/min and $\dot{V}_E$ of 13 ml/kg/min following a 20 week training period for eight disabled men. In his follow up study he found increases of 0.35 l/min $\dot{V}_{O_2}$ max and 21.3 l/min $\dot{V}_E$ max after a 26 week running program using sedentary adults.

Up to 12 percent increases in $\dot{V}_{O_2}$ max and $\dot{V}_E$ max were reported by Nilsson (14:56) and Grimby (9:6). These improvements in cardiorespiratory components represent an increase in the body's ability to do more work in a given period of time which indicates a higher level of physical fitness.

Summary

The effects of exercise programs on the paraplegic are not well documented. The percent body fat can be lowered with adequate exercise but blood pressures may not fall, especially when using arm cranking as an exercise routine. Lung volumes are not affected by transection levels below Th 4, which gives one an excellent opportunity for measurement and predictive tests. Maximal heart rates do not always drop following training regimes but $\dot{V}O_2$ max and $\dot{V}_E$ max will significantly increase following most stressful and long range aerobic training programs.

Chapter 3

PROCEDURE

The purpose of this study was to develop a cardiovascular exercise program and monitor its effects on a paraplegic subject. Anthropometric, physiological and perceptual parameters were investigated prior to and every two weeks during the 10 week study. The training program consisted of three exercise bouts per week.

The Subject

The subject (D.L.W.) was a 37 year old male employed at Eatern Illinois University in Charleston, Illinois during the spring of 1980.

Background Information

The subject had a complete transection of the spinal cord near the Th 4 level. This resulted in loss of both afferent and efferent control of his body below the mid chest region. Other limitations that caused him physical disability included amputation of both legs at the hip, severe lordosis and scoliosis of the spinal column, partial neurological loss of the extensor muscles of the right hand and elevated blood pressure. An autobiography may be found in Appendix A.

Motivation

This investigation began as the result of the subjects awareness of a decreased ability to perform physical work. Being employed and self sufficient, he noticed increasing physical difficulty in wheelchair locomotion and in the completion of daily living tasks. He requested guidance from the Physical Education Department at Eastern Illinois University.

Training Program

According to Knutson (11:214), the paraplegic needs to be thoroughly evaluated before attempting to subject himself to above normal stress situations. Therefore, a thorough physical screening was performed by Dr. Stanley Huffman along with a resting and a progressive stress test using arm ergometry as the means of work. As a result of the examination, the subject was found to have elevated blood pressure and was directed to take Hydralazine (25 mg bid) and Hydrochorothiazide (50 mg od) to decrease peripheral resistance and as a diuretic. Training did not begin for two weeks after the examination to allow the medication to stabilize D.L.W.'s system and then heart rate and blood pressure were monitored closely to avoid any unnecessary risk.

The program consisted of 10 weeks of arm ergometry exercise with some modification during the last three weeks. The sessions began at approximately 8:00 A.M. three days a week and were held in the Eastern Illinois University Human Performance Laboratory. The subject would either drive his car from home or propel his wheelchair across campus to reach the facility. After a short rest period, blood pressures and heart rates were recorded after he had removed his shirt and was prepared to start the training period. Since a commercially manufactured arm ergometer was not available, a Monarch Bicycle Ergometer was modified for use as an arm cranking apparatus. The seat of the bike was removed and the front leg supports were placed on a 28 inch table that was held stationary. The rear bike supports were placed on the front portion of the wheelchair seat. D.L.W. then wheeled his chair forward stabilizing the rear support during heavy work loads.

When the bike was placed in position, the center axis of the crank was approximately four centimeters below the center axis of the shoulder and the arc formed by each revolution of the pedals did not allow the arm to reach full extension.

The exercise program consisted of arm cranking at various work loads and time periods. These training sessions were of an interval type containing four or five bouts of exercise. After each bout of exercise the blood pressures were determined with a sphygmomanometer and a stethoscope and recorded as quickly as possible. The recovery heart rates were determined with a stethoscope, counting the number of heart beats in six seconds and multiplying by ten to convert to beats per minute.

Modifications

Initial ergometer training sessions consisted of four bouts of exercise, one to four minutes in duration with a resistance up to 1.5 kilopound meters (kpm) per minute at 50 to 70 revolutions per minute. After two weeks of training it was determined that 1.5 kpm's was causing soreness in the shoulder and forearm. Since D.L.W. felt that working at a zero resistance was a waste of time, a constant resistance of 1.0 kpm was established along with a constant cranking speed of 60 revolutions per minute. The time of each work interval was increased as the fitness level improved.

During the last three weeks of the program, a one-half mile outdoor wheelchair route was established, (see Appendix B) allowing D.L.W. to make practical application of his improved cardiovascular fitness level.

Tests and Measurements

The training program was 10 weeks in duration and included three training sessions per week. Tests were administered on the initial Monday and every two weeks throughout the training period. A total of 11 tests were taken during each testing period. The items included bodyweight, skinfold thicknesses, reaction time, grip strengths, lung volumes, heart rates, blood pressures, resting pulmonary ventilations, resting oxygen consumptions, maximum pulmonary ventilations, and maximum oxygen consumptions.

To insure valid and reliable results, each test was administered in a constant and carefully planned order (see Appendix C). The tests below have not been placed in the testing order to reduce complexity in reporting test procedures and techniques.

Body Weight

The subject was weighed to the nearest one-half pound on a Healthometer scale. The reading was converted to kilograms, dividing the weight by 2.2. D.L.W. was weighed with his shirt, glasses and watch removed.

Skinfold Thickness

The skinfold thickness measurements were taken over five sites using a Lange Skinfold Caliper and techniques outlined by Consolazio (5:24). In order to keep the measurements as accurate and reliable as possible, the Director of the Human Performance Laboratory at Eastern Illinois University administered the test on all testing days.

All sites were on the right side of D.L.W.'s body. These sites included the cheek area between the zygomatic arch and the middle one-third of the mandible using a vertical fold, the area directly under the chin and anterior to the hyoid bone using a vertical fold, the chest area between the nipple and armpit over the pectoralis major using a diagonal fold, the back over an area distal to the inferior angle of the scapula using a vertical fold, and the tricep area over the middle one-third of the posterior aspect of the arm with the elbow bent at 90 degrees using a vertical fold.

The maximum skinfold thickness measurement was made by pinching a fold of skin firmly between the investigators thumb and index finger. The skinfold calipers trapped the fold of skin and subcutaneous fat. After the jaws of the caliper ceased to move, the measurement was recorded. At no time during the procedure did the investigator release the skinfold from his grip.

Reaction Time

The thumb reaction time of the subject was measured by a Dekan Athletic Performance Analyzer, Model 621 capable of measuring times to the nearest 0.01 seconds. D.L.W. was seated in a comfortable position with the stop button in his left hand. He was instructed to press the button as soon as he heard the buzzer. To keep the subject from anticipating the sound stimulus, the investigator would vary the amount of time between the "ready" command and the actual sound of the buzzer.

The subject was given one practice trial followed by six trials in succession, the results of which were recorded. The command of "ready" was used to prepare D.L.W. for each trial.

Grip Strength

Grip strength was determined by the use of an Ann Arbor Instrument Works Hand Dynomometer. The subject would squeeze an adjustable grip handle and the amount of pressure was then recorded to the nearest pound of force.

The test was administered by resetting the dial to zero and instructing D.L.W. to squeeze the instrument at a progressive rate without jerking or thrusting. Three trials were given for each hand, with the best score recorded. A one minute minimum rest period was used between each grip strength trial.

Lung Volumes

A Collins 13.5 Liter Respirometer was used to measure vital capacity (VC), timed vital capacity (TVC), and maximum breathing capacity (MBC). The respirometer was checked prior to each testing day for proper balance, water level, bell position, adequate kymograph paper, functional ink pens, and removal of the sadd valves and soda lime canister.

Vital Capacity. The subject was positioned in front of the respirometer while the test was explained to him. D.L.W. was infomed that the investigator was measuring the maximum amount of air he could expire following forced inspirations. A nose clip was positioned so as not to allow air to pass through the nostrils. Then a rubber mouth piece, attached to a hose from the respirometer was inserted into his mouth. At the same time the mouth piece was inserted, the kymograph motor speed was turned to 32 millimeters per minute (mm/min) as the subject was instructed to breathe in and out three times. On the third inspiration D.L.W. was instructed to inspire as much air as he could and then blow out or expire all the air possible from his lungs. The kymograph was turned to 160 mm/min during the third inspiration to allow easier and more accurate readings of the results. Three trials were given and the best score was recorded and standardized to Body Temperature Pressure Saturated (B.T.P.S.).

Timed Vital Capcity (TVC). The investigator explained to the subject that vital capacity was a dynamic lung volume test that measured the volume of air that could be expired from the lungs in one second following forced inspirations. As in testing vital capacity, the subject was seated in front of the respirometer and the nose clips and mouthpiece were properly positioned. The kymograph was turned to 160 mm/min as the subject was instructed to breathe in and out three times. On the third inspiration he was to take in as much air as possible. At the same time the kymograph speed was increased to 1920 mm/min. As soon as the subject had inspired as deeply as possible, he was instructed to expire all of the air as fast as possible. The best of the three trials was standardized to B.T.P.S. and used for calculation of timed vital capacity. A percentage of the vital capacity was found by dividing TVC by VC and multiplying by 100.

Maximum Breathing Capacity (MBC). As in the previous tests, an explanation of the measurement was given to help D.L.W. understand the purpose of the test. MBC was defined to him as the maximum amount of air that can be moved by the lungs in a 12 second period.

D.L.W. was positioned in front of the respirometer as in the previous tests. The ink pen was inserted into the ventilgraph pen holder and properly positioned on the drum of the kymograph. The nose clips and mouth piece were inserted and D.L.W. was instructed to breathe in and out as fast and deeply as he could for 12 seconds. The commands of "set" and "go" were used to prepare the subject and start the test at the proper time. On the command of "go" the kymograph was turned on at a speed of 160 mm/min. At the end of the 12 seconds the subject was instructed to stop and the kymograph was turned off at the same time. Three trials were given with a minimum of two minutes of rest given between each trial. The best of the three trials was standardized to B.T.P.S. and used for calculation purposes.

Blood Pressure

Blood pressure measurements were taken prior to the max $\dot{V}_{O_2}$ test at rest periods during the test and at five and 10 minutes following the test.

The measurements were taken with a Baumanometer Sphygmomanometer and a Riegor Bowles Stethoscope. The subject was seated with the arm slightly flexed and abducted with the forearm supinated. The forearm was positioned at approximately 150° to the humerus. The cuff was placed around the right upper arm with the lower edge of the cuff three centimeters above the antecebital space. The stethoscope was placed firmly over the artery in the antecebital space and the cuff pressure was quickly elevated to approximately 180 mm Hg at rest and 210 mm Hg immediately post exercise. At this point it was decreased slowly until the first heart beat was heard. This reading was recorded as the systolic blood pressure. Deflation of the cuff continued until the heart beat could no longer be heard. At this point the diastolic pressure was recorded.

Heart Rate

The heart rate was monitored max $\dot{V}_{O_2}$ using a Sanborn Model 500 VisoCardiette with chest leads at $\dot{V}_5$ and $\dot{V}_{5R}$. Procedures used in the preparation of electrode placement were the same as those used by Kobayshi (12:25) and Conroy (4:29). The skin was shaved on the chest for the initial testing day but not deamed necessary thereafter. A cotton-ball saturated with alcohol was briskly rubbed over the electrode site until the skin appeared red in color. The alcohol was then allowed to dry. Electrode jelly was placed on the contact screen of the electrodes and then the electrode was secured to the prepared area of the skin. A patient cable was attached to the electrodes and secured to the E.C.G. machine. All wires were secured to avoid any interference during arm cranking.

A five second sample heart rate was taken one minute prior to the max $\dot{V}_{O_2}$ test, and at the end of each minute of the test. In addition, heart rates were taken during each minute of recovery for 10 minutes. A heart rate ruler was used to determine the heart rate after each sample by measuring the distance between the "R" waves.

Oxygen Consumption ($\dot{V}_{O2}$) at Rest

The testing started after the subject sat quietly for 10 minutes in a comfortable position. He was usually encouraged to read an informative article that contained a noncontroversial topic. A 600 liter chain compensated tissot tank manufactured by the Collins Company was used to collect an expired air sample. Water level, proper balance, bell position, and other maintenance procedures were performed the day before testing. A flexible plastic hose was attached to the intake valve and an Otis-McKarrow Valve was attached to the other end. Attached to this open circuit was a rubber mouth piece that was inserted into D.L.W.'s mouth during testing. An initial meter stick reading (V_1) was recorded prior to the start of the test.

The subject was positioned in front of the intake valve with the Otis-McKarrow Valve suspended at head level to allow D.L.W. to sit and hold the mouthpiece in his mouth without the use of his hands. Once the nose clip and mouthpiece were in place the intake valve was opened. A Heur stop watch was used to time the 10 minute sample period. After 10 minutes, the intake valve was closed and a second meter stick reading was recorded ($\dot{V}_2$). The gas destratification fan was activated for one minute to mix the air inside the tank. The sample valve was opened and the hose flushed with expired air by compressing the bell of the tank. A metalized bag was attached to the sampling stop cock and a gas sample was acquired. This expired air sample was then analyzed by use of a Beckman Model E-2 Oxygen Analyzer and a Beckman LB-1 Medical Gas Analyzer to determine carbon dioxide content. The sample was corrected to Standard Temperature Pressure Dry (S.T.P.D.) and recorded as the resting $\dot{V}_{O_2}$.

Maximum Oxygen Consumption

Maximal $\dot{V}_{O_2}$ was recorded during the last 30 seconds of a graded interval arm cranking ergometer exercise. The subject sat in his normal exercise position and the equipment was placed in a manner that would not obstruct D.L.W.'s arm cranking. To his left was a Parkinson-Cowan CD-4 meter and the E.C.G. unit. In front of him was the Monarch Bicycle Ergometer, the Gray Lab Universal Time Clock and a metronome. To his right was the plexiglass mixing chamber, the Yellow Springs Instrument Company Telethermometer with an atmospheric lead placed inside the mixing chamber and the metalized sample bags. A flexible plastic hose was connected to the CD-4 meter at one end and the inlet side of the Jack Daniels Valve at the other. The expired air passed through the valve and another plastic hose that was connected to the plexiglass mixing area. This formed a one way open circuit with air flowing from the CD-4 meter to D.L.W.'s mouth and then into the mixing chamber.

