THE EFFECTS OF MARIHUANA ON SPECIFIC CARDIOVASCULAR PARAMETERS DURING EXERCISE

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Margaret F. Dosch

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UNIVERSITY OF WISCONSIN - LA CROSSE
School of Health, Physical Education and Recreation
La Crosse, Wisconsin 54601

Candidate: Margaret F. Dosch

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree: Master of Science. The candidate has completed her oral report.

Richard L. Hardy — Thesis Committee Member — 4/25/75 Date

Philip K. Wilson — Thesis Committee Member — 4/25/75 Date

Donald M. Rapp — Thesis Committee Member — 4/30/75 Date

This thesis is approved for the School of Health, Physical Education and Recreation.

Glenn M. Smith — Dean, School of Health, Physical Education and Recreation — 5-13-75 Date

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dedicated

with love

to the Significant Others in my life

who have taken the time

to Care...

ABSTRACT

The study was conducted to examine potential long term effects of marihuana upon the cardiovascular system before, during, and after submaximal exercise. The following specific cardiovascular parameters were used to compare long term marihuana users to non-users.

1) Resting heart rate and blood pressure
2) Exercise heart rate, blood pressure, and ECG changes
3) Immediate post-exercise heart rate, blood pressure, and ECG changes at two, four, and six minute intervals
4) Time on the treadmill to reach the exercise level of the target heart rate.

The two samples consisted of 23 computer matched pairs between the ages of 17 and 21. The subjects were solicited from the Personal Health and General Psychology classes offered in the curriculum at the University of Wisconsin-La Crosse. The screening and testing procedures were conducted over a period of two months.

The statistical model used in this study was the paired t test. The five percent level of confidence was the critical statistical value chosen for acceptance or rejection of the null hypothesis.

Significant differences between the marihuana users and non-users were found in heart rate and diastolic blood pressure during the post-exercise period. The users' heart rate was significantly lower than the non-users at four minutes post exercise. At four and six minutes post exercise the users' diastolic blood pressure was significantly higher than the non-users. There were no significant long term effects of marihuana on the resting cardiovascular parameters. The long term use of marihuana does not result in any apparent ECG changes.

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CHAPTER I

INTRODUCTION

In recent years the use of marihuana and its possible effects on health has been a subject of much controversy. Before any rational decision can be made about marihuana's effect on health, it is necessary to explore the long term effects of marihuana in man including the effects of its use on various measures of physical activity.

Some of the most reliable marihuana effects are observable in the cardiovascular system (Sec. HEW, 1972). It is, therefore, reasonable to wonder what effects long term use of marihuana might have on the cardiovascular functions of man and useful to assess if possible the risks to those individuals who have less than adequate cardiovascular functioning.

Statement of the Problem

Research has established that "physical activity sustains the cardiovascular system in a normal functional state and helps prevent cardiac failure" (Larson, 1974, p. 27). As yet, research has not determined whether or not long term use of marihuana results in any significant changes in the cardiovascular system during physical activity.

The purpose of this study was to evaluate some potential long term effects of marihuana on the cardiovascular system

by looking for marihuana effects during physical activity at submaximal workloads. This evaluation was accomplished by computer matching long term marihuana users to non marihuana users and examining the differences that exist among specific cardiovascular parameters. The cardiovascular parameters compared before, during, and after exercise were: 1) Heart Rate, 2) Blood Pressure, and 3) Electrocardiographic (ECG) Changes.

Scope of the Study

There were twenty-four female and twenty-two male subjects that participated in the modified standard Balke Treadmill Test. The specific cardiovascular parameters investigated were:

1) During exercise
   a) exercise heart rate, blood pressure, and ECG changes
   b) time on the treadmill to reach the exercise level of the target heart rate.
2) After exercise
   a) immediate post-exercise heart rate, blood pressure and ECG changes at two, four, and six minute intervals.

Questions to be Answered

It is intended that the following questions be answered as a result of this investigation:

1) What effects does long term use of marihuana have on exercise heart rate and blood pressure?
2) What effects does long term use of marihuana have on the specified ECG changes during exercise?
3) What effects does long term use of marihuana have on recovery heart rate and blood pressure?
4) What effects does long term use of marihuana have on the specified ECG changes during recovery?

Definition of Terms

Cannabis Sativa: A Hemp plant which is the principal biologic source from which marihuana and hashish are derived.

Delta-9-Tetrahydrocannabinol (THC): The principal psycho-active ingredient in marihuana.

Exercise ECG: The electrocardiogram is one of several valuable tools in assessing the state of the heart during exercise testing.

Hematocrit Test: To determine the percentage of volume of red blood cells.

Long term user: An individual using marihuana at least once a week for a minimum of eight months prior to the experiment.

Marihuana: A psycho-active drug derived from the flowering tops and leaves of the female Hemp plant, Cannabis Sativa or other cannabis varieties.

Non-User: An individual who has never used marihuana or who has not used it regularly for a year's period of time, and, has abstained from usage at least three months prior to the experiment.

Spirometer: An instrument to measure pulmonary function and in this study to test vital capacity (Lung capacity).

Standard Balke Treadmill Test: A standard testing procedure designed by Dr. Bruno Balke to determine the physiological changes during exercise as well as the subjects cardiovascular fitness level.

Submaximal workload: Any exercise workload below the subject's maximal exertional level.

Assumptions

For purposes of this study, it is assumed that:

1) The electrocardiogram is one of several reliable methods of measurement of good cardiac function and an indirect measure of somatic condition.
2) Changes from the baseline resting heart rate, blood pressure, and ECG are valid and reliable measures of changes in cardiovascular system and can be assumed to be related to marihuana usage after other known factors were screened for and eliminated.
3) Heart rate and blood pressure may be used as good indicators of exercise tolerance and hemodynamic status of individuals.

Limitations

The following are limitations of the study:

1) The results of the study are limited to the age range of the subjects.

2) The investigator did not know the quality of marihuana used by the experimental sample.

3) The investigator had only a limited amount of control concerning the subjects lifestyle.

Hypothesis

The null hypothesis for this investigation is that there will be no significant effect of long term use of marihuana on the examined cardiovascular parameters before, during, and after submaximal exercise.

CHAPTER II

REVIEW OF LITERATURE

There is little documented evidence which suggests the absence or presence of direct toxic effects of marihuana or whether associated disease states exist in Cannabis users (Jasinski, Haertzen & Isbell, 1971, p. 204). In particular, there has been very little revealed about the cardiovascular effects of marihuana, especially its long term effects as related to exercise. Most of the research has been accomplished while the subjects were under the influence of the drug and during physical inactivity.

The intent of this review was to present what research there was related to the effects of marihuana on the cardiovascular functions of man under a variety of conditions and controls. The review of literature relative to this study was divided into the following categories: 1) marihuana's effect on heart rate, 2) marihuana's effect on blood pressure, and 3) marihuana's effect on ECG changes.

Heart Rate

Heart rate is a consistent and objective measure of the effects of marihuana and it has been generally established that the use of marihuana does increase heart rate (Aronow & Cassidy, 1974; Beaconsfield, Ginsburg & Rainsbury, 1972; Isbell, Gorodetzsky, Jasinski, Claussen, Spulak & Korte, 1967;

Johnson & Domino, 1971; Roth, Tinklenberg, Kopell & Hollister, 1972; Weiss, Watanabe, Lemberger, Tamarkin & Cardon, 1972).

Weiss et al. (1972) showed a significant increase in heart rate in eight healthy subjects after orally administering a THC dose of "0.3 mg/kg body weight, dissolved in 1 ml. of 95 percent ethanol and diluted in cherry syrup" (p. 672). This oral dose was approximately equal to one or two smoked marihuana cigarettes which has an estimated dose of 5 mg of THC.

A marihuana dose of 600 mg containing 1.5% THC was administered by Clark, Greene, Karr, MacCannell and Milstein (1964) over a fifteen minute period by inhalation to twenty-eight subjects. The results indicated the most consistent cardiovascular response to marihuana was tachycardia.

At Stanford Medical Center Roth et al. (1972) found that subjects smoking one cigarette containing 20 mg of THC over a 10 minute period showed an increase in the heart rate within 15 minutes after the smoking began.

Isbell et al. (1967) compared the following THC doses: 120 mcg/kg orally, 480 mcg/kg orally, 50 mcg/kg by smoking, and 200 mcg/kg by smoking. The results of this comparison indicated that the resting pulse rates were consistently elevated and there was a highly significant relationship between dosage and heart rate.

