8710671

Morocco, Kathleen M.

AGE, PHYSICAL ACTIVITY PATTERNS, ESTROGEN LEVELS AND CENTRAL CIRCULATORY RESPONSES OF POSTMENOPAUSAL WOMEN TO ACUTE SUBMAXIMAL EXERCISE

The University of North Carolina at Greensboro ED.D. 1986

University Microfilms International 300 N. Zeeb Road, Ann Arbor, MI 48106

PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark __√__.

1. Glossy photographs or pages ____
2. Colored illustrations, paper or print ____
3. Photographs with dark background ____
4. Illustrations are poor copy ____
5. Pages with black marks, not original copy __✓__
6. Print shows through as there is text on both sides of page ____
7. Indistinct, broken or small print on several pages __✓__
8. Print exceeds margin requirements ____
9. Tightly bound copy with print lost in spine ____
10. Computer printout pages with indistinct print ____
11. Page(s) ________ lacking when material received, and not available from school or author.
12. Page(s) ________ seem to be missing in numbering only as text follows.
13. Two pages numbered ____. Text follows.
14. Curling and wrinkled pages ____
15. Dissertation contains pages with print at a slant, filmed as received ____
16. Other ________________________________

AGE, PHYSICAL ACTIVITY PATTERNS, ESTROGEN LEVELS AND CENTRAL CIRCULATORY RESPONSES OF POSTMENOPAUSAL WOMEN TO ACUTE SUBMAXIMAL EXERCISE

By

Kathleen M. Morocco

A Dissertation Submitted to the
Faculty of the Graduate School at the
University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Greensboro
1986

Approved by

Dissertation Adviser

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

Dissertation Adviser ______________________

Committee Members ______________________

____

____

2 April 1986
Date of Acceptance by Committee

2 April 1985
Date of Final Oral Examination

MOROCCO, KATHLEEN M. Age, Physical Activity Patterns, Estrogen Levels and Central Circulatory Responses of Postmenopausal Women to Acute Submaximal Exercise. (1986) Directed by: Dr. Diane Spitler. 173 pp.

The purpose of this study was to determine the relationships between age, physical activity patterns, estrogen levels, estrogen supplement and central circulatory responses of postmenopausal women to acute submaximal exercise. In addition, the relative influence of these four variables on central circulatory responses to acute submaximal exercise in postmenopausal women was investigated.

Nineteen postmenopausal women, ages 44-63 years, participated in the study. Four subjects were taking estrogen supplement. A physical activity questionnaire was administered to survey past and present occupational and spare-time physical activities. Subjects completed a bicycle ergometer stress test to maximal exertion and on a subsequent day, a 30-minute submaximal bicycle ergometer test at 55% of their maximal aerobic capacity.

Blood was drawn from the antecubital vein prior to and immediately after submaximal exercise and analyzed for hematocrit and total estrogen (radioimmunoassay). Cardiovascular responses were recorded at intervals during rest, exercise, and recovery. Stroke volume, cardiac output, and myocardial contractility were estimated from impedance data obtained using the Minnesota Impedance Cardiograph.

Age and physical activity patterns were not significantly related. As age increased, cardiac output, stroke volume, and contractility decreased. Estrogen concentrations were negatively related to heart rate and contractility. Physical activity patterns were positively

related to cardiac output and stroke volume and were significant in all but one of the models used to explain central circulatory variability. The regression models used in this study only accounted for 38 to 66% of the variability in any dependent variable during minute 29 of exercise and immediate post-exercise.

These data suggest that physical activity patterns may significantly influence central circulatory output during submaximal exercise. Chronological aging, subjective recall of physical activity patterns and circulating levels of estrogen did not fully nor equally explain the variation in central circulatory responses to acute submaximal exercise in postmenopausal women.

ACKNOWLEDGMENTS

I want to express sincere appreciation to the members of my committee who gave willingly of their time and expertise in the design of this study and in the development of this manuscript. They have each made a significant and unique contribution to my professional and personal growth.

Appreciation is expressed to Dr. George Lawson and Martha Teague of Wesley Long Community Hospital for their professional assistance and for allowing me the opportunity to complete part of my data collection in their laboratory.

Gratitude is expressed to the many people involved in the data collection who gave of their time and whose encouragement and continued support throughout the study will always be remembered and appreciated.

To my friends who have supported and believed in me throughout these past four years, I owe a special thank you. I want to express sincere appreciation to my friends who worked behind the scenes in the preparation of this manuscript.

Above all, I am indebted to my parents whose encouragement, support, and love has always been there for me. For all those years of unselfish giving, this dissertation is dedicated to my parents, Marie and John Mc Avoy.