The subject would start the test by cranking at a rate of 60 revolutions per minute (rpm) with a one-half kilo-pound meter load for three minutes. Cranking speed was kept constant by use of the metronome. At two minutes and 15 seconds into the bout, the nose clips were put into place and the mouth piece connected to the Jack Daniels Valve was inserted. From 2:15 until 2:30 the system was flushed. Having already determined an initial volume recording (V_1) on the CD-4 meter, a 30 second $\dot{V}_E$ sample was begun at 2:30 and an expired air sample was taken from the mixing chamber by means of a vacuum pump into an evacuated metalized bag. At 3:00 the CD-4 meter was read again and the cranking was stopped for one minute. The temperature of the air sample was taken by means of the thermometer, immediately after an adequate sample of air was obtained. After one minute of rest, the cranking was again started at a higher work load and procedures duplicated until the subject could continue no longer. An outline of the test can be found in Appendix D.

$\dot{V}_E$ for each sample was found by subtracting the initial CD-4 reading from the final reading and then standard-izing the value of S.T.P.D. from a nomogram using the air temperature in the mixing chamber and the barometric pressure.

Maximum $\dot{V}O_2$ was determined following the methods described earlier and multiplied by the "true O_2". The greatest calculated $\dot{V}_E$ and $\dot{V}O_2$ samples taken were used as the maximum volumes.

Perceptions of the Subject

The subject was requested to develop written observations of any pertinent feelings of pain, depression, and etc., that he felt were related to the exercise training program. These notes were compiled and are included in Appendix E. A list of summarizing comments after the termination of study were collected and are contained in Appendix F.

Chapter 4

ANALYSIS OF THE DATA

This case study was involved with the development and monitoring of an exercise program for a paraplegic amputee. A total of 30 exercise sessions were held during the 10 week program. Responses to the program were measured by a selected battery of tests given prior to the start of the training program and every two weeks throughout the training period. The findings of the six testing periods are presented and discussed. In addition, a section has been included to present some observations concerning the training program.

Discussion of the Findings

Body Weight

The body weight of D.L.W. did not change substantially during the 10 week training period. The initial weight of 61.38 kilograms (kg) was reduced to 59.77 kg or approximately 2.6 percent (%) during the first six weeks of training. The final four weeks showed a slight increase of weight (0.5 kg).

According to Mathews (13.291) a slight decrease or constant body weight is expected during an aerobic exercise program. Siegel (18.26) found no reduction in total body weight following three day per week work outs for 15 weeks in sedentary adults.

D.L.W. was considered to be well within the boundries of these guidelines with little or no loss in body weight at the end of the training program. Figure 1 shows the results of body weight throughout the study.

Skinfolds

The five skinfold sites consisting of the cheek, chin, pectoralis, subscapular, and tricep areas were totaled and charted on Figure 2. The results after the termination of the training program showed a 13% decrease in the total skinfold thickness. This drop was especially evident in the last four weeks of training. The chest area showed the largest decrease in skinfold thickness from 40 to 27 millimeters. Other areas remained approximately the same or slightly lower than the initial measurements.

Pollock (15:423) reported that body fat could be reduced if exercise bouts were performed three to five times per week and each contained an energy expenditure of 300 to 500 kilocalories (kcal). Wilson (20:444-450) stated that when energy expenditure exceeds energy intake, body fat is reduced.

The total kcal expenditure estimated for each training period in Figure 3 shows D.L.W. approaching the 300 kcal minimum. (Calculations may be found in Appendix G for the development of this graph.) Subcutaneous fat was reduced in

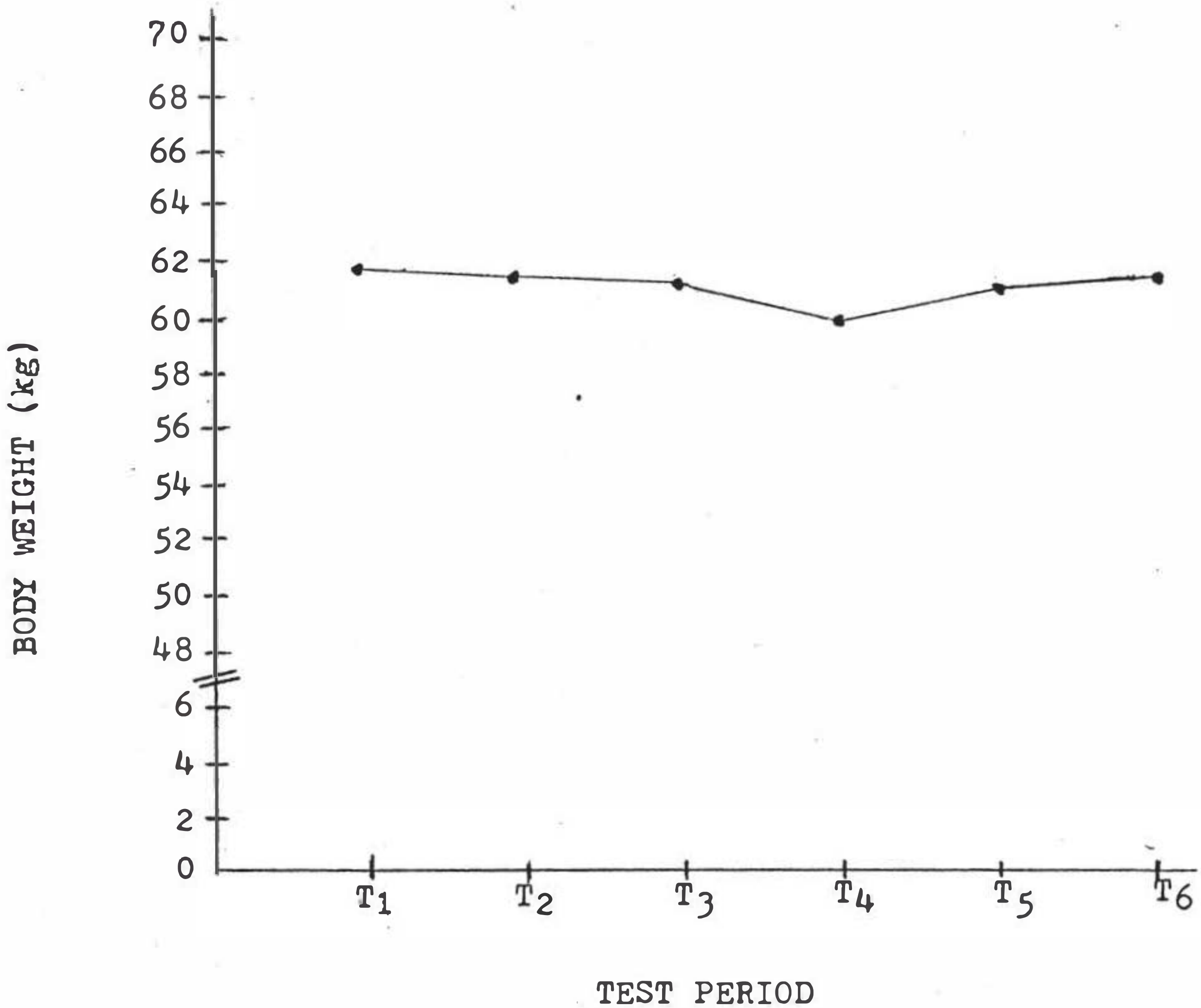


Figure 1

Body Weight

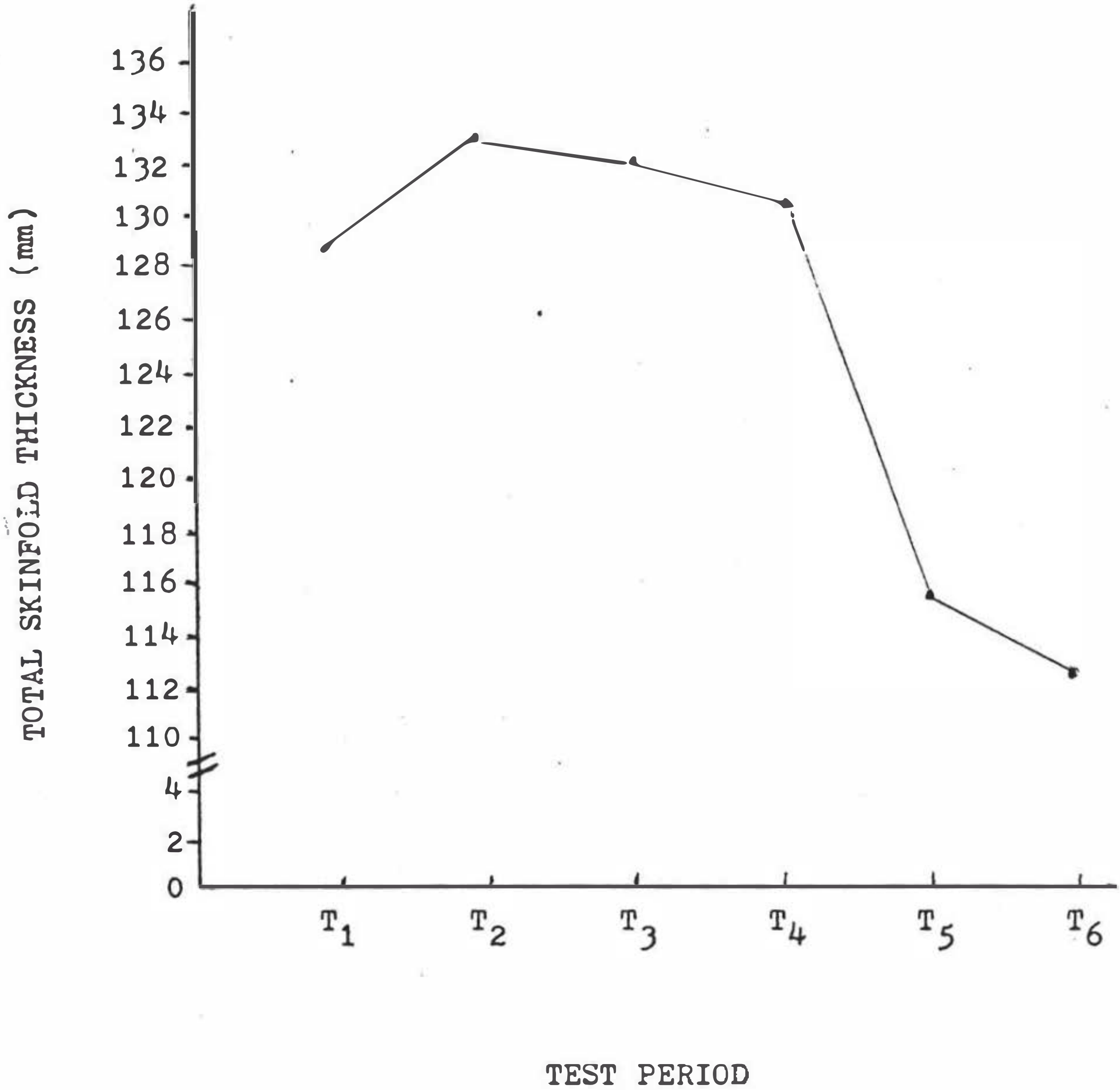


Figure 2

Total Skinfold Thickness

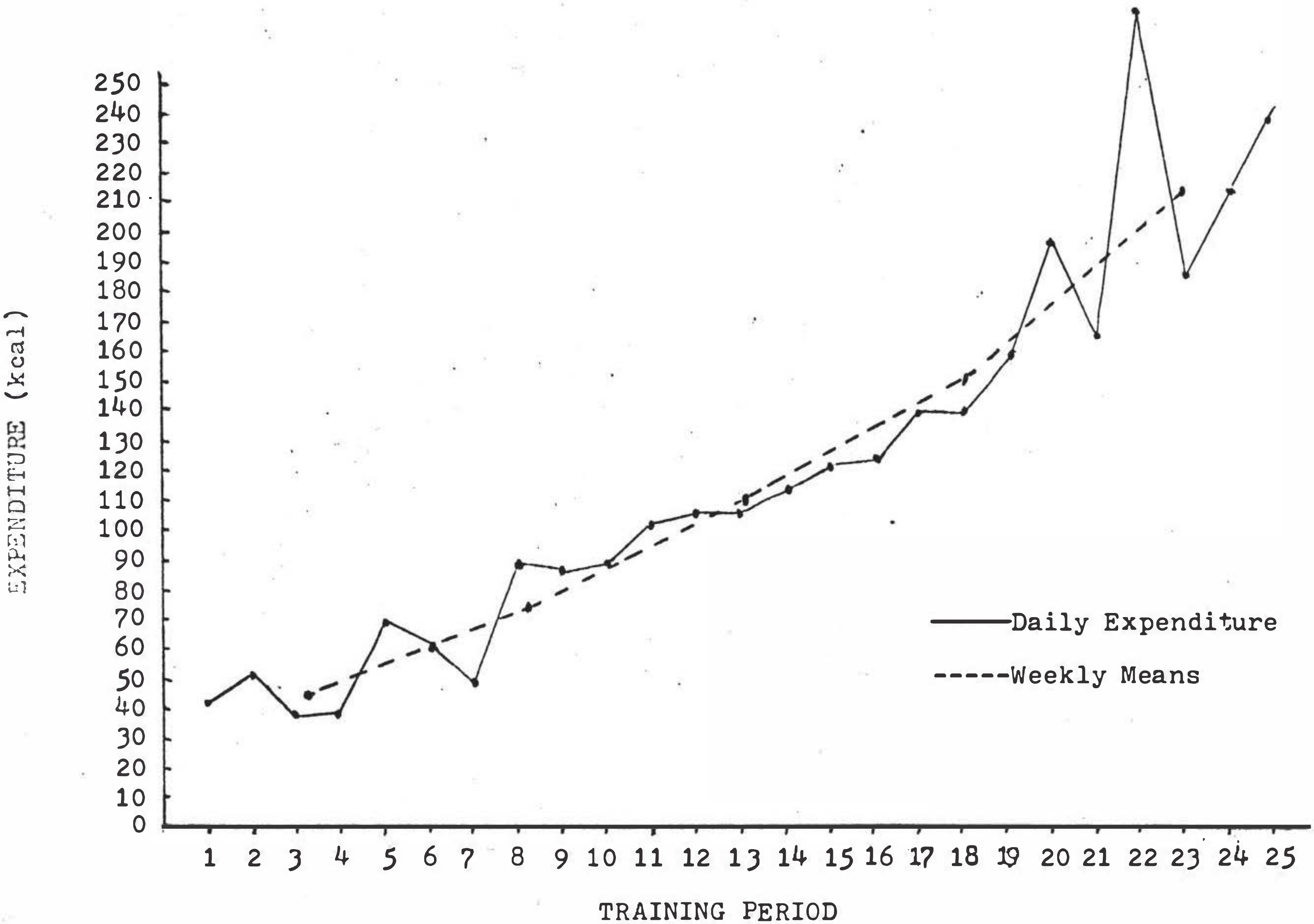


Figure 3

Caloric Expenditure

the selected sites and especially the chest area of the subject.