In a two part study Johnson and Domino (1971) administered marihuana as 300 mg cigarettes. The first part of the study occurred in 1969 when 10 subjects received low doses of

marihuana that were analyzed at one time to contain 0.5 percent THC and at another time to contain 0.2 percent THC. In this low dose study the subjects smoked from two to five cigarettes. The second part of the study occurred in 1971 when 15 subjects smoked from one to four cigarettes of high doses of marihuana which contained 2.9 percent THC. They found that the increase in heart rate is dose-related and that marihuana-induced tachycardia continues for at least 90 minutes.

Munch (1966) indicates that "small doses produce tachycardia (rate up to 120/min. or greater)" (p. 15) while Roth et al. (1972) and Johnson and Domino (1971) reported that THC could produce tachycardia as great as 140 beats per minute or more.

Beaconsfield et al. (1972) and Kiplinger and Manno (1971) also observed that pulse rate rose and remained elevated up to one hour after administration of the drug and even longer depending on the dosage.

Blood Pressure

Hollister, Richards, and Gillespie (1968), Isbell et al. (1967), and Johnson and Domino (1971) have commented on the inconsistent effects of THC on blood pressure. Various investigators have reported that blood pressure may increase, decrease, or remain the same following administration of THC.

Jasinski et al. (1971) found no significant effects of THC on systolic blood pressure. Munch (1966) indicates that there is either a slight drop in blood pressure or else it remains unchanged. At the Addiction Research Center Isbell et al. (1967) observed his subjects after resting 10 minutes in bed and found that there were no significant changes in systolic and diastolic blood pressure following THC use.

Weiss et al. (1972) feel that the difference in the literature may partly reflect failure to note the effects of posture. At the Clinical Center of the National Institute of Health the subjects reportedly "showed an increase in recumbent MBP /mean blood pressure/. Upright MBP fell slightly overall, but this change was not statistically significant.... The results in the upright position are in general agreement with those of Hollister and associates (1968) whose subjects demonstrated mild orthostatic reduction in systolic and diastolic blood pressure after delta-9-THC" (Weiss et al., 1972, p. 682).

In a study of 10 healthy doctors Beaconsfield et al. (1972) established that in naive smokers "systolic pressure increased slightly in some subjects, but overall there was no significant change" (p. 210). Clark et al. (1974) noted that the small rise in blood pressure found in a study of experienced and non-experienced users could be a result of an increase in cardiac output. An elevation in systolic but not diastolic blood pressure was found by Roth et al. (1972).

Johnson and Domino (1971) found no significant changes in blood pressure with low doses of THC, however, at high

doses there was a significant increase in both systolic and diastolic blood pressure.

In Aronow and Cassidy's study (1974) using patients with angina pectoris due to coronary disease, significant increases in both systolic and diastolic blood pressure occurred.

ECG Changes

Kochar and Hosko (1973) state that few comments have been made on alterations in the electrical activity of the heart, and that "previous exposure to marihuana may play a role in determining the severity of electrocardiographic changes produced by a given dose of THC" (p. 27).

Hollister et al. (1968) observed no ECG changes even after oral doses of THC as high as 70 mg. In contrast, Beaconsfield et al. (1972) observed that the main change in five of six subjects was an increased width and decreased amplitude of the P wave in Lead 2. These changes occurred during and for approximately 30 minutes after smoking.

In Kochar and Hosko's study (1973) there was no change in the P wave but T-wave changes were observed. Also, T-wave inversion in Lead 3 was reported by Beaconsfield et al. (1973). Johnson and Domino (1971) observed flattened T-waves, particularly in the chest leads in many of their subjects, but, this was not a consistent result. They found that "T wave changes induced by exercise are more prominent than those induced by the marihuana smoking" (Johnson & Domino,

1971, p. 765). The decision of Johnson and Domino (1971) that marihuana produces minor ECG changes agrees with the conclusion of the study by Hollister et al. (1968).

Two subjects in the high-dose study by Johnson and Domino (1971) developed premature ventricular contractions (PVC's). Roth et al. (1972) note that "although these are the only two reports of VPC's /PVC's/ associated with marihuana intoxication in the literature, it should be realized that most experimenters have determined the pulse by palpation, an unreliable method of detecting arrhythmias, or have taken only short ECG tracings, which are inadequate for determining the frequency of such events" (p. 534). These investigators then designed a study in which there was continuous monitoring of the ECG during marihuana intoxication. The results of this study suggested that the incidence of PVC's in young male subjects were not ordinarily increased by marihuana.

The S-T segment is a cardiovascular variable that has been examined in healthy subjects as well as in patients having angina pectoris. Kochar and Hosko (1973) observed prominent S-T segment elevations in a study of healthy subjects. In the study with ten angina pectoris patients Aronow and Cassidy (1974) did not observe ischemic S-T depressions while the patients smoked marihuana or placebo-marihuana. There was also "no significant difference in the amount of maximal ischemic S-T-segment depression...after exercise-induced angina was observed between the control periods, after smoking of marihuana, and after smoking of placebo-marihuana" (Aronow & Cassidy, 1974, p. 66). However, these

investigators did find that "ischemic S-T-segment depression at the onset of exercise-induced angina pectoris occurred earlier and after less exertion after smoking of marihuana as compared to the control periods and after smoking of placebo-marihuana" (p. 67). They concluded that "smoking one marihuana cigarette decreases exercise performance in patients with angina pectoris due to coronary disease" (p. 67).

CHAPTER III

METHODOLOGY

Research Design

The study was designed to observe the long term effects of marihuana upon the cardiovascular system during exercise. The following cardiovascular parameters were used to compare long-term marihuana users to non-users:

1) resting heart rate, blood pressure and a twelve lead ECG.
2) exercise heart rate, blood pressure and an ECG.
3) immediate post-exercise heart rate, blood pressure and an ECG.
4) recovery heart rate, blood pressure and an ECG at two, four, and six minute intervals post exercise.
5) time on the treadmill to reach the exercise level of the target heart rate.

The submaximal workloads were established by using the standard Balke Treadmill Test and modifying it with a pre-determined target heart rate.

Apparatus Used

The equipment used for these tests were the following:

1) Quinton Treadmill Model No. 24-72
2) Quinton Cardiotachometer Model No. 609.

3) Quinton ECG Monitoring System Model No. 621

4) Marquette Electrocardiograph

5) Collins Respirometer Serial No. 2136

6) Adams Readacrit ™ CT-3400

Personnel Used

The primary investigator was assisted by the consulting physician, and four trained student technicians. The investigator was always in the same room with the subjects while they were on the treadmill. Whenever possible each technician assumed the same duties and responsibilities throughout the study to insure consistency in testing and recording procedures. The following is a description of the responsibilities of the personnel:

1) Place electrodes on subjects

2) Take and record resting heart rate, blood pressure, and ECG

3) Monitor and record exercise heart rate, blood pressure, and ECG

4) Monitor and record post exercise heart rate, blood pressure, and ECG

5) Change the grade of the exercise workload

6) Coordinate the peak exercise and immediate post-exercise data collection

7) Take and record the subjects' vital capacity

8) The consulting physician interpreted the exercise ECG changes

Selection of Sample

The subjects were solicited from the Personal Health and General Psychology classes offered in the curriculum at the University of Wisconsin-LaCrosse. It was decided that the combination of these courses presented a good cross section of available freshman and sophmore students since one course is a general elective and the other course is a basic studies elective. At a general introductory meeting of 206 interested volunteers the investigator explained the purpose and the procedures of the experiment as well as the requirements expected of the subjects. One hundred thirty-four volunteers decided to participate in the research study by filling out the profile information sheet (Appendix A).

Subjects Matched

A computer program was designed to match the subjects using the following criteria obtained from the profile sheets:

1) marihuana usage or non-usage
2) cigarette smoking or non-smoking
3) obesity factor
4) usage of other drugs
5) age
6) sex
7) race (Appendix B)

The computer program for the obesity factor was established by taking the measurements of weight, height and body frame

size and comparing them to the statistical data from Metropolitan Life Insurance Company (Appendix C).

The subjects were matched according to marihuana usage and non-usage and cigarette smoking and non-smoking. For all other factors under consideration the subjects were matched as closely as possible.