Grip Strength

The grip strength of D.L.W.'s left hand did not change more than 7.8% which was not regarded as a major increase. The right extremity showed a reduction in strength from 41 pounds to 26 pounds when measured on the hand dynomometer. This decrease represents a loss of 36.5%. The training program did not include strength development, it was thought that wheeling outdoors might help increase strength. A determination could not be made whether the added exercise caused further impairment of the effected limb or if other factors unknown to the investigator and subject were responsible for this decrease in strength. See Figure 4 for the exact test by test results.

Reaction Time

The subjects reaction time was very consistent during all testing periods excluding the first and last test. The first could be regarded as a learning experience even though five trials were allowed for learning purposes prior to the test. No sound explanation was available for the slower reaction time during the final test. The investigator did feel, however, that D.L.W. was not concerned with this particular measurement during the final testing day which may have contributed to his slower time. Figure 5 illustrates the six periods graphically.

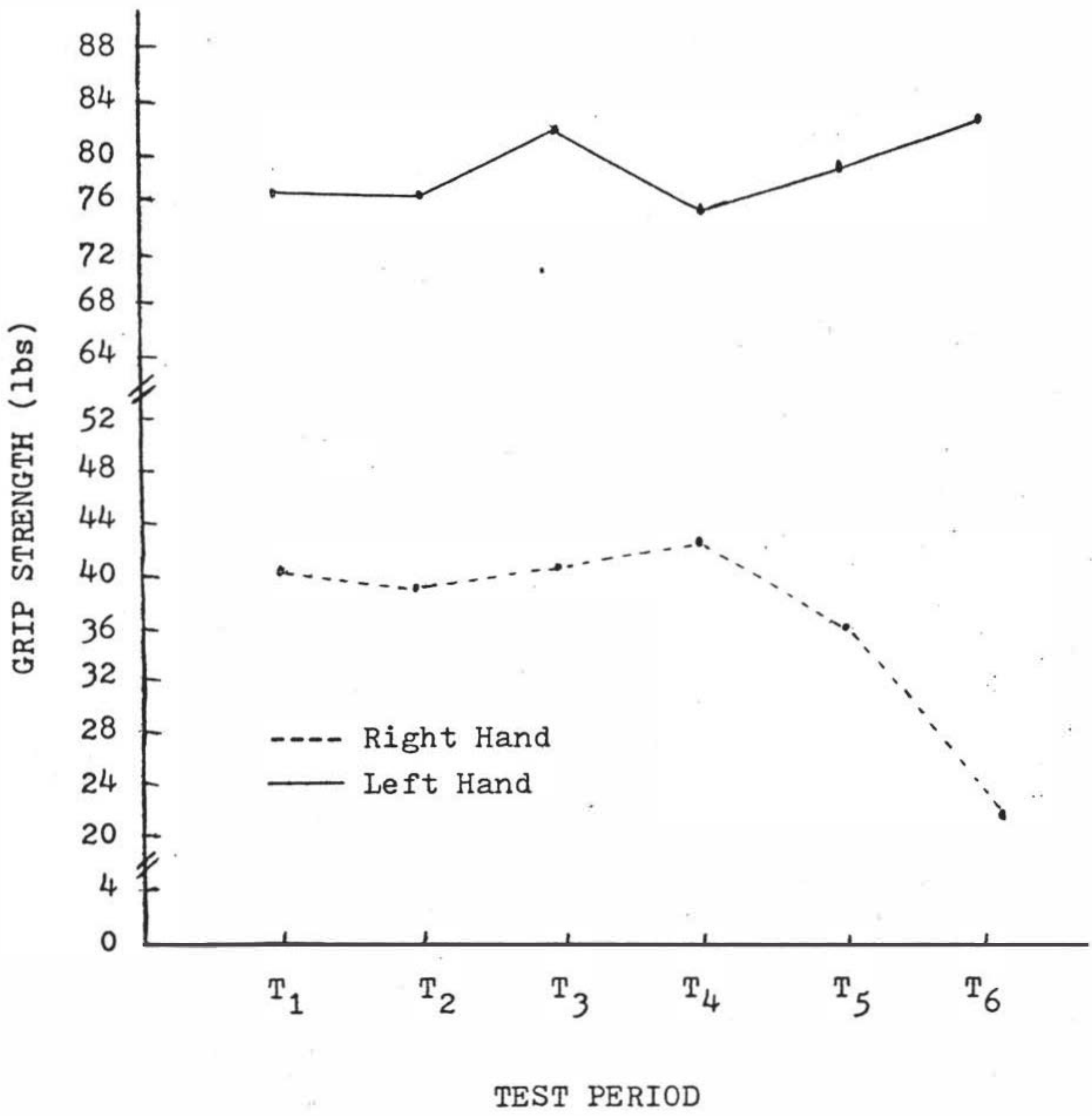


Figure 4

Grip Strength

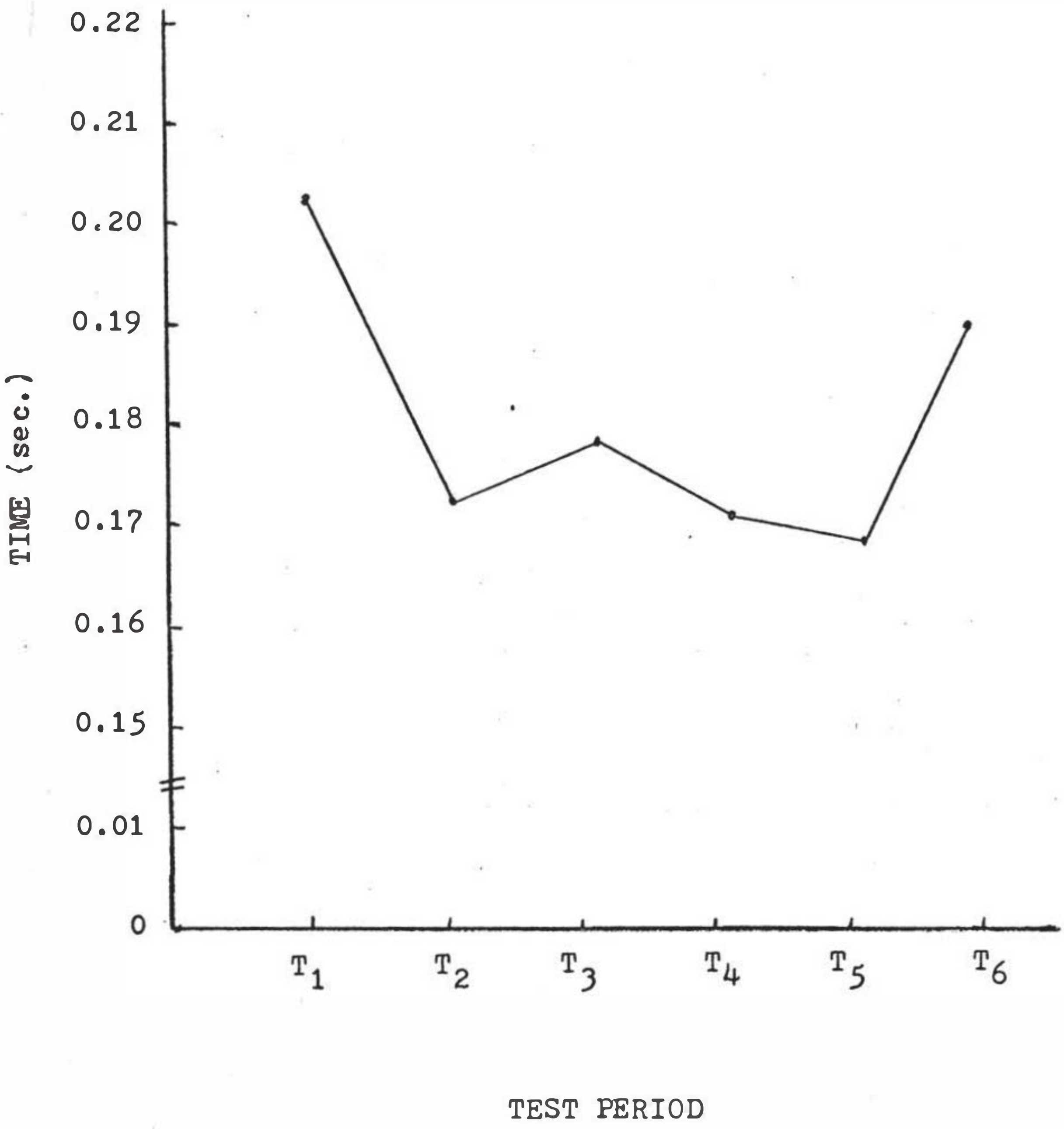


Figure 5

Reaction Time

Lung Volumes

The three lung volumes measured were vital capacity (VC), timed vital capacity (TVC), and maximum breathing capacity (MBC). Each represent a different aspect of lung function during exercise.

Vital Capacity. In this measurement of total usable lung capacity, D.L.W. increased from 1.41 to 1.9 liters (l). This increase represents a 34% development of usable lung area.

Zwiren (21:96) reported that vital capacity measurements in paraplegics were near the normal population. Vital capacity, as reported by DeVries (8:151), for adult males from 30 to 50 years old would be approximately 4.21. Hjeltness (10:109) reported that VC would remain relatively unchanged in paraplegics following training.

When compared to the above findings, D.L.W.'s VC is considerably lower than the normal populace. Also, the results of this study showing a 34% increase in VC disagree with the findings of Hjeltness. Because of spinal curvature and a degree of uncertainty as to which respiration musculature was available to D.L.W. due to paralysis, the entire discussion of respiration becomes less than objective.

Timed Vital Capacity. The subjects maximum ability to expire air in one second was increased by 7% from the initial volume of 1.29 liters per second (l/sec) to the final test of 1.39 l/sec. This small increase did not seem significant because of the 20% flucuations from one test period to another.

Hjeltness (10:109) found that timed vital capacity remained constant in paraplegics following an exercise program of 15 weeks duration. The present study agrees with the results of Hjeltness. TVC% was lower during each test except the final measurement. This decrease was caused by the increasing VC and almost constant TVC. Figure 6 illustrates this point very well.

Maximum Breathing Capacity. The subjects maximum ability to move air through his lungs estimated in 12 second MBC test, shows an increase from the initial 28.3 liters per minute (l/min) to 63.7 l/min during test five. This increase found in test five was 125% greater than the initial score.

Zwiren (21:96) stated that paraplegics and sedentary adults had no significant difference in maximum breathing capacity volumes. Pollock (17:464) found MBC's in middle aged men to be 137 to 142 l/min in a 20 week exercise study.

The subject involved in this study was well below the normal sedentary adult populace. Paralysis, lordosis and scoliosis attributed to be the major causes of the reduced MBC found in D.L.W. See Figure 7 for the training effects of the lung volume measurements.

Resting Oxygen Consumption ($\dot{V}_{O_2}$)

D.L.W.'s resting $\dot{V}_E$ and $\dot{V}_{O_2}$ decreased during test two and three when compared to the initial test. The following tests four and five found an increase in both $\dot{V}_E$ and $\dot{V}_{O_2}$.

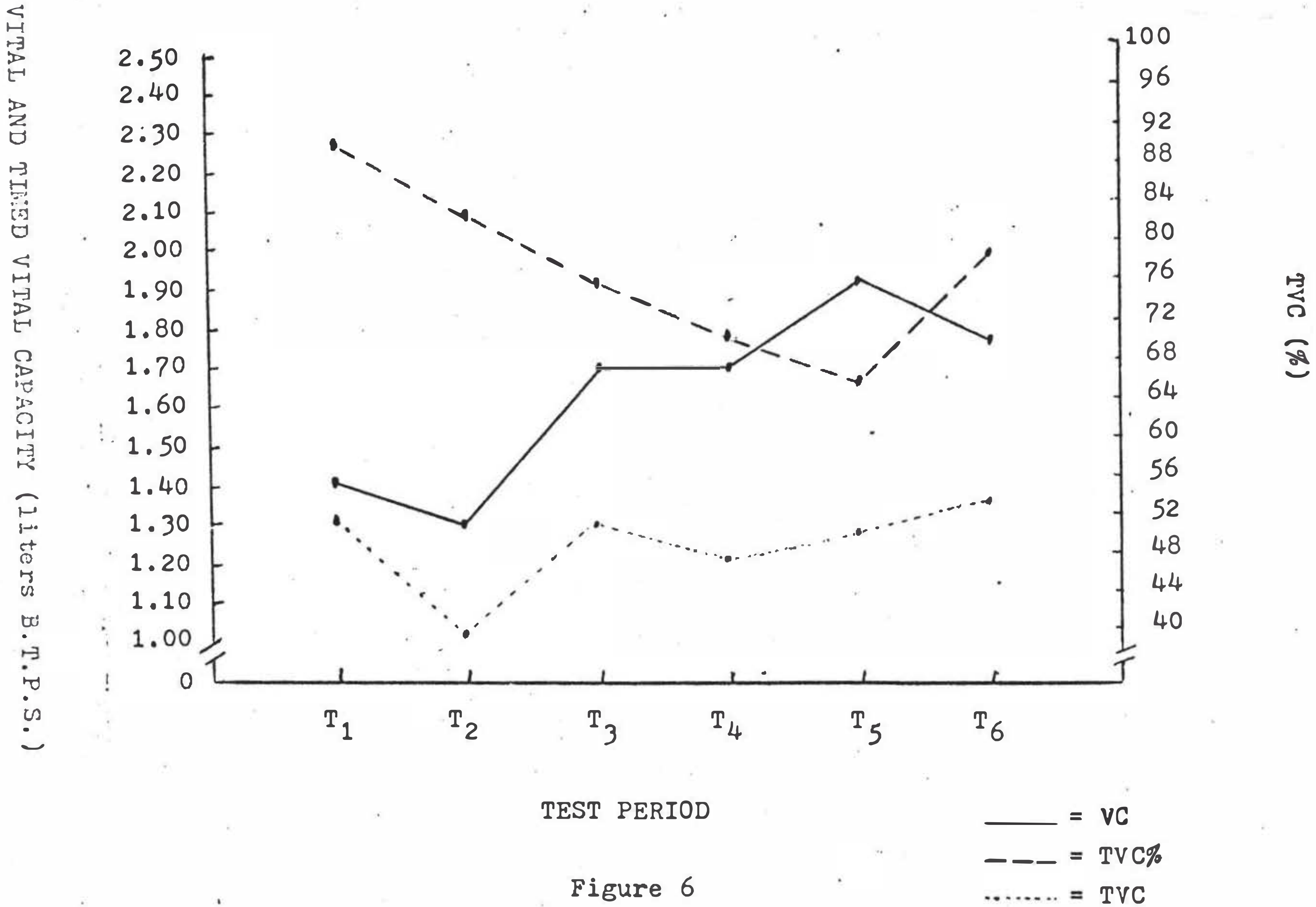


Figure 6

Vital Capacity and Timed Vital Capacity

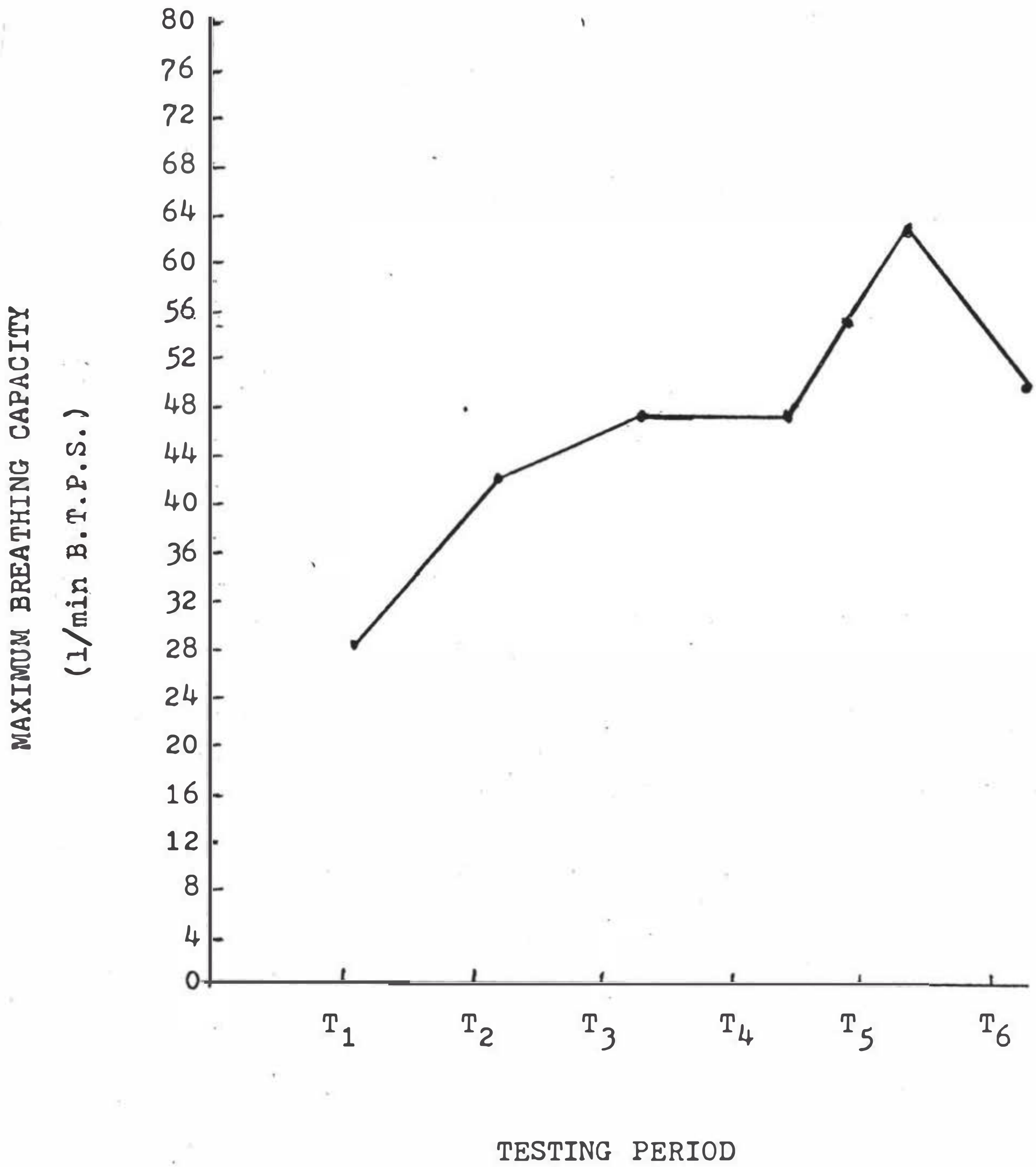


Figure 7

Maximum Breathing Capacity

During test five, the investigator and his assistant were discussing a controversial topic that D.L.W. immediately expounded upon after the test was over. It was felt by the investigator that this emotional arousal definitely affected the test. (See Figure 8)

Resting $\dot{V}_E$ is reported to be from four to 15 liters per minute in untrained adults according to Mathews (13:166). D.L.W.'s result places him well within the range of adult norms by having volumes of 7.21 to 7.76 l/min move through his lungs. These changes found in D.L.W.'s $\dot{V}_E$ are considered very small.

Mathews (13:217) also reported that resting $\dot{V}_{O_2}$ in untrained adults is approximately 0.300 l/min. Clarke (3:223) reported, however, that the resting $\dot{V}_{O_2}$ in paraplegics is lower than adult men. D.L.W.'s initial test score of 0.280 l/min was close to the standard set by Mathews. Four weeks later, D.L.W.'s resting $\dot{V}_{O_2}$ was 0.164 or 41% below his initial measurement. The remaining tests were also well below the normal adult average. This low $\dot{V}_{O_2}$, plus the limited possibilities for vigorous exercise may account for the inability of some paraplegics to control a desired body weight.

Maximum Oxygen Consumption

The maximal $\dot{V}_{O_2}$ test for D.L.W. was kept within the limits of safety since a physician was not in attendance and defibrillation equipment was not available. When the investigator felt D.L.W. was not able to complete another three minute bout of arm cranking with an increased load, the test was terminated. This margin of safety left a small amount of error in the maximal $\dot{V}_{O_2}$ tests, however, it was felt that this margin of safety was of great importance.

Maximum $\dot{V}_E$ was increased 39% in the first two weeks of training from 23.0 to 32.9 l/min. After two weeks of training the max $\dot{V}_E$ remained nearly constant during test three and four. Test five revealed a drop of 10 l/min from the 32.9 l/min found in test two. The final test was close to the test three and four results at 28.1 l/min.

Pollock (15:120) found an increase in max $\dot{V}_E$ from 97 to 118 l/min in disabled subjects. Again, it should be noted that D.L.W.'s level of transection and spinal curvature may have affected his maximal $\dot{V}_E$ greatly.

Actual max $\dot{V}_E$ and predicted max $\dot{V}_E$ by the MBC test are shown in Figure 9. The predicted results were constantly higher, especially during test five when the actual $\dot{V}_E$ was at it's lowest point. Predicted values are usually higher because of the shorter test time and no muscle fatigue. However, it is evident that the actual $\dot{V}_E$ tests were not parallel with the predicted values. When the subject was forced to put on nose clips and insert the mouthpiece, an emotional strain was placed on the subject, which had a negative effect on the test results. D.L.W. would enter an anaerobic work state by not breathing at his maximal level and lower both the max $\dot{V}_E$ and max $\dot{V}_{O_2}$ results.

The greatest $\dot{V}_{O_2}$ measurements were found in test two

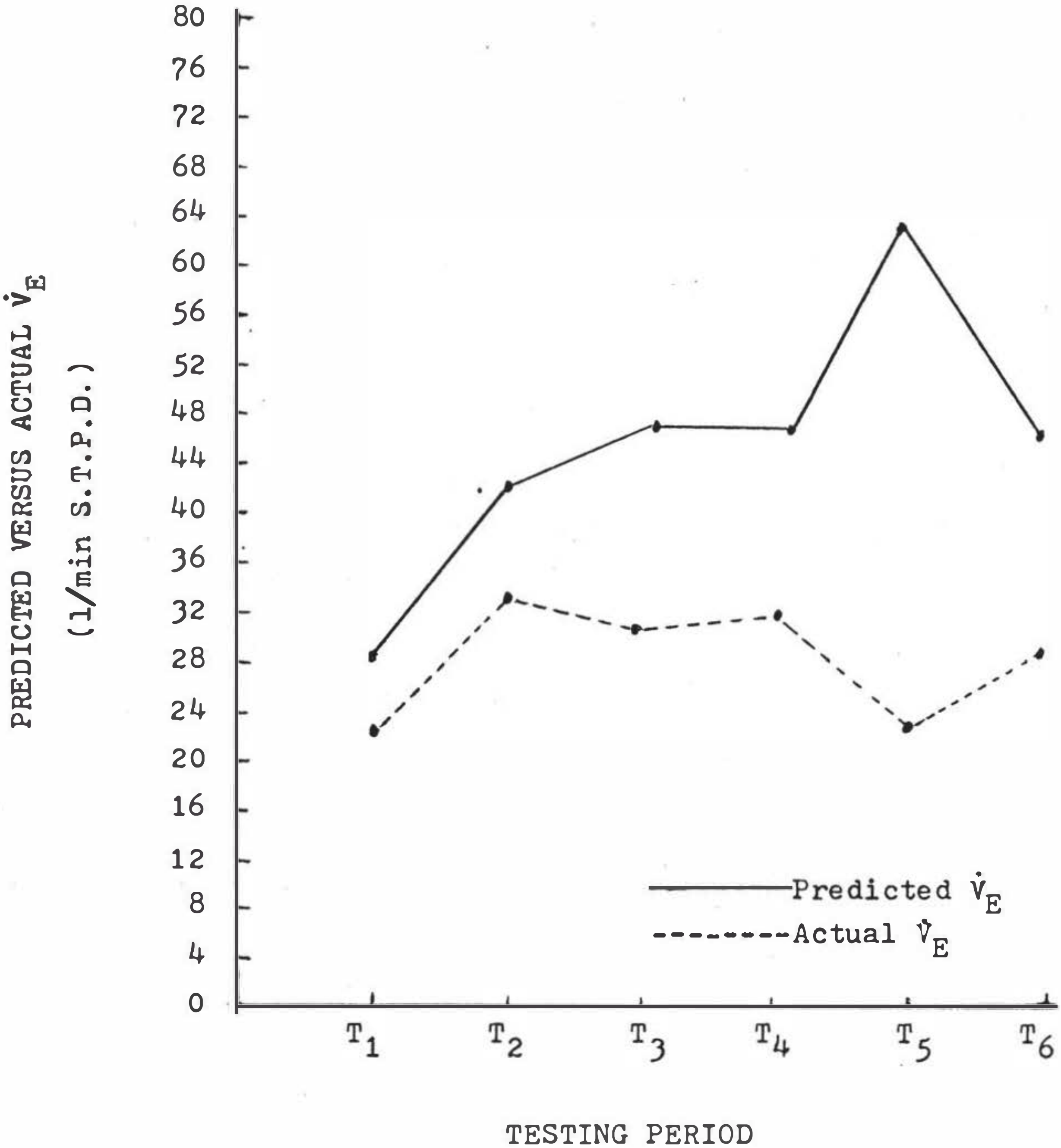


Figure 9

Predicted Versus Actual $\dot{V}_E$

also. The max $\dot{V}_{O_2}$ was recorded at 1.27 l/min which represents an increase of 10% from the initial results. The remainder of the testing periods followed an almost linear relationship with max $\dot{V}_E$ findings. This is not unordinary because $\dot{V}_E$ multiplied by "true O_2" equals $\dot{V}_{O_2}$. Tests three, four, and six were almost equal to test one, while test five again, was lowest found value of max $\dot{V}_{O_2}$.

Nilsson (14:54) found an increase in mean max V_{O_2} from 1.88 to 2.08 l/min or 12% after seven weeks of training three days per week in paraplegic subjects. Pollock (15:120) found disabled adults increasing their max $\dot{V}_{O_2}$ from 1.88 to 2.23 l/min following 20 weeks of arm pedaling three times per week.

Both studies indicate that D.L.W.'s max $\dot{V}_{O_2}$ is much lower than other populations studied. Unless the subject could increase his max $\dot{V}_E$ greatly, the results will probably remain lower than other paraplegic populations. D.L.W.'s reduced max $\dot{V}_{O_2}$ results throughout the testing periods can only be explained as an emotional tension causing an inability to do work.

During the final two weeks of training, a nose clip and mouthpiece were used to help the subject become more familiar and comfortable with the pieces of equipment. Also D.L.W. followed the testing schedule to help him become more familiar with test procedure. As a result, the final test did show an increase in both max $\dot{V}_E$ and $\dot{V}_{O_2}$ from previous tests. Max $\dot{V}_E$ and $\dot{V}_{O_2}$ results may be found on Figure 10.

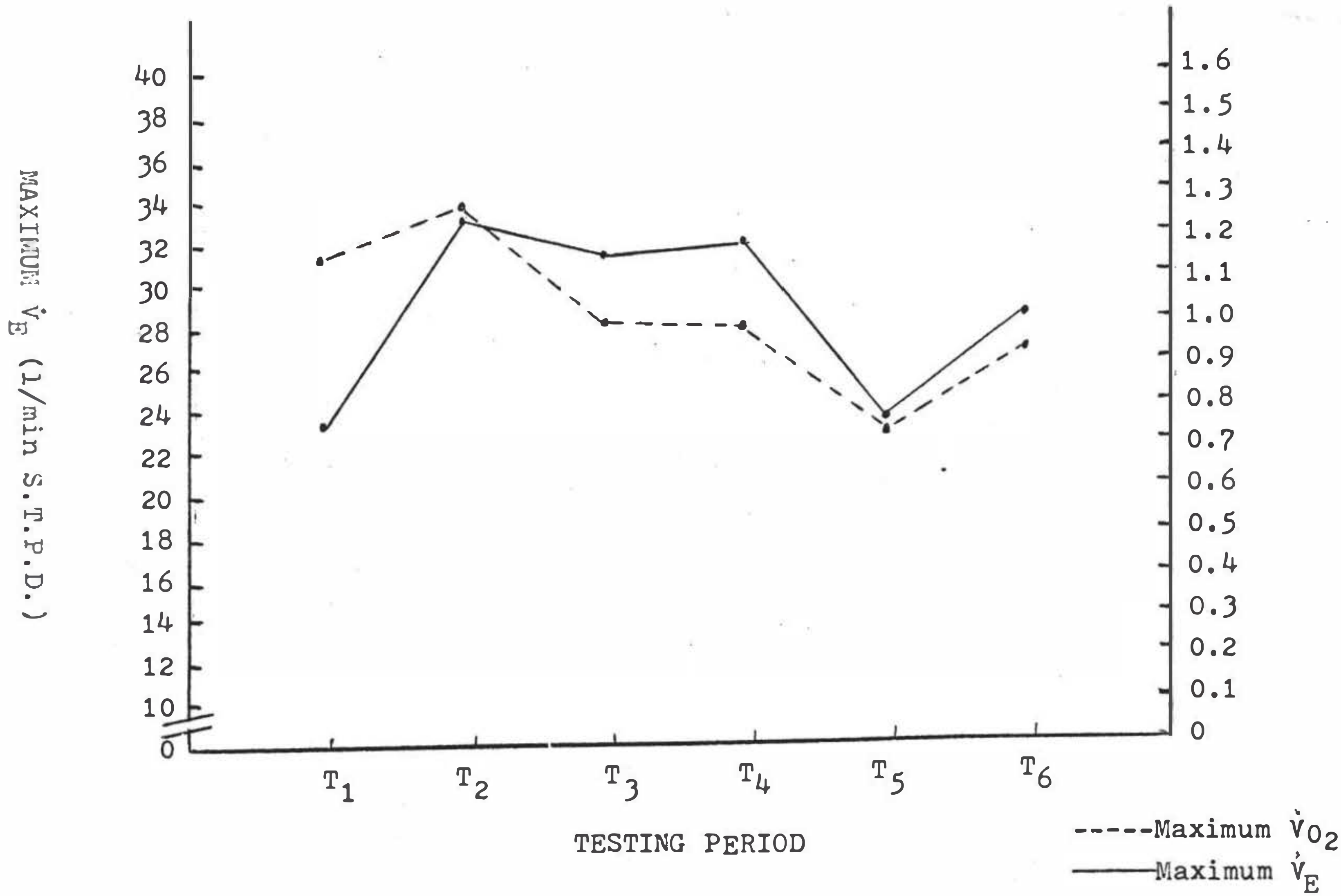


Figure 10

Maximum $\dot{V}_E$ and $\dot{V}_{O_2}$

Blood Pressure

Systolic and diastolic blood pressures were measured and recorded during the rest intervals of the max $\dot{V}O_2$ test and following the test. The maximum systolic blood pressures taken during the exercise were extremely constant with the exception of test four. During test four the pressure rose from the normal 190 to 200 mm Hg level, up to 230 mm Hg. D.L.W. commented that he almost passed out during this exercise bout. Diastolic pressures remained between 80 and 96 mm Hg throughout the study. A slow steady decline was observed during the first eight weeks of testing. The final test resulted in an increase which canceled out a very benificial effect. See Figure 11 for these results.