The mean age of the non-users was 18.95 years with a standard deviation of .82 while the users had a mean age of 19.04 years with a standard deviation of .92 (Table 1).

In the non-users sample there were 14 white females and 9 white males while the users sample contained 1 black and 9 white females and 13 white males (Table 1).

Table 1

Summary of the Subjects' Age, Sex, and Race

	Control Mean	Experimental Mean	Control Standard Deviation	Experimental Standard Deviation
Age	18.95 years	19.04 years	.824	.928
Sex	9 males 14 females	12 males 10 females		
Race	23 whites	1 black 22 whites		

The mean height for the non-users sample was 67.65 inches with a standard deviation of 3.32. In the users sample the mean height was 68.32 with a standard deviation of 3.79 (Table 2).

The non-users had a mean weight of 139.21 pounds and a standard deviation of 18.14 with a mean obesity factor of .01 and a standard deviation of .02. The frame sizes of the non-users sample were 1 large, 19 medium and 3 small (Table 2). In the users sample the mean weight was 147.60 pounds with a standard deviation of 24.12 and a mean obesity factor of .01 with a .04 standard deviation. The frame sizes of the users sample were 4 large, 15 medium, and 4 small (Table 2).

Table 2

Summary of the Subjects' Height, Weight, Frame Size, and Obesity Factor

	Control Mean	Experimental Mean	Control Standard Deviation	Experimental Standard Deviation
Height	67.65 inches	68.32 inches	3.324	3.797
Weight	139.21 lbs.	147.60 lbs.	18.143	24.120
Frame Size	1 large 19 medium 3 small	4 large 15 medium 4 small		
Obesity Factor	.01	.01	.029	.048

Seventeen subjects from each sample were non-cigarette smokers while six subjects in each sample smoked cigarettes. The number of cigarettes that each subject smoked was expressed in pack years (Appendix B). Pack years is calculated as the number of packs smoked per day times the length of time in years that the subject has smoked.

Each subject's usage of other drugs was evaluated by the consulting physician as light, moderate or heavy (Appendix B). The drugs considered in this category were:

1) caffeine
2) alcohol
3) CNS Stimulants
4) CNS Depressants
5) Psychotomimetics

A summary of each drug is found in Table 3.

Table 3

Summary of the Subjects Other Drug Usage

	Control	Experimental
Caffeine	4 None 19 Light	2 None 21 Light
Alcohol	5 None 17 Light 1 Moderate	0 None 15 Light 3 Moderate 5 Heavy
CNS Stimulants	22 None 1 Light	11 None 12 Light
CNS Depressants	21 None 2 Light	20 None 3 Light
Psychotomimetics	23 None	13 None 10 Light

Fifty-six volunteers, 28 males and 28 females between the ages of 17 and 21 were originally matched.

Measurement Procedures

Screening Procedure Measurement

Each of the fifty-six subjects was mailed an information sheet explaining the protocol for the screening procedures. The subjects were given three weeks to complete the screening procedures. A follow up by telephone was made to those subjects who had not participated in the screening procedures by the beginning of the third week. At this time five subjects dropped from the study.

Fifty-one subjects participated in a physical examination including a hematocrit and a health history at the University of Wisconsin-LaCrosse Health Center. The hematocrit techniques were done according to the procedures explained in Page and Culver (1960). The subjects also had a pulmonary function test and a standard resting twelve lead ECG taken at the Human Performance Laboratory. The pulmonary function test was used to determine the subjects' vital capacity and was done with a respirometer according to the procedures described by Ricci (1970). The consulting physician interpreted these tests which showed no significant abnormalities in any of the subjects and therefore allowed the subjects to participate in the investigation (Appendix B).

The mean hematocrit for the non-users sample was 42.34 with a standard deviation of 3.78. The users sample had a mean value of 44.06 with a standard deviation of 3.42 (Table 4).

The non-users had a mean vital capacity of 94.04 with a standard deviation of 10.88 while the users had a mean of 94.86 and a standard deviation of 17.64 (Table 4).

All of the subjects resting ECG's were within normal limits (Appendix B).

Table 4

Summary of the Subjects
Hematocrit and Vital Capacity

	Control Mean	Experimental Mean	Control Standard Deviation	Experimental Standard Deviation
Hematocrit	42.34	44.06	3.785	3.425
Vital Capacity	94.04	94.86	10.881	17.641

Testing Procedure Measurements

The subjects scheduled their exercise test so that it would fit into their academic schedules. A written reminder was sent to each subject approximately 48 hours prior to their scheduled exercise test. This reminded each subject that 24 hours prior to the exercise test the subjects were instructed to abstain from marihuana, cigarette smoking, coffee, tea, sodas, aspirin, cold tablets, alcohol and any other drugs unless prescribed by a physician. If the subjects were unable to abstain they were instructed to notify the primary investigator or the consulting physician in charge of the experiment and then were rescheduled.

Upon arrival at the Human Performance Laboratory the subjects were required to sign a consent form (Appendix D) stating that they understood the nature of the experiment and that they had abstained from the indicated drugs. The subjects then rested in a sitting position in the Human Performance Laboratory for at least 15 minutes prior to the exercise test. During this time the resting heart rate and blood pressure were recorded and the electrodes were placed on the subject. The electrode placement was a simple bipolar lead with the reference electrode on the manubrium and the monitoring lead at chest position V5. The ground lead was placed at "RL." This procedure was according to the description by Blackburn (1967). A modified standard Balke Treadmill Test (Appendix E) was then administered to all subjects, as follows:

First, the subjects participated for a three minute period of exercise at a low work intensity while heart rate, ECG, and blood pressure were recorded. This accommodation period was done "to familiarize the subject with the equipment and with the type of work required" (Larson, 1974, p. 475). Next, the subjects rested for two minutes in a chair while any technical difficulties were adjusted. Again the subjects' heart rate, blood pressure and ECG were recorded. Finally, the subjects were ready to participate in the actual test. The test started at the workload intensity of the accommodation period, 2.5% grade at 3.0 miles per hour for two minutes. At the end of each two minute phase the grade

was increased 2.5% while the speed remained the same. Blood pressure was taken the last 45 seconds of each workload phase and the heart rate and ECG were recorded the last 15 seconds of each workload phase. The test was terminated when one of the following predetermined conditions occurred:

1) the subject suffered chest discomfort and/or pain
2) the subject showed signs of distress either physically or verbally
3) systolic blood pressure exceeded 240-250 mm/Hg
4) diastolic pressure rose to more than 125 mm/Hg
5) pulse pressure declined even though there was an increase in workload intensity
6) any significant arryhthmias or greater than 10 PVC's per minute
7) a heart rate of 188 beats per minute was reached according to the ECG recording.

To determine what the target heart rate for the submaximal test should be, the investigator found in the literature that "Balke (1954) and Balke et al. (1954) showed by several criteria that a limitation of optimal cardiovascular and respiratory function exists when a pulse rate of 180 beats per minute is reached during a gradually increased workload" (Consolazio, Johnson & Pecora, 1963, p. 371). Also, Sheffield (1972) proposed the termination of the exercise when the subjects "heart rate reaches 90% of the expected maximal heart rate predicted according to his age" (p. 11), and Larson (1974) suggests that the test should terminate when the subject

"reaches a level of approximately 80% of its estimated maximal value" (p. 487). The average maximal heart rate for the age groups involved in this study can be assumed as 200 beats per minute for 16-20 years of age and 190 beats per minute for 21-35 years of age (Larson, 1974). Based on these findings the submaximal exercise test was terminated when the heart rate reached within a range of 177 to 190 beats per minute.

When the subjects reached their predetermined target heart rate and a 15 second ECG was recorded, they were immediately brought down to a steady state of 1.5 mph at 0% grade for two minutes of recovery walking. Both the grade and the speed were reduced simultaneously and the subjects heart rate and ECG were recorded within 10 seconds of beginning the immediate post-exercise task of recovery walking. Within 10 seconds after the treadmill had reached the level of 1.5 mph at 0% grade the subjects ECG, heart rate and blood pressure were recorded for a second immediate post-exercise evaluation. Subjects were given a two minute, four minute, and six minute recovery period in a sitting position directly following the immediate post-exercise phase. The ECG and heart rate were monitored the first 15 seconds of each new recovery phase and the blood pressure was taken immediately afterwards. Data collected (Appendix B) from these measurement procedures were uniformly recorded on special inventories (Appendix F). During the testing procedures five more subjects dropped from the investigation.