Post exercise readings taken five minutes after the max VO_2 test showed no difference in the systolic or diastolic readings. The mean recovery systolic pressure was 152 mm Hg while the diastolic mean was 84 mmH g.

Since D.L.W. was taking medication for hypertension, the discussion of the training effect on blood pressure during maximal exercise remains very unreliable. Any change in blood pressure may be due to the medication, intensity of the exercise, or both.

Maximal Heart Rate

Maximal heart rates remained approximately the same throughout the 10 week training program. Maximal rates were recorded from 130 to 148 beats per minute during maximal $\dot{V}O_2$

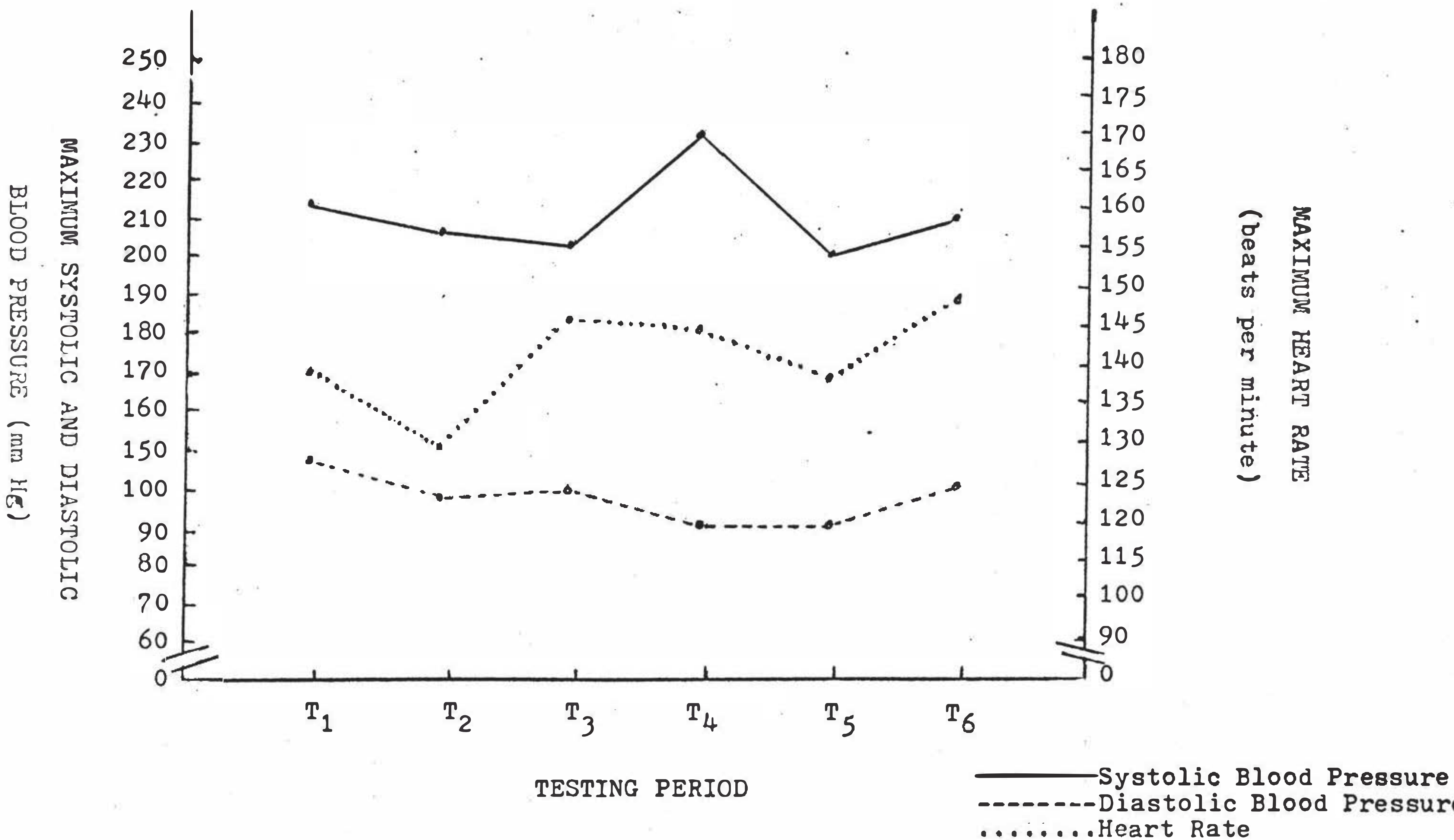


Figure 11

Maximum Blood Pressure and Heart Rate

test periods. This slight difference was not felt to be important because of the safety factors mentioned earlier. See Figure 11 for graph of the results.

Nilsson (14:55) reported heart rates up to 200 beats per minute in his study using paraplegic adults. He also concluded that most paraplegics have heart rates within the normal adult limits. Mathews (13:257) reported that heart rates of 150 to 159 beats per minute were adequate for a training effect in adults 30 to 39 years old.

D.L.W. could not bring his maximum heart rate near to the suggested 150 beats per minute goal set by Mathews. This indicates that his paralysis has affected the maximum heart rate he is able to attain. This could indicate some sympathetic nerve loss, as was mentioned in Chapter 1, which controls the maximum heart rate level.

The Training Program

During each training session, blood pressure, heart rate and total work done were monitored. These three variables were considered to allow the investigator to monitor the subject as well as other changes brought about because of the training program.

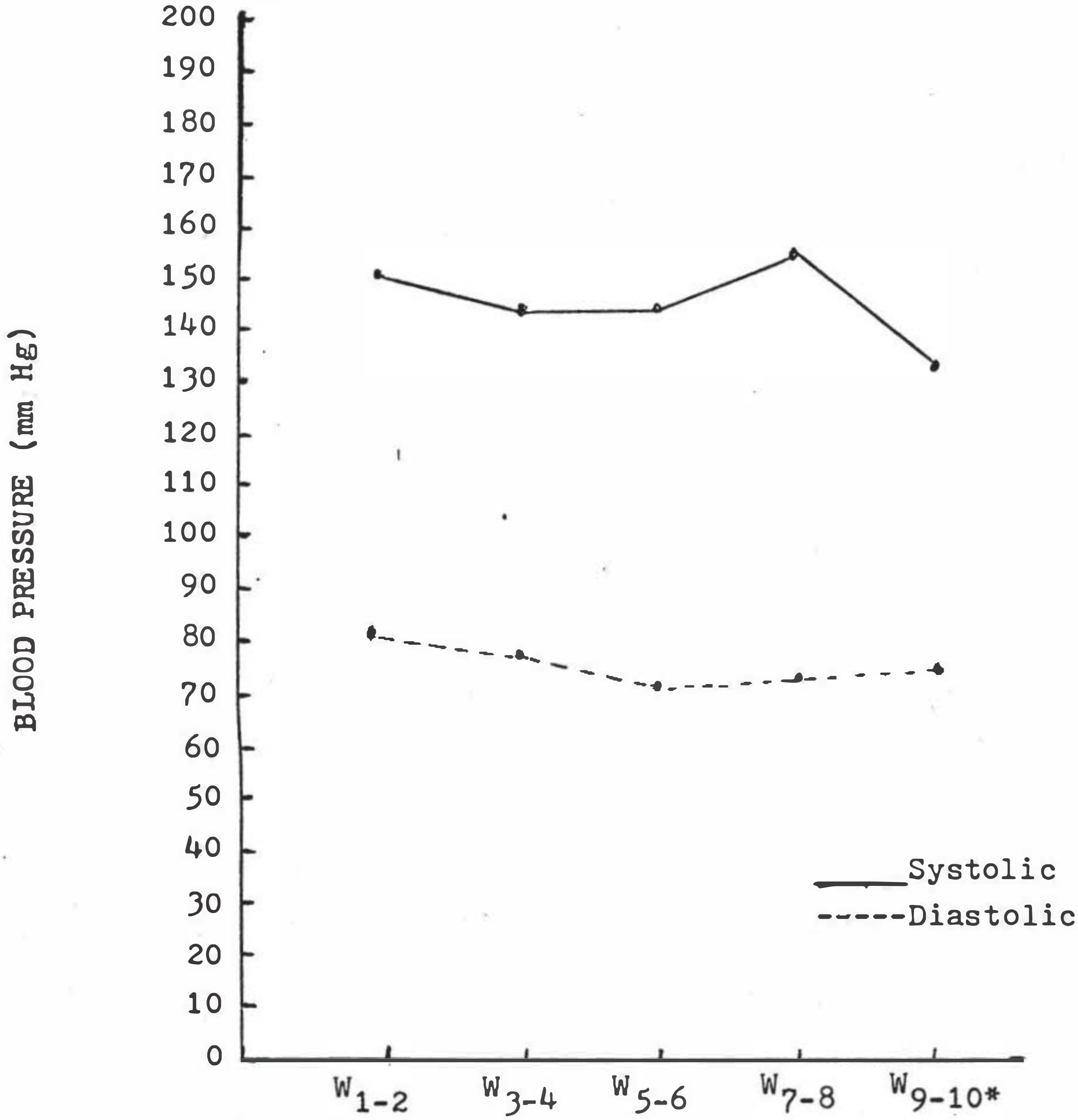
Blood Pressure

A resting blood pressure of 170 mm Hg systolic and 90 mm Hg diastolic was found during a test feasibility trial three weeks prior to the start of the study. One week later, D.L.W. began taking the hypertension medication as prescribed by the physician. The first training session three weeks after the implementation of the medication found the subject's systolic pressure 18 mm Hg lower and the diastolic pressure 10 mm Hg lower than the initial findings. Because of these results, changes in blood pressure during the study cannot be fully attributed to the training program.

Blood pressures were, however, taken at three different times during each training session. These readings were taken at rest, immediately following each exercise interval and five minutes after the final exercise bout.

Blood Pressure at Rest. Resting systolic and diastolic blood pressures were taken prior to the start of each training session. These measurements were averaged for two week time periods. The intervals from the initial to the sixth week showed a decline in both systolic and diastolic pressures. Systolic fell from 151.5 to 147.0 mm Hg and diastolic dropped from 82.5 to 71 mm Hg. Increases in both systolic and diastolic pressures for the remaining of the program were then observed (see Figure 12).

De Vries (8:130) reported that systolic pressures exceeding 140 mm Hg at rest are on the border line for hypertension as is 90 mm Hg diastolic. Pollock (15:421) found resting blood pressures in paraplegics to average 138 mm Hg systolic and 89 mm Hg diastolic. Following 20 weeks of arm pedaling, the blood pressures did not change significantly. Mathews (13:221) states, however, that a reduction in blood



TWO WEEK TRAINING MEANS

*The resting blood pressures taken during weeks 9-10 were not taken during true resting states because of vigorous exercise bouts prior to the readings.

Figure 12

Resting Blood Pressures

pressure is a benefit from an exercise program.

D.L.W.'s blood pressure is higher than the pressures found by Pollock, but remained constant instead of dropping as suggested by Mathews. D.L.W.'s systolic pressure still remained in the borderline hypertension area throughout the training program while diastolic pressures were within the normal limits. The increased blood pressure during the last four weeks was felt to be due to an inconsistent training schedule, the reduction of arm cranking, and a negative tendency to hold his breath during the propulsive phase of wheeling. Mathews (13:145) refers to this breath holding as the "Valsalva Maneuver", which causes systolic and diastolic pressures to increase beyond values normally seen during exercise and thus reducing the effects of exercise on resting blood pressure.