Statistical Design

The comparison was based on the differences between heart rate, blood pressure, and ECG during rest, exercise, and recovery. The paired t test was used to determine the differences between the two matched samples. The mean and standard deviation were calculated for each parameter in both samples and the .05 level of significance was accepted for this investigation.

Validity and Reliability

It was assumed that the heart rate, blood pressure, and ECG measurements observed at rest, exercise, and recovery were a valid and accurate criteria for examining long term effects of marihuana on the cardiovascular system.

For the reliability of the investigation, the resting 12 lead ECG, heart rate, and blood pressure and the modified standard Balke Treadmill Test were repeated in about 10% of each sample and no significant differences were found between the results of the two tests.

CHAPTER IV

ANALYSIS OF DATA

The purpose of this study was to evaluate some potential long term effects of marihuana on the cardiovascular system by looking for possible marihuana effects before, during, and after exercise at submaximal workloads. This was accomplished by comparing several cardiovascular measures between marihuana users and non-users. Heart rate, blood pressure, and ECG changes were the cardiovascular measures observed. The time required for the subject to reach the predetermined heart rate while participating in the modified Balke Treadmill Test was also noted. This chapter is subdivided as follows: 1) Results and 2) Discussion.

Results

The results were obtained from a total of 23 matched subjects between the ages of 17 and 21.

The statistical model used in this study for the analysis of data was the paired t test.

The description of data is divided into three areas: 1) heart rate, 2) time required to reach peak heart rate, and 3) blood pressure.

Heart rate

Resting. The mean resting heart rate of the non-users was 78.73 b/m (beats per minute) with a standard deviation of

10.32. In the users the mean value showed 77.78 b/m with a standard deviation of 10.93. The difference between the means of the two samples was not statistically significant (Table 5).

Two minute post-exercise. The difference in the mean heart rates at two minutes post-exercise was not significant. The non-users had a mean heart rate of 122.26 b/m with a standard deviation of 7.04. The users had a lower mean heart rate of 118.73 b/m with a standard deviation of 11.18 (Table 5).

Four minute post-exercise. The mean heart rates at four minutes post-exercise showed a significant difference between the users and non-users. The non-users had a higher mean value of 101.60 b/m compared to 95.52 b/m of the users. The standard deviation of the non-users was 7.72 as compared to 11.64 for the users. The computed t value was 2.41 ($df=22$); $p<.01$ (Table 5).

Six minute post-exercise. At six minutes post-exercise the mean heart rate for the non-users was 98.05 b/m while the users was 92.89 b/m. The standard deviation for the non-users was 8.69 and 10.33 for the users sample. The difference between these means were not significant (Table 5).

Time to reach Target Heart Rate

The mean time for the non-users was 14.84 minutes with a standard deviation of 3.47. The users mean time value was approximately the same, 14.20 minutes with a standard

deviation of 3.70. The difference between these means was not significant (Table 6).

Table 5

Summary of Mean Heart Rates
Results and Statistical Comparison

	Control Mean b/m	Experimental Mean b/m	t Score	Probability
Resting	78.73	77.78	0.308991	.380 (NS)
Two minute post-exercise	122.26	118.73	1.38966	.089 (NS)
Four minute post-exercise	101.60	95.52	2.41526	**.012
Six minute post-exercise	98.05	92.89	1.54159	.070 (NS)

** Significant at the .05 level

Table 6

Summary of Mean Time to Reach Target Heart Rate

Results and Statistical Comparison

	Control Mean	Experimental Mean	t Score	Probability
Time to reach Target Heart Rate	14.84	14.20	.795048	.217 (NS)

Systolic Blood Pressure

Resting. The mean resting systolic blood pressure was 111.30 mm/Hg with a standard deviation of 10.35 for the non-users. The users had a mean resting systolic blood pressure of 114.56 mm/Hg and a standard deviation of 13.72. The difference between the means was not significant (Table 7).

Peak exercise. The mean systolic blood pressure at the peak of exercise was 152.39 mm/Hg with a standard deviation of 20.38 for the non-users. The users had a mean value of 151.52 mm/Hg with a standard deviation of 22.83. The difference between the means of the two samples was not significant (Table 7).

Two-minute post-exercise. At two minutes post-exercise the mean systolic blood pressure for the non-users was 128.26 mm/Hg with a standard deviation of 16.48. The mean systolic blood pressure for the users was 127.60 mm/Hg with a standard deviation of 14.91. The difference between the means of the two samples was not significant (Table 7).

Four-minute post-exercise. The mean four minute post-exercise systolic blood pressure was 116.52 mm/Hg with a standard deviation of 12.37 for the non-users. The users had as a mean value 115.43 mm/Hg and a standard deviation of 14.60. The difference between the means of the two samples was not significant (Table 7).

Six-minute post-exercise. The systolic blood pressure at six minutes post-exercise indicated a mean value of

109.21 mm/Hg with a standard deviation of 11.81 for the non-users. The users' mean value was 107.63 mm/Hg with a standard deviation of 14.65. This difference was not significant (Table 7).

Table 7

Summary of Mean Systolic Blood Pressure Results and Statistical Comparison

	Control Mean mm/Hg	Experimental Mean mm/Hg	t Score	Probability
Resting	111.30	114.56	-.874818	.195 (NS)
Peak exercise	152.39	151.52	.161153	.436 (NS)
Two minute post exercise	128.26	127.60	.152	.440 (NS)
Four minute post exercise	116.52	115.43	.321111	.375 (NS)
Six minute post exercise	109.21	107.63	.430405	.336 (NS)

Diastolic Blood Pressure

Resting. The non-users mean resting diastolic blood pressure was 74.13 mm/Hg with a standard deviation of 11.44. The mean value for the users was 73.47 mm/Hg with a standard deviation of 11.32. The difference between the means of the two samples was not significant (Table 8).

Peak exercise. The mean diastolic blood pressure at the peak of exercise for the non-users was 68.91 mm/Hg compared

to 66.08 mm/Hg for the users. The standard deviation for the non-users was 18.21 while the users sample had a standard deviation of 13.89. The difference between the means of the two samples was not significant (Table 8).

Two minute post-exercise. The non-users had a mean two minute post-exercise diastolic blood pressure of 65.21 mm/Hg with a standard deviation of 12.74. The users had a mean value of 67.17 mm/Hg with a standard deviation of 11.56. The difference between the means of the two samples was not significant (Table 8).

Four minute post-exercise. The mean diastolic blood pressure at four minutes post-exercise showed a significant difference between the users and the non-users. The non-users mean value was 66.08 mm/Hg with a standard deviation of 17.64 while the users had a mean value of 73.69 mm/Hg with a standard deviation of 11.30. The t value was computed as -1.90 ($df=22$); $p<.03$ (Table 8).

Six minute post-exercise. At six minute post-exercise there was a significant difference between the means of the two samples. The mean diastolic blood pressure for the non-users was 68.15 mm/Hg with a standard deviation of 9.60. The users had a higher mean value of 74.47 mm/Hg with a standard deviation of 11.29. The computed t score was -2.10 ($df=18$); $p<.02$ (Table 8).

Table 8

Summary of Mean Diastolic Blood Pressure

Results and Statistical Comparison

	Control Mean mm/Hg	Experimental Mean mm/Hg	t Score	Probability
Resting	74.13	73.47	.202176	.420 (NS)
Peak exercise	68.91	66.08	.591743	.280 (NS)
Two minute post exercise	65.21	67.17	- .55728	.291 (NS)
Four minute post exercise	66.08	73.69	-1.90247	**.035
Six minute post exercise	68.15	74.47	-2.10046	**.025

** Significant at the .05 level

Discussion

Resting heart rate is a reliable indicator of physical fitness and is therefore found to be lower in individuals that are physically fit (Astrand, 1972; Bevegard, 1960; Cooper, 1970; & Fox, 1966).

Several studies (Isbell et al., 1967; Johnson and Domino, 1971; & Roth et al., 1972) have indicated that short term effects of marihuana increases the resting heart rate.

In looking for possible long term effects of marihuana there was no significant differences between the non-users' and the users' mean resting heart rates (control, 78.73 b/m

and experimental, 77.78 b/m). This result suggests that the cardiovascular fitness level was the same.