Blood Pressure During Exercise. The maximum blood pressures found during the training sessions followed the same pattern as the resting blood pressure readings. Mean systolic pressures dropped from 168.8 to 152.4 mm Hg during the first three, two week training sessions. Diastolic pressures dropped from an average of 79.6 mm Hg during the first two weeks to 62.5 mm Hg during weeks seven and eight. The final four weeks showed a rise in systolic pressure of 11 mm Hg while the diastolic pressure increased 12.5 mm Hg during the final two weeks of training. (See Figure 13)

The evidence that blood pressures were dropping again

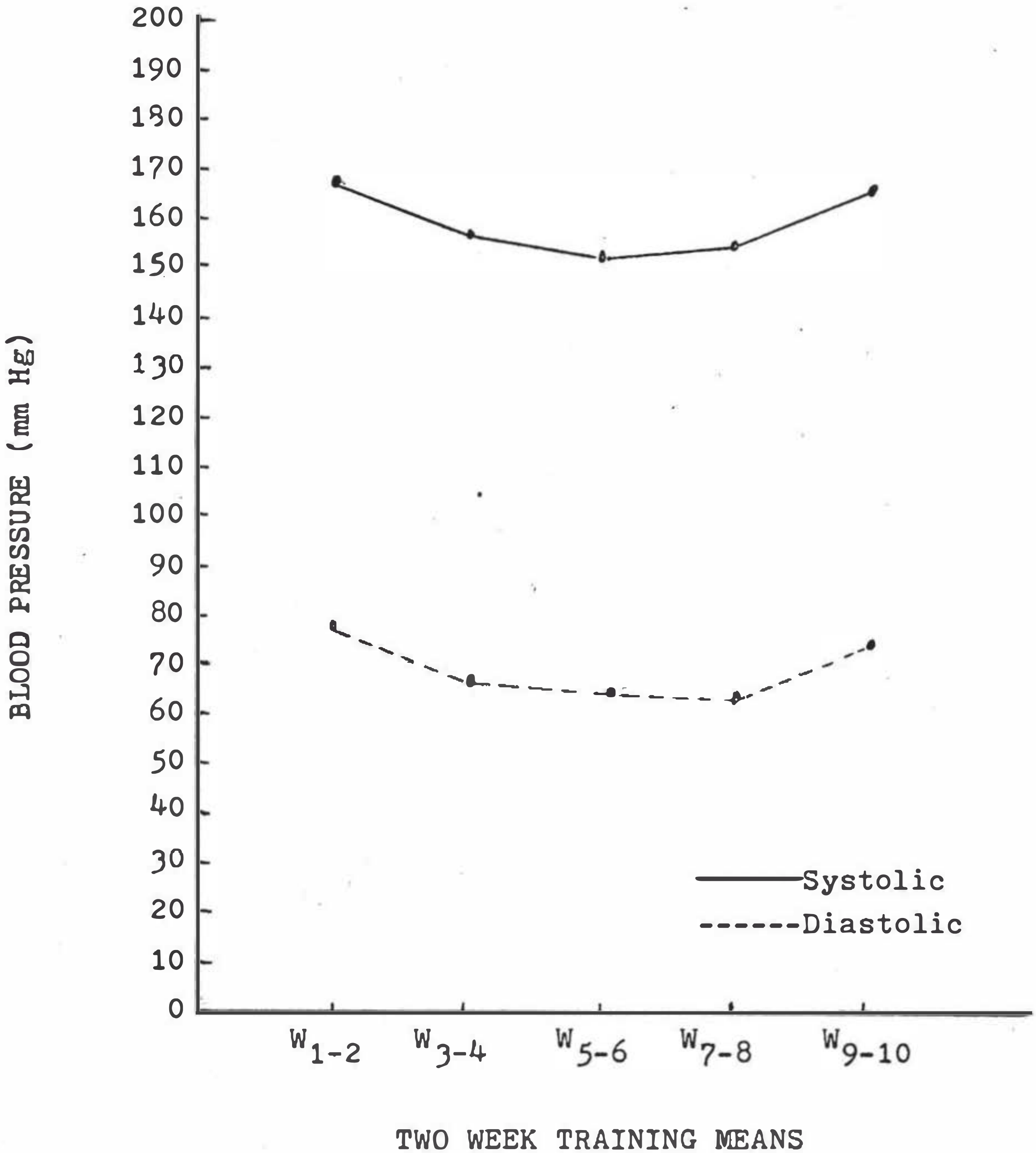


Figure 13

Maximum Training Blood Pressure

indicated that either the exercise and/or the medication was improving the cardiovascular system. The increase during the last two weeks was again attributed to the wheeling instead of continuous cranking that was used during the first seven and one-half weeks.

Blood Pressure During Recovery. Five minute recovery systolic blood pressure showed a decline when viewed from start to finish. The first four weeks showed an average blood pressure of similar scores in systolic and diastolic pressures. Systolic pressure then decreased from 145.8 to 137.0 mm Hg during weeks seven and eight. Weeks nine and 10 showed an increase from 50.7 to 76.5 mm Hg. (See Figure 14)

Pollock (15:421) found five minute recovery blood pressure in paraplegics to be an average of 135 mm Hg systolic and 82 mm Hg diastolic after a 20 week hand cranking training program.

D.L.W.'s recovery blood pressures are approximately the same as those reported by Pollock (15:421). The systolic pressure was within 2 mm Hg, and the diastolic pressure within 6 mm Hg, if the final two week interval is used as a comparative result. When pressures during weeks seven and eight were used, D.L.W.'s diastolic blood pressure was 31.3 mm Hg, lower than the above study. However, again, the subject was taking medication for hypertension and again, this discussion is less than subjective.

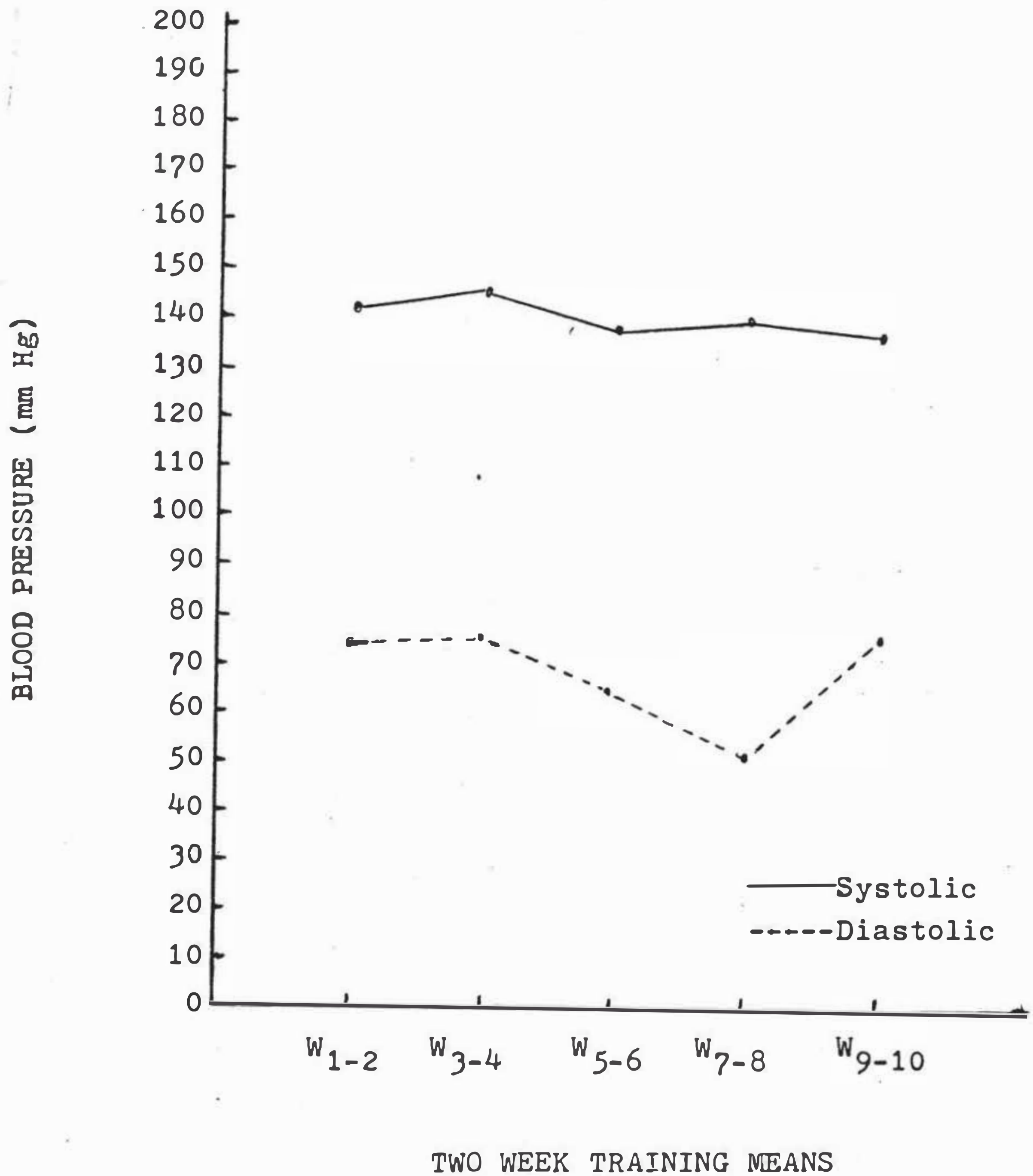


Figure 14

Recovery Blood Pressure

Training Heart Rate

Following the initial stress test given to D.L.W., it was determined his maximum heart rate was near 145 beats per minute. A target training effect heart rate minimum of 120 beats per minute was used. Training heart rates were recorded after every bout of cranking and was averaged over two week periods. Heart rates slightly above 120 beats per minute were reported except for weeks six and seven where they dipped slightly below the target level. (See Figure 15)

According to Mathews (13:257), target heart rates for adults between 30 to 50 are suggested to be 150 beats per minute. The results show heart rates in this study somewhat lower than normal, but adequate for the subject involved in this training program.

Perceptions By the Subject

Though not analyzed in a quantitative manner, D.L.W. made daily comments and summarizing statements relative to the project. (See Appendix E and F respectively.) The observations below are concerned with how the subject percieved the testing procedure, training program and the effects of the program on his daily living.

Testing Procedure

D.L.W. felt the laboratory setting did not affect the subject psychologically unless he was not aware of the on-going events. If D.L.W. was not informed, he was very

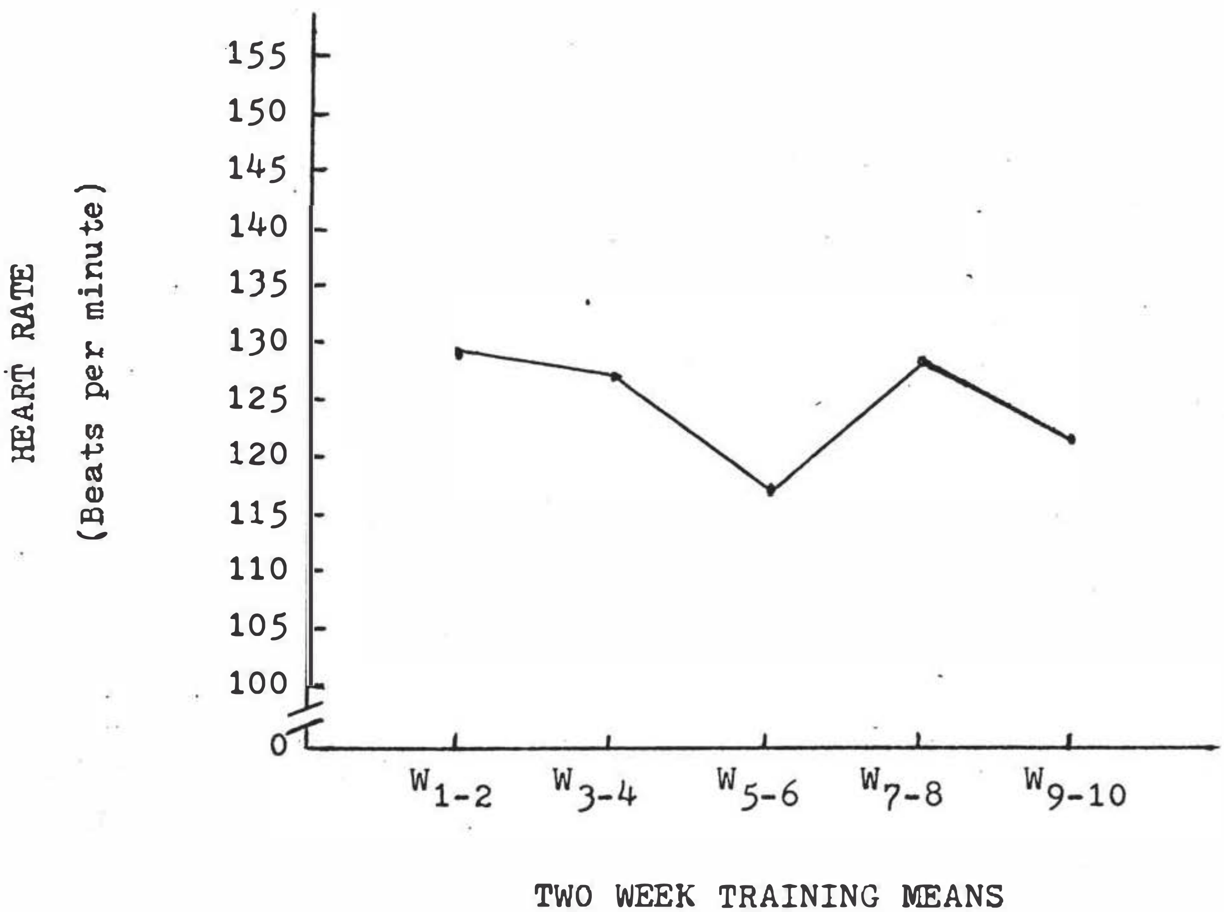


Figure 15

Training Heart Rates

inhibited because of his background. An open avenue of communication was therefore very important. The testing procedure of countdowns, inserting mouthpieces, putting on nose clips and etc., caused anxiety. D.L.W. felt the testing was less stressful emotionally when the mouthpiece and nose clip were left in position at all times. He felt this prevented much of the high tension atmosphere.

Workouts using the nose clips proved to be very beneficial according to D.L.W. He felt the low test results of test five were because of the inhibition mentioned above. Relaxation therapy or desensitization therapy would help the subject adapt better to testing procedure and equipment use according to D.L.W.

Training Program

The overall feeling by the subject was that the program was very beneficial. The workouts left D.L.W. refreshed immediately after the workout with a period of fatigue overtaking him about noon each workout day.

A combination of cranking and wheeling was felt to be the best training routine. Cranking seemed to work the cardiovascular system the hardest while wheeling tired the muscular system before cardiovascular strain would occur.

Because breathing through the mouth was difficult and caused an uncomfortable dryness in the mouth, sipping water in between work bouts helped decrease the problem.

During the training period, wheezing while breathing during exercise became less apparent as the program progressed. D.L.W. felt that this was due to an increased ability to use his lungs and to breathe deeper.

Headaches were present after each exercise session for the first two weeks. After that time, there was no longer any pain. D.L.W. could give no explanation for this phenomenon.

Daily Living

No effect on human relations was apparent to D.L.W. He did feel though, that he slept better and was more eager to get up in the morning on the exercise days.

Increased stamina made it much easier maneuvering around campus which was the greatest benefit of the training program. D.L.W. felt the ability to accomplish his daily living tasks was improved by the program.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The intent of the study was to establish a 10 week cardiovascular exercise program for a paraplegic amputee and evaluate the effects through a selected battery of physiological tests and measurements. Included were, body weight, skinfold thickness, reaction time, grip strength, static and dynamic lung volumes, heart rate, blood pressure, resting $\dot{V}O_2$ and maximum $\dot{V}O_2$. A careful training record was kept and the subject also made observations concerning his feelings about the training.

The subject, D.L.W. was a 37 year old male faculty member at Eastern Illinois University in Charleston, Illinois. D.L.W. was given a complete physical examination and a stress test before the training program was initiated. Prior to the study, D.L.W. weighed 60 kilograms, was hypertensive and was very motivated to improve his fitness level.

The three day per week training program consisted of arm cranking using a modified bicycle ergometer. The subject was gradually conditioned until he could crank continuously for 15 minutes and a total of 30 minutes of interval work time. During nice weather, the subject would wheel himself in his wheelchair on a predesignated sidewalk course outdoors.

Formal training periods were held from February 28, 1980 to April 25, 1980. The tests were given prior to the start of the program, and every two weeks during the training program. All tests were administered in the Human Performance Laboratory at Eastern Illinois University.

Conclusions

Based on the findings of this investigation, the following conclusions appear warranted. The cardiovascular exercise program as performed in this study was helpful in reducing selected anthropometric measurements and increasing the cardiovascular fitness level of the 37 year old paraplegic amputee. This conclusion was based on the following findings:

1. Total skinfold thickness over the selected sites decreased.

2. The subject developed an increased ability to ventilate air.

3. Improved vital capacity, timed vital capacity and maximum breathing capacity lung measurements resulted.

4. There was an increased ability to do aerobic work for extended periods of time.

5. The subject reported a noticeable increased ability to perform daily living tasks without shortness of breath.

6. The subject was able to increase his caloric expenditure.

Subjective Observations

While it was difficult to assess psychological influences as a result of the physiological changes, it is important to note that the subject appeared to get increased enjoyment through rising early in the morning and being involved in the exercise program. Motivation levels were extremely high throughout the investigation. In fact, this high motivation seemed to hinder the subjects ability to work at maximal levels during certain testing periods. After termination of the project, the subject was planning to continue the program as soon as a personal stationary bicycle was modified to suit his needs.

Recommendations

Based on the experiences of this study the following recommendations are warranted.

1. Similar studies using arm cranking as a mode of exercise, should be conducted using a control group of normal subjects and handicapped subjects.

2. A study concerning the immediate and long range effects of arm cranking on blood pressure should be conducted with a large number of subjects.

3. An alternate method of determining cardiovascular fitness levels, other than open circuit respirometry should be determined for paraplegics. An example may be standardization of a norm for arm ergometry work loads and the fitness level assessed to a corresponding heart rate with a specific kilopound load as done by Astrand (2:24-27) and his Monarch Bicycle Ergometer.

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APPENDIX

APPENDIX A

Autobiography of D.L.W.

D.L.W. was born in what is now the pool room of Hour House, a residential alcohol treatment facility, in Charleston, Illinois on February 25, 1943. He was the second child in a family of 7 children, 3 boys coming first, then 4 girls. During the early years of his life the family moved between several small towns in central-east Illinois while his father, supported by his mother, pursued a doctorate in education following service in World War II. During this time D.L.W. never went to the same school two years in a row.

When he was the age of 12, D.L.W.'s family moved to the area near Pittsburgh, Pennsylvania where his father assumed a teaching position with the University of Pittsburgh, and his mother a position as a teletype setting machine operator with a suburban newspaper.

At the age of 16, after a long period of deterioration, D.L.W. had both legs amputated at the hip due to a cancerous tumor on the spinal cord. After two years he returned to the public school system and completed high school in 1963 at Penn Hills High School, near Pittsburgh.

In the fall of 1963 he entered the University of Pittsburgh with the intent of majoring in history to become a history teacher. During this course of study, he became

APPENDIX A (continued)

enamoured with Southeast Asian Studies, and decided he wanted to specialize in the area of Southeast Asian History. This did not prove agreeable to the School of Education at Pittsburgh, therefore D.L.W. told them they could keep their teaching degree, and finished out his undergraduate college years with a B.A., majoring in History.

Upon graduation D.L.W. discovered that a B.A. in History was not very good preparation for any specific occupation. He took Civil Service Exams for the state of Pennsylvania and went to work for the Department of Welfare in Washington County Pennsylvania. After a year there he left to look for work in the private sector of the economy. Because of his disability and more importantly because of the unspecialized nature of his training and work experience, finding work was very difficult.

If he could have, D.L.W. would have gone into farming with his grandfather, near Bushton, Illinois, however his disability precluded that. This was, and continues to be the focal point of much psychological pain and frustration. However, D.L.W. has chosen not to be absorbed by this and to go on with what he could do.

At this time he decided to return to school and began looking for a specialized degree that would enable him

APPENDIX A (continued)

to compete more effectively in the job market.

The year working for the Department of Welfare, the Civil Rights Movement, the Poor People's Campaign of 1968 led by Martin Luther King Jr., and the horror story growing in Indochina, tweeked D.L.W.'s social conscience. With this and his own experience of social and economic injustice, it seemed natural for him to look for a graduate degree in a human services type of program.

In January of 1969, he began study for a Master's degree in Rehabilitation Counseling at the University of Pittsburgh.

The orientation of this program was the study of psychological aspects of disability. During this course of study D.L.W. was exposed to different models of counseling, including different models of group counseling. He was very impressed with the Encounter Group as a model of personal growth. So much so, that for the next three summers he participated in the University of Illinois Summer Institute for Training Facilitators of Encounter Groups, two, as a participant, and one as a member of the training staff, the only non-Ph.D on the 8 member staff!

After completing 54 hours of his Master's program, (the program required 60 hours) D.L.W. became dissatisfied with the way the projects he was working on in his last

APPENDIX A (continued)

class were going. He decided to drop it for a while and move on to other things. At this time he was heavily involved in the issue of accessibility of the University of Pittsburgh, to persons with physical disabilities. In June of 1970, he took an incomplete grade in his course and quit school. He then took a position as a research assistant at Pittsburgh to work full time on their accessibility study. He was later to write a grant proposal for a Black Lung Treatment Program for Appalachian Hospital-Beckley (West Virginia) for which he received credit for completing the requirement of his M.Ed. He received that degree in 1973.

In April of 1971, with his part of the research on the accessibility study finished, D.L.W., following his roots back to Appalachia, took a position with Appalachian Regional Hospitals, Inc. at the hospital in Beckley, West Virginia.

The position was that of Patient's Advocate. This was a period of a lot of activity in the area of consumer activism. The president of Appalachian Regional Hospitals, T.P. Kipkens, had a strong committment to persons (who were patients) being treated with dignity and respect, and with quality care. His concept of a hospital was that it is not a place for professional people to mine dollars and where the people as patients get lost, or untreated through a jungle of red tape, rules, and regulations. He decided that the people

APPENDIX A (continued)

needed their own watchdog within the hospital to insure that they indeed were treated with dignity, respected, and that their requests and complaints would not be lost amidst the red tape. D.L.W. was to be the guinea pig, and develop this position at Beckley.

The concept of Patient's Advocate was borrowed from that of the Ombudsman in Sweden. However, they changed the name to that of Advocate, believing it would be more easily understood.

The years of patient advocacy were challenging, very rewarding, educational, exciting, and stressful. The former came from the whole experience, the latter stemmed from the extreme hostility towards the concept, taken out on D.L.W. personally, from most of the physicians.

D.L.W. fell in love with the Appalachian region, the culture, and the people. Looking back from today, he felt more "at home" there than any place he has lived to date. There were frustrations that were a result of his disability, it was difficult not being able to climb those mountains, to wade a trout stream, or to be a "new pioneer". That though, was only part of the experience. The most important part of any place a person lives is the people we have as true friends. For, to paraphrase Emerson, "a friend is someone with whom I may think aloud". Some of the best and most lasting friends

APPENDIX A (continued)

in D.L.W.'s life are those he made while in West Virginia.

In the first several years with Appalachian Regional Hospital-Beckley, D.L.W. was increasingly given new responsibility. While still serving as Patient's Advocate in 1973 he conducted a feasibility study for home health services. As such he was assigned Acting Coordinator of Home Health Service. He developed the position of Home Health Liaison Nurse, and coordinated the services that were offered in the home by the hospital. Also in 1973, because of his experience and training in Group Counseling, D.L.W. became one of two Co-facilitators for couples and family therapy, for the hospitals' Alcohol, Drug and Psychiatric Program (known as AR-CAP).

By the fall of 1974, the position of Patient's Advocate was becoming defunct due to lack of support during a power struggle in corporate headquarters in which, unfortunately, T.P. Hipkens and many of the ideas to which he was committed were ousted.

In September of 1974 D.L.W. was asked to take over the coordination of treatment and administration of Unit-5, the residential transitional treatment component of AR-CAP. At this time he assumed full time responsibility as Coordinator of Unit-5.

The Patient's Advocate position was never refilled, and the noble experiment in helping people become more fully

APPENDIX A (continued)

involved in their health care, their hospital stay (when necessary) made more comfortable, understandable, and in making hospital personnel and physicians more responsive to the needs and wants of those they serve, went by the wayside.

It was while Coordinator of Unit-5 that D.L.W. was able to put into practice much of his learning about therapy and helping people-as-clients learn that they can give up destructive ways of coping with life for those ways that are more satisfying. It was there that with the support of a young, more holistically oriented psychiatrist, David Ames, and with the help of a staff that, with the exception of one, was genuinely warm, caring, sharing, and willing, that one of the most progressive treatment programs for persons coping with life through alcohol, other drugs, and craziness began to emerge.

In late 1975, while still Coordinator of Unit-5, D.L.W. had one of his most profound personal learning experiences. It was during a workshop in Family Therapy, from a T.A. Gestalt, and Systems model, led by George and Ruth McClendon, held at the Southeast Institute. Part of the workshop design allowed for two days of therapy for the therapist. In a group with eight other people and facilitated by Ruth McClendon, D.L.W. got in touch with how much of his life he devoted to work, to the depreciation of his ability

APPENDIX A (continued)

to play and have fun, or otherwise "get out of his head". This was something he had known intellectually for a long time, however it too was just in the head, and the insight into this, its roots, and its importance as an issue effecting day to day living did not come about until the therapy with Ruth. The exercise program D.L.W. became involved in as a result of wanting to improve the condition and functioning of his body, related directly back to the piece of work with Ruth.

During his summers at the University of Illinois Institute for Training Facilitators of Encounter Groups, D.L.W. became exposed to Gestalt Therapy (amongst others). After doing some reading on his own, he decided he wanted to study it more in depth. In the summer of 1976, he attended a one week workshop in Gestalt Therapy at George Williams College (in Downers Grove, near Chicago). This workshop was sponsored by the Gestalt Institute of Chicago. The Institute at that time had a weekend training program in which one could immerse him/herself in Gestalt Therapy and after three years gain certification. That, with the increasing disintegration of what D.L.W. felt was the unique and promising work of Unit-5, encouraged him to begin to look for work closer to Chicago in order to further his education at the Gestalt Institute of Chicago. In the fall of 1976 D.L.W.

APPENDIX A (continued)

left West Virginia to take a position as Staff Therapist with the La Porte County (Indiana) Community Mental Health Center. In January of 1977 he became a trainee in the Gestalt Institute of Chicago.

D.L.W. had often times thought about returning to the Charleston, Illinois area to explore his roots there. However the "right" opportunity or "right" time never seemed to coinside. This changed in December of 1977 when a position as a counselor was offered to him in Hour House (the once small, woodframe hospital in which he was born).

The job in La Porte had been good, he'd met some good people, and made a few friends, but these were not many, and the area just did not feel like home. It, and many of the people D.L.W. met, did not have a feel of permanency. He decided to take the job in Charleston. He would continue his training at the Gestalt Institute one weekend a month.

After returning to Charleston, D.L.W. worked for two years as a Therapist in the Community Mental Health System, gradually becoming more discouraged. What evolved for him was at this point in time, there was too much politics and bureaucracy involved in this system, the committment to allow necessary changes was not presently existent in the public (the communities) at large, the state, local and federal governments, or most individual people, and the system's

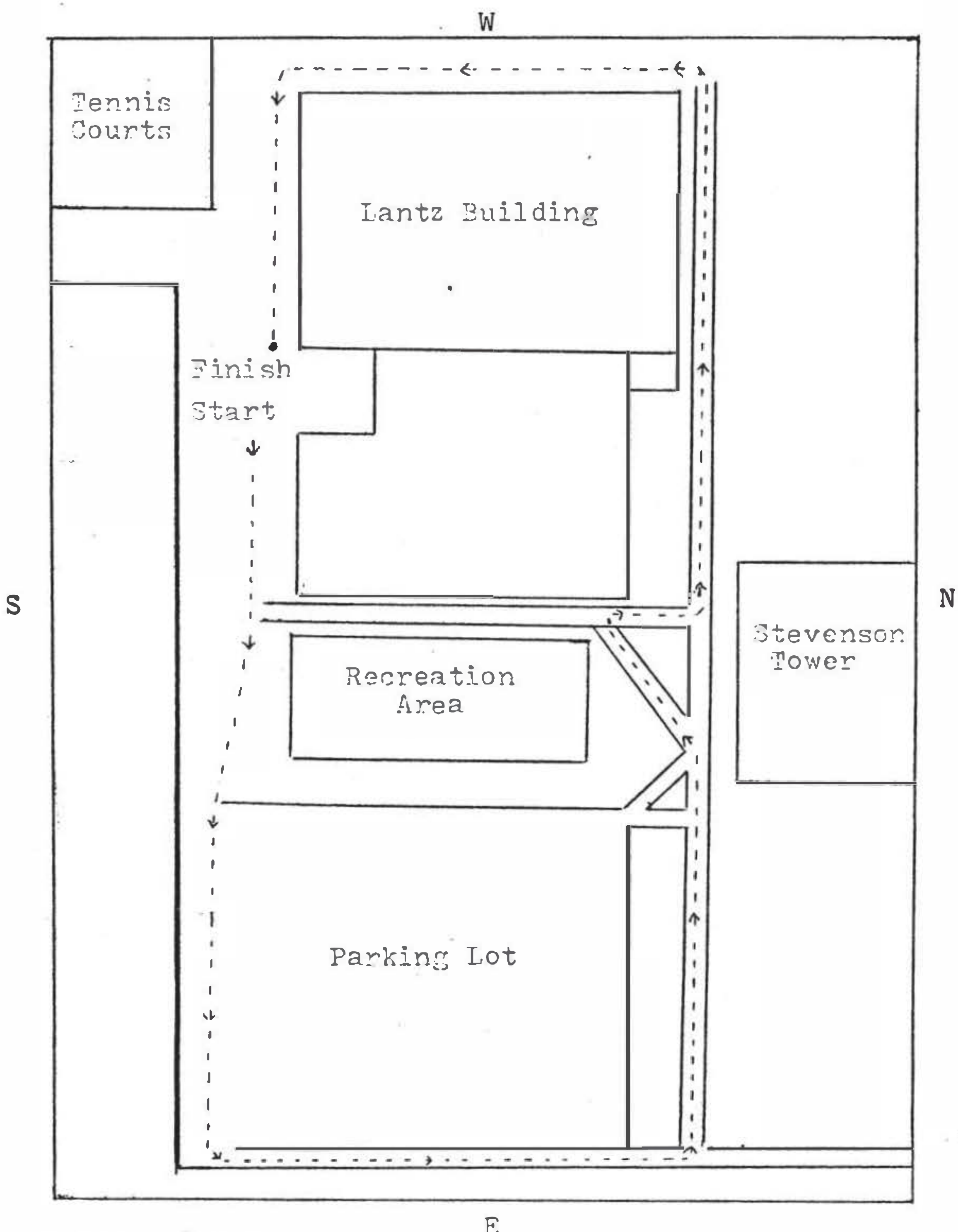
APPENDIX A (continued)

investment and interest was not in helping people quit acting crazy, but rather in having a class of people believing that they are crazy and/or defined that they are crazy.