There also was no significant difference between the two samples in the time required to reach the target heart rate. The non-users' mean peak exercise time was 14.84 and for the users, 14.20. This result indicates that the two samples showed similar responses to exercise at a given workload. Between minute 14 and minute 16 the workload was 3.0 mph with a grade of 20.0%. This data suggests that there were no significant differences between the two samples in terms of physical fitness level or the heart rate response to exercise.

Although the physical fitness level was approximately the same between the two samples, the recovery period of the users was shorter than the recovery period of the non-users. At two minutes the non-users mean heart rate was 122.26 b/m while the users had a mean heart rate of 118.73 b/m. At four minutes the non-users had a mean heart rate of 101.60 b/m while the users had a significantly lower mean heart rate of 95.52 b/m. At six minutes the non-users again had a higher mean heart rate of 98.05 b/m compared to the users' mean heart rate of 92.89 b/m.

Since there was no significant difference between the two samples with respect to these measures of physical fitness level, the shorter recovery period of the marihuana users suggests that more blood was being supplied both to the peripheral system and to the heart.

While the data indicates an increase in blood flow to the peripheral system, it is not known whether the increase is due to force of contraction of the heart and the stroke volume or due to peripheral vasodilation. Several researchers (Beaconsfield et al., 1972 & Weiss et al., 1972) indicated that peripheral vasodilation and increase blood flow was a short term effect of marihuana on the cardiovascular system. This data suggests it may be a long term effect as well.

Several studies (Isbell et al., 1967, and Jasinski et al., 1971) have indicated that short term effects of marihuana showed no significant changes in resting blood pressure.

The data collected in this study indicated that there were no significant differences between the two samples in terms of mean resting blood pressure measures (control, 111.30/74.13 mm/Hg and experimental, 114.56/73.47 mm/Hg).

At two minutes post-exercise the non-users' had a mean systolic blood pressure of 128.26 mm/Hg while the users had a lower mean systolic blood pressure of 127.60 mm/Hg. At four minutes the mean systolic blood pressure of the non-users was 116.52 mm/Hg while 115.43 mm/Hg was the mean value of the users sample. At six minutes the non-users had a mean systolic blood pressure of 109.21 mm/Hg while the users had a mean systolic blood pressure of 107.63 mm/Hg. This indicates that vasodilation of the peripheral system which is a normal result of exercise appears to be continuing during the recovery period. This might explain the lower blood pressure in the users sample.

At two minutes post-exercise the non-users had a mean diastolic blood pressure of 65.21 mm/Hg while the users had a mean diastolic blood pressure of 67.17 mm/Hg. At four minutes the mean diastolic blood pressure of the non-users was 66.08 mm/Hg while the users had a significantly higher mean diastolic blood pressure of 73.69 mm/Hg. At six minutes the non-users had a mean diastolic blood pressure of 68.15 mm/Hg while the users again had a significantly higher mean diastolic blood pressure of 74.47 mm/Hg. The significantly higher mean diastolic blood pressure values for users supports the same interpretation of dilated peripheral vessels. At peak exercise no significant differences were seen in either systolic or diastolic blood pressures.

This data indicates that both increased force of contraction and increased stroke volume of the heart, as well as peripheral vasodilation could occur at the same time. An increased force of contraction, peripheral vasodilation, and a resulting increased blood flow results from the stimulation of the sympathetic nervous system, which is known as the beta-adrenergic mechanism.

In reviewing the literature this investigator did not find indications of how the sympathetic nervous system stimulation might be increased. Two possibilities have been mentioned in the literature:

1) An effect on the central nervous system to release more norepinephrine and epinephrine to activate the sympathetic nervous system.

2) An increase in the effect of norepinephrine and epinephrine on the alpha and beta receptors.

The alpha and beta receptors are found in most tissues of the body but the most sensitive areas include:

1) heart
2) peripheral blood vessels, particularly the arterioles
3) bronchials of the lung
4) certain endocrine sites

Basic research has shown that most central nervous system depressants can exhibit a rebound effect whereby after the acute phase of drug use there is often an increase above baseline levels of the secretion of norepinephrine and epinephrine. This has not been specifically shown to be true for marihuana in the data available, therefore any discussion would be theoretical.

ECG measures of the two samples were not significantly different. Two subjects from each sample showed ECG changes. Subject #15 in the non-users sample indicated consistent S-T flattening and depression at 2 and 3 mm and T-wave inversion. The other non-user subject was #19 who showed 1 mm S-T depression at 3/4 exercise and at peak exercise.

In the users sample, subject #23 indicated 1 mm S-T depression at peak exercise. The second subject, #10, in the users sample showed T-wave inversion prior to the peak exercise workload and also showed 1 mm S-T depression at the peak workload.

Minor ECG changes occurred in both samples and it was concluded that these changes were probably not related to marihuana.

CHAPTER V

SUMMARY

The purpose of this study was to examine potential long term effects of marihuana upon the cardiovascular system before, during, and after submaximal exercise. The following specific cardiovascular parameters were used to compare long term marihuana users to non-users:

1) Resting heart rate and blood pressure.
2) Exercise heart rate, blood pressure, and ECG changes.
3) Immediate post-exercise heart rate, blood pressure and ECG changes at two, four, and six minute intervals.
4) Time on the treadmill to reach the exercise level of the target heart rate.

The two samples consisted of 23 computer matched pairs between the ages of 17 and 21. The subjects were solicited from the Personal Health and General Psychology classes offered in the curriculum at the University of Wisconsin-LaCrosse. The screening and testing procedures were conducted over a period of two months.

The statistical model used in this study was the paired t test. The five percent level of confidence was the critical statistical value chosen for acceptance or rejection of the null hypothesis.

Conclusions

The following observations were made:

1) Marihuana has no significant long term effects on the resting cardiovascular parameters.
2) The cardiovascular fitness level between long term users and non-users was not significantly different.
3) Post-exercise time period was shorter in marihuana users than non-users:
    a) heart rate at four minutes post-exercise was significantly lower in the users sample.
    b) diastolic blood pressure at four minutes and six minutes post-exercise was significantly higher in the users sample.
4) Long term use of marihuana does not result in any apparent ECG changes.

Recommendations

1) A similar study conducted with a larger sample of subjects.
2) A similar study conducted to compare users during marihuana consumption to non-users during exercise.
3) A similar study conducted to include cardiac output measurements.
4) A similar study conducted to determine the effect of long term use of marihuana on total fitness.

BIBLIOGRAPHY

Aronow, W.S., and Cassidy, J. Effect of Marihuana and Placebo-Marihuana smoking on Angina Pectoris. The New England Journal of Medicine, 1974, 291 (2), 65-67.

Astrand, P.O. Health and Fitness, Stockholm, Skandia Ins. Comp. Pub., 1972, 13-19.

Beaconsfield, P., Ginsburg, J., and Rainsbury, R. Cardiovascular Effects in Man and Possible Mechanisms. The New England Journal of Medicine, 1972, 287 (5), 209-212.

Bevegard, S., Holmgren, A. and Johnson, B. The effect of Body Position on the Circulation at Rest and During Exercise with special reference to the influence on Stroke Volume. Acta Physio. Scand., 1960, 49, 279-298.

Blackburn, H., Taylor, H.L., Okamote, N., Rautaharju, P., Mitchell, P.L. and Kerkhof, A.C., In M. J. Karvonen and A. J. Barry (Eds.), Physical Activity and the Heart, Springfield, Illinds, Charles C. Thomas, 1967, 101-133.

Clark, S.C., Greene, C., Karr, G.W., MacCannell, K.L., and Milstein, S.L. Cardiovascular Effects of Marihuana in Man. Can. J. Physiol. Pharmacol., 1974, 52, 706-719.

The Committee on Exercise. Exercise Testing and Training of Apparently Healthy Individuals: A Handbook for Physicians. New York, AHA, 1972.

Consolazio, C.F., Johnson, R.E., and Pecora, L.J. Physiological Measurements of Metabolic Functions in Man. New York: McGraw-Hill, 1963.

Cooper, K.H., The New Aerobics, M. Evans and Company, Inc., New York, 1970, 92-118.

Fox, S.M., and Haskell, W.L., Physical Activity and Health Maintenance. Journal of Rehabilitation, 1966, 32, 89-92.

Hollister, L.E., Richards, R.K., and Gillespie, H.K. Comparison of tetrahydrocannabinol and synhexyl in Man. Clinical Pharmacology and Therapeutics, 1968, 9, 783-791.