With this in mind, D.L.W. took a position with Eastern Illinois University in the fall of 1979 in the Counseling Center and working on architectual and program accessibility for persons handicapped. In many ways this has been a coming to full circle, and the job has allowed him to return to begin filling out the part of him he learned in therapy with Ruth, was so atrophied. He not only enjoys his work, but also his photography, puttering around in his flower and vegetable gardens, friends and other times away from the job.

APPENDIX B

Outdoor Training Course



1 lap = ½ mile

APPENDIX C

Order of Testing

1. 10 minute rest period
2. 10 minute resting $\dot{V}_{O_2}$
3. Vital Capacity Test (three trials)
4. Timed Vital Capacity Test (three trials)
5. Maximum Breathing Capacity Test (one trial)
6. Skinfold Thickness Measurements (five sites)
7. Maximum Breathing Capacity Test (one trial)
8. Reaction Time Test (six trials)
9. Maximum Breathing Capacity Test (one trial)
10. Grip Strength (three trials alternating hands)
11. Maximum $\dot{V}_{O_2}$ Test

APPENDIX D

Maximum $\dot{V}_{O_2}$ Test

The exercise bout is terminated if the heart rate is greater than 140 b/m or fails to return to a level lower than 120 b/m in a one minute recovery. Systolic blood pressure cf greater than 200 mm Hg or diastolic pressure of 96 mm Hg or greater will also cause termination of the test.

Minutes	Revolutions per min.	Kilopond Load	Blood Pressure	Heart Rate	V_{O_2} ml/kg/min	V_E l/min
Rest						
0 - 1	60	0.5				
1 - 2	60	0.5				
2 - 3	60	0.5				
3 - 4						
4 - 5	60	1.0				
5 - 6	60	1.0				
6 - 7	60	1.0				
7 - 8						
8 - 9	70	1.0				
9 - 10	70	1.0				
10 - 11	70	1.0				
11 - 12						
12 - 13	70	1.5				
13 - 14	70	1.5				
14 - 15	70	1.5				

APPENDIX E

Daily Notes By the Subject

2/18/80

Range of difficulty (third ride) a 3 on range of 20 to 1.

Difficulty breathing through mouth, along with difficulty in swallowing and dryness of mouth.

Pain (sensation like eating cold ice cream, not throbbing like headache) in center front of head up through 3:30.

More awareness of lungs, similar to eating mentholated cough drops, through 3:30.

Aware of sitting more squarely in chair (both shoulders against the back) when at rest immediately after session - at first positioning myself thus was unconscious, later in day I became aware of moving to this position to relax or be at rest.

Went to bed at 10:30.

2/19/80

Awoke early - 4:00 A.M. Couldn't go back to sleep - don't associate this with yesterday as it's been happening lately - last 2 or 3 weeks.

Upon awakening and beginning to move around I became aware of sore muscle in right arm. Soreness continued through mid-morning (10:30).

Not aware of sitting back in chair during A.M.

Stomach mildly uncomfortably disturbed - ate big breakfast.

No lunch other than about 9 saltines.

5:30 P.M. began to notice low back pain, it comes and goes (over the past several years) and I think not related to exercise regimen.

APPENDIX E (continued)

2/20/80

Soreness in right arm continues, not interfering with any activity - noticed upon awakening.

Soreness in muscle in back - arm pit down radiating around to under right shoulder.

Last 3 minute ride on bicycle in series would rate a 4 on a scale of 1 to 20 - not as strenuous as the last one on Monday - pulse pounding in left temple.

Mouth dry after workout.

Nose plugged up - eustacian tubes plugged up - both of these began to clear about 11:30 A.M. (1½ hours after workout).

Headache - same type as Monday - mostly gone by 1:45 P.M.

Muscle left side of neck - I noticed being sore shortly after workout.

Around 12:30 P.M. began to feel tired - even sleepy, towards 1:00 P.M. I began to feel hungry for something sweet like a candy bar - avoided that and had tea with honey instead.

Around 2:15 noticed warmth in back of neck - lasted about a half hour consciously, then I got into work and it recessed into background.

Around 10:15 P.M. - felt tightness across top of chest in high breast area - felt when moving not resting.

2/22/80

Wheeled all way from Lantz to Counseling Center without stopping - at top of hill (walking angling from Lantz east entrance northeast towards 4th Street) I began to run out of breath and almost stopped, but told myself no - take it easy and keep going as far as you can - made it to Counseling Center.

11:30-45 got sleepy within 1 hour of workout - recovered and felt new energy within a half hour.

Some soreness in back of right arm triceps area later in day.

APPENDIX E (continued)

Headache mentioned after first day now much more mild but still noticeable.

Congestion of nose mentioned, I believe in last report noticable for hour or so immediately after work out.

Weekend

Tightness across chest again noticed.

Soreness in muscles in lower arms both noticed because of awareness of muscles, neither was restrictive.

2/25/80

Sleepy for just a few moments after returning to office.

Mild headache throughout day.

Soreness in neck noticeable thoughout day.

No congestion in nose after work out noticed today, however I did go into work out with congestion of lungs and throat. This seemed to disappear after work out.

Nothing else seemed to standout as unusual during the day concerning new awarenesses in muscles, breathing etc.

2/37/80

Soreness in biceps yesterday and this morning.

I had thoughts last night about not coming in today. I dreaded the first heavy three minute ride and gasping for air and my pulse pounding in my temple (left) even though my thoughts included that I'd feel better after the workout. However 4 minute ride today surprised me with the feeling of ease with which I accomplished it. And entire workout did not seem as strenuous as some that have gone before.

Soreness in biceps gone after workout although some tightness felt in arms throughout the day.

7:00 P.M. mild soreness in biceps - I became aware of again.

APPENDIX E (continued)

Thursday Morning - 9:00-10:00 A.M. - Soreness in left bicep noticable more or very little in right one.

2/29/80

Tightness in stomach from the time I got up (bloated - light feeling) maybe one to many quarts of Stroz last night or could it be the Polish Sausage for breakfast this morning?

1:00 P.M. panicky feeling during first ride - stopped - load seemed heavy - time seemed interminable - maybe I'm paying too much attention to the clock - much disappointment after such positive feelings about Wednesdays' ride. I did feel good though about recovering and completing the 4 minute rides and I think 3 minute rides after crapping out.

Sunday - Felt good rest of day through late evening hours - tightness in stomach went away - stayed up til 2:00 A.M. Saturday.

No soreness over Saturday noticed.

3/3/80

Nothing unusual noticed over weekend in terms of muscle soreness.

This morning the second and third rides on the bike seemed very difficult on a 20 to 1 scale, I'd say about a 2. The work out on the bike seemed harder today than it did two weeks ago. The difficulty seemed to be in breathing. Panicky again on 2nd ride and I think this affected the 3rd.

No noticable after effects in the 4 hours following the ride.

3:00 P.M. I went from Counseling Center to Science Building, had to stop 3 times to get breath - but windy weather may have accounted for that. During this walk I became aware of soreness in muscle in right arm - shoulder - to upper right breast area (in the front) after this walk I became aware of soreness in right triceps area.

No headache.

Tightness in stomach - I was aware of from about 12 noon -

APPENDIX E (continued)

through 6:00 P.M. Ate cheese, apple and sour orange after coming back from workout.

6:00 P.M. while thinking about this mornings rides and looking over Fridays' notes I wonder if my difficulty is mostly comming from my head.

3/4/80

Upon arising and for first hour - soreness in neck - right side.

About 4:20 began to notice lower back pain - I don't think it has anything to do with workout.

No breakfast - except glass of milk.

No lunch.

4 cups of tea during day (Compfrey tea) no sweetner.

Didn't get out of office all day.

3/7/80

10 minutes to the lab and 10 minutes back - no unusual soreness noted remainder of day.

5:00 P.M. no usual soreness noted rest of day.

3/10/80

Ride on 0 to 20 scale, I'd rate todays ride about 10. Felt good about the workout today.

Soreness in shoulders today.

Slept well, woke up feeling rested around 2:00 A.M. Lay there until 3:30 before falling back to sleep.

Tuesday - soreness noted in shoulders not severe. Nothing else noted unusual today.

APPENDIX E (continued)

3/12/80

Wheeled over and back today, I didn't have to stop and it only took me about 10 minutes over, but a couple of times I thought I was going to have to stop.

The first ride (3 minute) seemed tough - I was worried from that, that the 5 minute ride was going to really be difficult. I don't think though that it felt as hard as the 3 minute one. The entire workout today seemed more difficult than on Monday or last Friday, but I felt good afterward and the ride back to the Counseling Center was easier than the one over.

1:00 P.M. felt tired, yawning and sleepy - closed eyes for 20 minutes - felt rested afterwards.

5:00 aware of soreness in shoulders and right shoulder blade area (the latter though has been around for a couple of years so I don't believe it bothering me today is related to workout). Soreness also noticed in right side of neck.

Thursday - Slept well, woke up at 2:00 and went back to sleep very shortly afterwards. Woke up with headache in front of head - ate breakfast, did 5 quick pull-ups on chinning bar, it seemed easy.

Headache gone by 11:00 A.M.

3/26/80

Wheeled over today, didn't have to rest even though the ride seemed tougher than it was two weeks ago. Nothing eaten or drunk except vitamin pills, blood pressure medication, and about 6 ounces of water.

2nd five minute ride seemed hardest today.

2:30 P.M. No unusual muscle soreness noticed.

Something that I believe is different with me since I began this exercise program is that often before I would often awaken once or twice a night with my left arm and hand asleep. This was uncomfortable and I would arouse myself to stretch the arm and move the fingers to remove the tingly fuzzy feeling. This has been going on for many years and I've attributed it to a pinched nerve in my left shoulder due to my lordosis.

APPENDIX E (continued)

However, I noticed in the past couple of weeks that, although this has not entirely gone away, it has abated a great deal and nothing else is new in my activity.

3/31/80

4th ride today really tough in terms of breathing - I think I kept better time than two weeks ago (when we first did this part of the evaluation) but I felt closer to passing out this time, than then. First 3 rides much easier than before. I still don't like the nose clip and find it difficult to breathe through my mouth. However, I don't feel I was as anxious about the nose clip as I have been before, and I think I handled it and the mouthpiece better than at other times.

I did not notice anything unusual during the day.

4/1/80

I have been noticing myself wheezing lately. I don't believe it is a cold. It is not uncomfortable. It feels as if I am breathing from deeper within my lungs.

4/2/80

After a bad - or rather poor start today, I had a hard workout, but felt good afterwards. I believe the poor start was related to too much drink (beer), food, and late hours last night. I didn't hit the rack until about 2:00 A.M. last night.

Because of not eating anything before workout, I ate afterwards (2 hard boiled eggs, two tangerines, and a banana). Despite this I felt real hungry around 1:00 P.M. (ate a grilled cheese sandwich), I also felt real sleepy around 2:00 P.M., I got over this by 3:00 P.M. and felt re-energized.

4/8/80

No apparent problems today with way over - not working out yesterday as usual. I was still somewhat congested from a mild cold of last Thursday and Friday and I didn't think I was going to be able to keep up my times on the various rides. I surprised myself, pleasantly so, by not losing any time.

APPENDIX E (continued)

Next to last ride was the most difficult.

4/9/80

I got up this morning and said to myself, "self!" - no - I said, "I'm gonna push that middle ride to 15 minutes today." Then I was feeling strong enough, when it actually came down to it - I was disappointed, however satisfied that I did push the next to last ride to 7 minutes.

No usual soreness noted lately.

4/10/80

Surprised myself with a 15 minute ride right out of the gate today. Soreness in lower arms noted on second ride - after going around the building - it seems the muscle that runs down the top of the arm from inside the elbow to the thumb - this was severe(not painful) during the second ride and not so severe but soreness still notecable at 5:00 P.M.

I had a meeting at Applied Arts and Education Building this afternoon and wheeled over there with a walking companion. I really noticed the increase in stamina I've developed since 8 weeks ago. I did not have to stop and was able to make a pace about the rate of a regular walking gait.

Not looking forward to having my nose plugged off on Monday, nor the last ride on the bike, however, I'll work harder at not getting so mentally involved.

APPENDIX F

Summarizing Comments by the Subject

Testing Procedure

The testing procedure of countdowns, nose clips, mouth pieces and etc., caused a lot of anxiety.

New or prolonged testing caused inhibition.

Breathing through the mouth was very difficult to learn because of his background.

The testing was less stressful emotionally if the mouthpiece and nose clip was left in position at all times.

The laboratory setting did not effect the subject as long as all questions were answered and all tests were explained.

Felt that the low T_5 results were from lack of cranking exercise.

Relaxation therapy or desensitation therapy would help the subject adapt to testing apparatus.

Training Sessions

The overall feeling of the program was that it was very worth while.

D.L.W. left feeling refreshed after workouts.

The combination of wheeling and cranking was the best training routine.

At first the training was hard. The morning seemed

APPENDIX F (continued)

refreshing, but he would feel tired around noon.

Leaning forward seemed to help the lordosis of the back.

Rythmic breathing should be initiated as needed.

Dryness in the mouth was always present but sipping water helped.

During the training period, wheezing became less and less apparent.

Headaches were not a problem after the first few weeks.

Sleeping habits were improved as the program progressed.

Long warm ups usually resulted in better training sessions and lower blood pressure.

The subject felt he climbed and peaked in V_{O_2} after the first three weeks. The program then became boring.

Daily Living

The training program was felt to have no effect on human relations.

Maneuvering around campus became much easier by the eighth week.

Food intake remained approximately the same throughout the period.

Coffee and tea affected the workouts by limiting performance. Therefore, it was not consumed prior to activity.

APPENDIX F (continued)

During the longer periods of exercise and the last few weeks of training, less beer was consumed to prevent a bloated feeling.

D.L.W. felt it was easier to get up in the morning at 6:00 to 6:30 A.M. because of physiological and psychological benefits.

APPENDIX G

Approximating Caloric Expenditure

An estimate of the number of kilocalories (kcal) used each training session was accomplished by finding the mean $\dot{V}_{O_2}$ at the training workload of 360 kilopound meters (kpm). Since every liter of oxygen consumed required approximately five kcal of energy, the investigator multiplied five times 0.88 (mean $\dot{V}_{O_2}$) and divided by 360 kpm. This answer represented the number of kcal burned for every kpm of work; each exercise session was described in terms of total kpm performed. The respective daily totals were multiplied by 0.022604 kcal/kpm to find an estimated energy expenditure per training day.

A Kafranni McKalis Meter was used to determine the $\dot{V}_{O_2}$ required for each lap on the outdoor course. This amount was multiplied by 5 kcal/liter and the number of laps wheeled. The total caloric work for the training session was the sum of the outdoor wheeling and the laboratory hand cranking. A total kcal use was then estimated for each day graphed on Figure 12.

VITA

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