Isbell, H., Gorodetzsky, C.W., Jasinski, D., Claussen, U., Spulak, F.V., Korte, F. Effect of (-) Delta-9-Trans-Tetrahydrocannabinol in Man. Psychopharmacologia, 1967, 11, 184-188.

Jasinski, D.R., Haertzen, C.A., and Isbell, H. Review of the Effects in Man of Marijuana and Tetrahydrocannabinols on Subjective State and Physiologic Functioning. Annals New York Academcy of Sciences, 1971, 191, 196-205.

Johnson, S. and Domino, E.F. Some Cardiovascular Effects of Marihuana Smoking in Normal Volunteers. Clinical Pharmacology and Therapeutics, 1971, 12, 762-768.

Kiplinger, G.F. and Manno, J.E. Dose-Response Relationships To Cannabis in Human Subjects. Pharmacological Reviews, 1971, 23 (4), 339-347.

Kochar, M.S. and Hosko, M.J. Electrocardiographic Effects of Marihuana. The Journal of the American Medical Association, 1973, 225 (1), 25-27.

Larson, L. (Ed.) Fitness, Health, and Work Capacity: International Standards for Assessment. New York, MacMillan, 1974.

Lemberger, L., Axelrod, J., and Kopin, I.J. Metabolism and Disposition of Tetrahydrocannabinols in Naive Subjects and Chronic Marijuana Users. Annals New York Academcy of Sciences, 1971, 191 (a), 142-154.

Munch, J.C. Marihuana and Crime. Bull. Narcot., 1966, 18 (2), 15.

Page, and Culver. A Syllabus of Laboratory Examinations in Clinical Diagnosis. Cambridge, Mass., Harvard University Press, 1960, 52-59.

Ricci, B. Experiments in the Physiology of Human Performance. Philadelphia, Lea and Febiger, 1970, 132-138.

Roth, W.T., Tinklenberg, J.R., Kopell, B.S., and Hollister, L.E. Continuous Electrocardiographic Monitoring during Marihuana Intoxication. Clinical Pharmacology and Therapeutics, 1973, 14 (4), 533-540.

The Secretary of Health, Education and Welfare, Marihuana and Health, Second Annual Report to Congress, May, 1972, 147-148.

Tennessee Heart Association Physical Exercise Committee. Physician's Handbook for Evaluation of Cardiovascular and Physical Fitness. Nashville, Tennessee Heart Association, 1972.

Weiss, J.L., Watanabe, A.M., Lemberger, L., Tamarkin, N.R., and Cardon, P.V. Cardiovascular effects of Delta-9-Tetrahydrocannabinol in Man. Clinical Pharmacology and Therapeutics, 1972, 13, 671-684.

APPENDIX A

Profile Sheet

Name _____

Local Address _____

Phone Number _____

Age _____

Sex _____

Race _____

Weight (without shoes) _____

Height _____

Frame size _____

Smoke Tobacco Cigarettes: Yes _____ No _____

Marihuana User _____ Non-User _____

Have you used other drugs: Yes _____ No _____

If Marihuana User:

How long have you been doing marihuana?

_____ years _____ months

How many times a week do you do marihuana?

_____

If Non-User:

Have you ever experimented with marihuana?

Yes _____ No _____

If the answer is yes:

How long did you do it? _____ Years _____ Months

How many times a week? _____

APPENDIX B

MARIHUANA USAGE

Subject #	Control	Experimental
1	NU	3 years; 4x/week
2	NU	2½ years; 2x/week
3	NU	3 years; daily
4	NU	1½ years; 2x/week
5	NU	2 years; 3-4x/week
6	NU	9 months; daily
7	NU	1 year; 2x/week
8	NU	4 years; 1x/week
9	NU	1½ years; 6x/week
10	NU	3 years; 5x/week
11	NU	1¼ years; 2x/week
12	NU	1 year; 1x/week
13	NU	3 years; 4-5x/week
14	NU	2 years; 2x/week
15	NU	5 years; daily
16	NU	2 years; 2-3x/week
17	NU	4 years; daily
18	NU	3 years; 2-3x/week
19	NU	4 years; daily
20	NU	1½ years; 3-4x/week
21	NU	8 months; 1-2x/week
22	NU	1½ years; 3x/week
23	NU	1½ years; 2-3x/week

NU = Non-User

CIGARETTE SMOKING

Subject #	Control	Experimental
1	NS	NS
2	NS	NS
3	NS	NS
4	NS	NS
5	NS	NS
6	NS	NS
7	NS	NS
8	NS	NS
9	NS	NS
10	NS	NS
11	NS	NS
12	NS	NS
13	NS	NS
14	NS	NS
15	NS	NS
16	NS	NS
17	NS	NS
18	1.14	.5
19	.5	4
20	2	1
21	.16	.14
22	4	1
23	.75	1.5
	17 Non Smokers 6 Smokers	17 Non Smokers 6 Smokers

Amount smoked expressed in pack years

AGE

Subject #	Control Years	Experimental Years
1	21	19
2	18	18
3	20	20
4	19	19
5	18	18
6	20	20
7	20	20
8	19	19
9	19	21
10	18	17
11	19	19
12	18	19
13	20	21
14	19	19
15	18	19
16	19	19
17	19	19
18	19	19
19	19	19
20	19	19
21	18	18
22	18	18
23	19	19
Mean	18.95	19.04
S.D.	.82	.92

SEX

Subject #	Control	Experimental
1	M	M
2	M	M
3	M	M
4	M	M
5	M	M
6	M	M
7	M	M
8	M	M
9	M	M
10	F	F
11	F	F
12	F	M
13	F	F
14	F	M
15	F	M
16	F	F
17	F	M
18	F	F
19	F	F
20	F	F
21	F	F
22	F	F
23	F	F
	14 Females 9 Males	10 Females 13 Males

RACE

Subject #	Control	Experimental
1	W	W
2	W	W
3	W	W
4	W	W
5	W	W
6	W	W
7	W	W
8	W	W
9	W	W
10	W	W
11	W	W
12	W	W
13	W	W
14	W	W
15	W	W
16	W	W
17	W	W
18	W	W
19	W	W
20	W	W
21	W	W
22	W	B
23	W	W
	23 Whites	1 Black 22 Whites

HEIGHT

Subject #	Control Inches	Experimental Inches
1	70	74
2	74	68
3	69	72
4	67	76
5	71½	71
6	69½	71
7	70	69½
8	74	73½
9	66	70
10	66	68
11	63	63
12	68	67
13	69	63
14	63	71
15	60½	66
16	68	63
17	68	70
18	66	63½
19	67	63
20	70	68
21	65	69
22	67½	67
23	64	65
Mean	67.65	68.32
S.D.	3.32	3.79

WEIGHT

Subject #	Control lbs.	Experimental lbs.
1	179	195
2	155	150
3	149	165
4	130	190
5	158	158
6	155	155
7	155	166
8	160	166
9	148	155
10	131	144
11	120	115
12	145	150
13	145	108
14	120	175
15	105	145
16	148	125
17	140	155
18	112	126
19	119	110
20	134	127
21	116	140
22	135	115
23	143	160
Mean	139.21	147.60
S.D.	18.14	24.12

FRAME SIZE

Subject #	Control	Experimental
1	L	L
2	M	M
3	M	M
4	M	L
5	M	M
6	M	M
7	M	L
8	M	M
9	M	S
10	M	M
11	M	M
12	M	M
13	M	S
14	S	M
15	S	M
16	M	M
17	M	M
18	M	M
19	S	S
20	M	M
21	M	L
22	M	S
23	M	M
	1 Large 19 Medium 3 Small	4 Large 15 Medium 4 Small

OBESITY FACTOR

Subject #	Control	Experimental
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	.03	.03
10	0	0
11	0	0
12	.013	.02
13	0	0
14	.06	.06
15	.009	.01
16	.03	.02
17	0	0
18	0	0
19	0	0
20	0	0
21	0	0
22	0	0
23	.13	.23
Mean	.01	.01
S.D.	.02	.04

CAFFEINE

Subject #	Control	Experimental
1	1	1
2	1	1
3	1	0
4	1	1
5	1	1
6	1	1
7	1	1
8	0	1
9	1	1
10	1	1
11	0	1
12	1	1
13	1	1
14	0	1
15	0	0
16	1	1
17	1	1
18	1	1
19	1	1
20	1	1
21	1	1
22	1	1
23	1	1
	4 None 19 Light	2 None 21 Light

0 = None and 1 = Light

ALCOHOL

Subject #	Control	Experimental
1	1	2
2	0	1
3	0	1
4	0	1
5	1	1
6	1	1
7	2	1
8	0	2
9	1	3
10	1	1
11	1	3
12	1	1
13	1	1
14	1	3
15	0	2
16	1	3
17	1	1
18	1	1
19	1	1
20	1	1
21	1	3
22	1	1
23	1	1
	5 None 17 Light 1 Moderate	0 None 15 Light 3 Moderate 5 Heavy

0 = None, 1 = Light, 2 = Moderate, and 3 = Heavy

CENTRAL NERVOUS SYSTEM STIMULANTS

Subject #	Control	Experimental
1	0	1
2	0	0
3	0	1
4	0	0
5	0	0
6	0	1
7	0	0
8	0	0
9	0	1
10	0	1
11	0	1
12	0	0
13	0	1
14	0	0
15	0	1
16	0	1
17	0	1
18	0	1
19	0	0
20	0	0
21	0	0
22	0	0
23	1	1
	22 None 1 Light	11 None 12 Light

0 = None and 1 = Light

CENTRAL NERVOUS SYSTEM DEPRESSANTS

Subject #	Control	Experimental
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	1
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
17	0	1
18	1	1
19	0	0
20	0	0
21	1	0
22	0	0
23	0	0
	21 None 2 Light	20 None 3 Light

0 = None and 1 = Light

PSYCHOTOMIMETICS

Subject #	Control	Experimental
1	0	1
2	0	0
3	0	1
4	0	0
5	0	1
6	0	1
7	0	0
8	0	0
9	0	1
10	0	1
11	0	1
12	0	0
13	0	1
14	0	0
15	0	1
16	0	0
17	0	1
18	0	0
19	0	0
20	0	0
21	0	0
22	0	0
23	0	0
	23 None	13 None 10 Light

0 = None and 1 = Light

HEMATOCRIT

Subject #	Control	Experimental
1	44	49
2	43	48
3	45	44
4	46	50
5	44	45
6	46	50
7	48	43
8	52	48
9	41	43.5
10	45	38
11	40	42
12	39	48
13	44	42
14	38	44
15	41	45
16	39	41
17	44	42
18	43	40
19	38	45
20	37	41
21	38	39
22	38	43
23	41	43
Mean	42.34	44.06
S.D.	3.78	3.42

VITAL CAPACITY

Subject #	Control	Experimental
1	99	87
2	83	79
3	100	94
4	91	124
5	103	98
6	105	73
7	80	89
8	97	95
9	104	101
10	81	115
11	90	91
12	104	68
13	102	92
14	95	93
15	87	128
16	107	88
17	90	128
18	107	96
19	92	79
20	81	89
21	68	90
22	87	66
23	110	119
Mean	94.04	94.86
S.D.	10.88	17.64

RESTING ECG

Subject #	Control	Experimental
1	WNL	WNL
2	WNL	WNL
3	WNL	WNL
4	WNL	WNL
5	WNL	WNL
6	WNL	WNL
7	WNL	WNL
8	WNL	WNL
9	WNL	WNL
10	WNL	WNL
11	WNL	WNL
12	WNL	WNL
13	WNL	WNL
14	WNL	WNL
15	WNL	WNL
16	WNL	WNL
17	WNL	WNL
18	WNL	WNL
19	WNL	WNL
20	WNL	WNL
21	WNL	WNL
22	WNL	WNL
23	WNL	WNL

WNL = Within Normal Limits

HEART RATE

RESTING

Subject #	Control b/m	Experimental b/m
1	79	81
2	75	73
3	75	94
4	65	78
5	71	71
6	69	78
7	65	78
8	88	60
9	65	73
10	85	60
11	79	91
12	75	73
13	83	80
14	81	94
15	100	100
16	78	75
17	97	72
18	100	68
19	71	91
20	71	60
21	81	75
22	73	81
23	85	83
Mean	78.73	77.78
S.D.	10.32	10.93

HEART RATE

TWO MINUTE POST-EXERCISE

Subject #	Control b/m	Experimental b/m
1	108	113
2	118	126
3	118	115
4	124	125
5	122	84
6	120	118
7	127	118
8	124	110
9	120	125
10	138	114
11	116	126
12	125	126
13	127	138
14	125	118
15	116	125
16	121	130
17	120	110
18	121	110
19	135	138
20	115	117
21	112	113
22	130	111
23	130	121
Mean	122.26	118.73
S.D.	7.04	11.18

HEART RATE

FOUR MINUTE POST-EXERCISE

Subject #	Control b/m	Experimental b/m
1	94	92
2	106	97
3	106	88
4	97	105
5	92	62
6	106	106
7	102	99
8	113	100
9	100	94
10	108	85
11	92	98
12	108	115
13	99	100
14	108	105
15	83	104
16	96	99
17	109	98
18	111	89
19	110	103
20	98	73
21	92	82
22	100	101
23	107	102
Mean	101.60	95.52
S.D.	7.72	11.64

HEART RATE

SIX MINUTE POST-EXERCISE

Subject #	Control b/m	Experimental b/m
1	92	95
2	107	90
3	98	94
4	89	71
5	96	98
6	114	89
7	98	90
8	108	85
9	96	86
10	80	103
11	102	103
12	83	100
13	104	95
14	100	83
15	96	120
16	105	85
17	94	84
18	93	96
19	108	98
Mean	98.05	92.89
S.D.	8.69	10.33

N = 19

TIME TO REACH TARGET HEART RATE

Subject #	Control Min.	Experimental Min.
1	18:30	15:35
2	18:40	15:05
3	19:00	19:45
4	21:30	20:05
5	16:35	16:40
6	18:45	14:00
7	15:40	16:00
8	15:45	16:20
9	20:40	14:30
10	13:30	13:10
11	11:30	7:20
12	11:45	14:20
13	10:00	7:40
14	12:20	20:20
15	10:30	16:45
16	10:30	9:50
17	11:45	18:05
18	14:00	13:00
19	16:30	8:40
20	12:45	11:50
21	15:20	10:45
22	11:00	12:45
23	15:00	14:30
Mean	14.84	14.20
S.D.	3.47	3.7

SYSTOLIC BLOOD PRESSURE

RESTING

Subject #	Control mm/Hg	Experimental mm/Hg
1	115	135
2	125	120
3	115	110
4	120	120
5	105	110
6	105	125
7	130	110
8	120	110
9	110	110
10	120	95
11	95	105
12	95	160
13	90	100
14	115	110
15	100	110
16	110	130
17	120	120
18	120	105
19	115	110
20	100	100
21	115	110
22	105	110
23	115	120
Mean	111.30	114.56
S.D.	10.35	13.72

SYSTOLIC BLOOD PRESSURE

PEAK EXERCISE

Subject #	Control mm/Hg	Experimental mm/Hg
1	185	180
2	180	165
3	160	175
4	150	145
5	160	150
6	150	160
7	145	125
8	160	165
9	215	160
10	150	130
11	135	130
12	150	210
13	125	140
14	135	175
15	130	145
16	135	140
17	145	185
18	160	155
19	130	140
20	140	130
21	155	120
22	145	130
23	165	130
Mean	152.39	151.52
S.D.	20.38	22.83

SYSTOLIC BLOOD PRESSURE

TWO MINUTE POST-EXERCISE

Subject #	Control mm/Hg	Experimental mm/Hg
1	145	140
2	160	155
3	110	130
4	140	130
5	130	105
6	135	125
7	130	130
8	140	135
9	155	130
10	120	130
11	140	95
12	100	150
13	110	110
14	140	140
15	95	130
16	130	130
17	120	150
18	140	140
19	120	115
20	120	115
21	110	120
22	125	115
23	135	115
Mean	128.26	127.60
S.D.	16.48	14.91

SYSTOLIC BLOOD PRESSURE

FOUR MINUTE POST-EXERCISE

Subject #	Control mm/Hg	Experimental mm/Hg
1	115	110
2	140	135
3	110	120
4	140	125
5	105	110
6	125	120
7	125	110
8	120	135
9	130	130
10	105	100
11	120	90
12	100	150
13	100	95
14	115	120
15	100	115
16	125	120
17	125	130
18	130	110
19	120	95
20	100	110
21	105	100
22	115	110
23	110	115
Mean	116.52	115.43
S.D.	12.37	14.60

SYSTOLIC BLOOD PRESSURE

SIX MINUTE POST-EXERCISE

Subject #	Control	Experimental
	mm/Hg	mm/Hg
1	105	110
2	100	115
3	120	120
4	100	105
5	120	120
6	120	115
7	130	115
8	100	100
9	105	70
10	105	140
11	125	120
12	95	110
13	125	100
14	110	90
15	120	105
16	95	100
17	90	95
18	105	100
19	105	115
Mean	109.21	107.63
S.D.	11.81	14.65

N = 19

DIASTOLIC BLOOD PRESSURE

RESTING

Subject #	Control mm/Hg	Experimental mm/Hg
1	80	90
2	90	80
3	65	65
4	60	80
5	80	75
6	80	60
7	80	60
8	75	80
9	70	70
10	35	60
11	80	70
12	65	105
13	70	75
14	80	80
15	60	75
16	75	80
17	80	85
18	80	60
19	80	70
20	75	60
21	80	65
22	80	65
23	85	80
Mean	74.13	73.47
S.D.	11.44	11.32

DIASTOLIC BLOOD PRESSURE

PEAK EXERCISE

Subject #	Control mm/Hg	Experimental mm/Hg
1	55	70
2	15	65
3	45	65
4	80	80
5	40	50
6	70	55
7	75	70
8	55	75
9	90	50
10	65	60
11	95	75
12	70	90
13	75	75
14	70	35
15	75	75
16	80	80
17	80	60
18	80	65
19	60	65
20	80	70
21	60	80
22	90	35
23	80	75
Mean	68.91	66.08
S.D.	18.21	13.89

DIASTOLIC BLOOD PRESSURE

TWO MINUTE POST-EXERCISE

Subject #	Control mm/Hg	Experimental mm/Hg
1	75	75
2	40	70
3	60	75
4	65	80
5	70	65
6	70	80
7	75	60
8	70	65
9	40	60
10	65	65
11	85	55
12	80	90
13	70	80
14	70	60
15	60	80
16	75	50
17	65	60
18	40	50
19	70	65
20	70	75
21	55	55
22	80	50
23	50	80
Mean	65.21	67.17
S.D.	12.74	11.56

DIASTOLIC BLOOD PRESSURE

FOUR MINUTE POST-EXERCISE

Subject #	Control mm/Hg	Experimental mm/Hg
1	80	90
2	85	75
3	50	75
4	60	80
5	70	85
6	70	80
7	70	70
8	75	75
9	60	60
10	60	75
11	80	50
12	75	105
13	70	65
14	80	75
15	60	80
16	75	70
17	55	70
18	0	60
19	80	70
20	75	70
21	55	75
22	80	60
23	55	80
Mean	66.08	73.69
S.D.	17.64	11.30

DIASTOLIC BLOOD PRESSURE

SIX MINUTE POST-EXERCISE

Subject #	Control mm/Hg	Experimental mm/Hg
1	80	80
2	70	75
3	60	80
4	80	80
5	65	80
6	80	75
7	65	60
8	65	70
9	75	60
10	75	110
11	80	80
12	60	80
13	55	75
14	50	65
15	70	75
16	65	70
17	55	65
18	80	60
19	65	75
Mean	68.15	74.47
S.D.	9.60	11.29

N=19

APPENDIX C

STATISTICAL DATA FROM METROPOLITAN LIFE INSURANCE CO.

Women

Height (shoes on)		Small Frame	Medium Frame	Large Frame
Ft.	In.			
4	10	92-98	96-107	104-119
4	11	94-101	98-110	106-122
5	0	96-104	101-113	109-125
5	1	99-107	104-116	112-128
5	2	102-110	107-119	115-131
5	3	105-113	110-122	118-134
5	4	108-116	113-126	121-138
5	5	111-119	116-130	125-142
5	6	114-123	120-135	129-146
5	7	118-127	124-139	133-150
5	8	122-131	128-143	137-154
5	9	126-135	132-147	141-158
5	10	130-140	136-151	145-163
5	11	134-144	140-155	149-168
6	0	138-148	144-159	153-173

Men

Height (shoes on)		Small Frame	Medium Frame	Large Frame
Ft.	In.			
5	2	112-120	118-129	126-141
5	3	115-123	121-133	129-144
5	4	118-126	124-136	132-148
5	5	121-129	127-139	135-152
5	6	124-133	130-143	138-156
5	7	128-137	134-147	142-161
5	8	132-141	138-152	147-166
5	9	136-145	142-156	151-170
5	10	140-150	146-160	155-174
5	11	144-154	150-16	159-179
6	0	148-158	154-170	164-184
6	1	152-162	158-175	168-189
6	2	156-167	162-180	173-194
6	3	160-171	167-185	178-199
6	4	164-175	172-190	182-204

APPENDIX D

I, the undersigned, have volunteered for this research experiment and assume full responsibilities for any injury or accident which may occur to me while participating in the activities as a subject in this experiment. If an accident or injury does occur to me during such participation, I will not consider the "on duty" laboratory assistant, the principal investigator, the individual or the individuals assigned as having authority over activities within the laboratory, any staff or faculty member of the University of Wisconsin-LaCrosse, or the University of Wisconsin system as being in any way responsible.

I consent to the preliminary screening tests including spirometry, a hematocrit, review of my health service records, and a resting electrocardiogram. I consent to the exercise treadmill test with ECG monitoring and blood pressure being taken periodically.

I consent to the use of data obtained from these experiments for statistical use knowing that complete confidentiality will be maintained in all events.

I do state that 24 hours prior to the exercise test I did not use any marihuana, alcohol, cigarettes, coffee, tea, sodas, aspirin, cold tablets or any other drugs of other sources, without notifying the principle experimenter or the physician associated with this research.

Signed: _____

Date: _____

Time: _____

Witness: _____

APPENDIX E

STANDARD TREADMILL TEST

Test Phase	Duration min	Energy Mets	Requirements $\dot{V}_{O_2}$ ml/kg/min	% grade at 80 m/min (3 mph)
Rest	10-20	1	3.5	---
Accommodation Period	3	4	14.0	2.5
Recovery	2	1	3.5	---
Actual Test	2	4	14.0	2.5
	2	5	17.5	5.0
	2	6	21.0	7.5
	2	7	24.5	10.0
	2	8	28.0	12.5
	2	9	31.5	15.0
	2	10	35.0	17.5
	2	11	38.5	20.0
	2	12	42.0	28.5
	2	13	45.5	25.0
	2	14	49.0	27.5
	2	15	52.5	30.0

APPENDIX F

SCREENING PROCEDURE DATA SHEET

Date: _____

Name: _____ Age: _____ Sex: _____

Height: ____ft. ____ inches Weight: ____lbs. Frame size:_____

Smoke Cigarettes: yes _____ no_____

Resting (Supine) ECG _____

P-R interval _____

QRS interval _____

S-T depression and slope _____

arrhythmias _____

PVC's _____

Heart rate _____

Other _____

Respiratory studies

Vital Capacity Pr.: _____ ob: _____ %: _____

Blood study

Hematocrit _____

EXERCISE TEST DATA SHEET

Name: _____ Date: _____

1. Preliminary Data - Rest phase 15-20 min.

Resting HR: _____

Resting BP: _____

2. Standard Treadmill Test - 3.0 mph

Phase	Min.	% grade	HR :45-:60	BP :15-:45
Accommodation Period	3	2.5	_____	___/___
Recovery (sitting)	2	___	_____	___/___
Actual Test				
1	0-2	2.5	_____	___/___
2	2-4	5.0	_____	___/___
3	4-6	7.5	_____	___/___
4	6-8	10.0	_____	___/___
5	8-10	12.5	_____	___/___
6	10-12	15.0	_____	___/___
7	12-14	17.5	_____	___/___
8	14-16	20.0	_____	___/___
9	16-18	22.5	_____	___/___
10	18-20	22.5	_____	___/___
11	20-22	27.5	_____	___/___
12	22-24	30.0	_____	___/___
MAX	_____	___	_____	___/___
Immed. Post (walk)	0-2		_____	___/___
			_____	___/___
Recovery (sitting)	2-4		_____	___/___
	4-6		_____	___/___
	6-8		_____	___/___