TABLE OF CONTENTS

Page

APPROVAL PAGE. ii

ACKNOWLEDGMENTS. iii

LIST OF TABLES. vi

LIST OF FIGURES. viii

CHAPTER

I. INTRODUCTION. 1

Statement of the Problem. 3
Definition of Terms. 3
Hypotheses. 4
Limitations of the study. 5
Significance of the study 5

II. REVIEW OF THE LITERATURE. 7

Effects of Age on Central Circulatory Responses to Exercise. 7
Central Circulatory Responses to Exercise in the Physically Active Female. 17
Effects of Estrogen on Central Circulatory Responses to Exercise in Women. 22
Impedance Cardiography as a Measure for Assessing Cardiac Function 27

III. METHODS, PROCEDURES, AND STATISTICAL ANALYSES. 36

Introduction. 36
Selection of Subjects. 37
Pilot Study. 37
Maximal Stress Test. 38
Submaximal Test. 40
Statistical Analyses. .43

IV. RESULTS. 45

CHAPTER Page

V. DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS. 77

Discussion. 77
Age, Physical Activity Patterns, and Central Circulatory Responses to Submaximal Exercise. . . . 78
Serum Concentration of Total Estrogen and Central Circulatory Responses to Submaximal Exercise. 83
Conclusions. 88
Recommendations for Future Research. 88

BIBLIOGRAPHY. 90

APPENDIX A. INFORMED CONSENT FORMS
PHYSICIAN REFERRAL FORMS
SELF-ADMINISTERED MEDICAL QUESTIONNAIRE
PHYSICAL ACTIVITY QUESTIONNAIRE. 103

APPENDIX B. ASSAY PROCEDURES. 118

APPENDIX C. ESTROGEN SUPPLEMENT. 122

APPENDIX D. BEST ESTIMATIVE MODELS FOR THE DEPENDENT VARIABLES MEASURED AT REST, EXERCISE, AND RECOVERY. 124

APPENDIX E. IMPEDANCE CARDIOGRAPHY IN THE ASSESSMENT OF CARDIAC RESPONSE. 130

APPENDIX F. PRIMARY SUBMAXIMAL DATA. 135

LIST OF TABLES

Table Page

1. Baseline Data. 46

2. Maximal Data. 47

3. Physical Activity Questionnaire Results. 48

4. Correlation Matrix Between Physical Activity Patterns and Age. 51

5. Group Means and Standard Deviations of Submaximal Rest, Exercise, and Recovery Data. 52

6. Serum Concentration of Total Estrogen at Rest and Immediate Post-Exercise (IPE). 59

7. Correlation Matrix Between Estrogen Levels and Physical Activity Patterns. 60

8. Correlation Matrix of Cardiac Output and Physical Activity Patterns, Age, Estrogen Levels, and Supplement. 62

9. Correlation Matrix of Stroke Volume and Physical Activity Patterns, Age, Estrogen Levels and Supplement. 64

10. Correlation Matrix of Heather Index and Physical Activity Patterns, Age, Estrogen Levels, and Supplement. 65

11. Correlation Matrix of Mean Arterial Blood Pressure and Physical Activity Patterns, Age, Estrogen Levels, and Supplement. 67

12. Correlation Matrix of Heart Rate and Physical Activity Patterns, Age, Estrogen Levels, and Supplement. 68

13. Best Estimative Models for Cardiac Output Measured During Rest, Submaximal Exercise, and Recovery. 70

14. Best Estimative Models for Stroke Volume Measured During Rest, Submaximal Exercise, and Recovery. 71

Table | Page

15. Best Estimative Models for the Heather Index Measured During Rest, Submaximal Exercise, and Recovery. 73

16. Best Estimative Models for Mean Arterial Blood Pressure Measured During Rest, Submaximal Exercise, and Recovery. 74

17. Best Estimative Models for Heart Rate Measured During Rest, Submaximal Exercise, and Recovery. 76

LIST OF FIGURES

Figure Page

1. Simultaneous Recording of ECG and Cardiac Impedance (dZ/dt)min. 35

2. Weighted Mean Occupational (PAO) and Lifespan Physical Activity Scores (LSPA), and Mean Physical Activity by Decade (PAD). Lines, SE. 50

3. Group Means for Cardiac Output Measured at Rest, Exercise, and Recovery. Lines, SE. 53

4. Group Means for Stroke Volume Measured at Rest, Exercise, and Recovery. Lines, SE. 54

5. Group Means for Heather Index Measured at Rest, Exercise, and Recovery. Lines, SE. 55

6. Group Means for Mean Arterial Blood Pressure Measured at Rest, Exercise and Recovery. 56

7. Group Means for Heart Rate Measured at Rest, Exercise, and Recovery. Lines, SE. 57

CHAPTER I

INTRODUCTION

Aging is a complex process which takes place from the moment of conception until death. Shock (1976) defined aging "as the progressive change which takes place in an animal, organ, tissue, or cell with the passage of time" (p. 3). The aging process reflects changes in an individual's ability to respond to physiological stress. Within this context, one could view the differences seen in cardiovascular parameters measured over time at both rest and during exercise as a result of this aging process. Extensive scientific inquiry has addressed the question of the effects of habitual physical activity on the rate of decline in bodily functions. Although it is not conclusive as to whether or not exercise affects the aging process itself, it is believed that exercise may help to reduce the decline in bodily functions often associated with aging.

The cardiovascular system plays an important role in the ability to perform physical work. The effects of aging on the cardiovascular system (20, 43, 57, 103, 104) and the response of the older adult to exercise (14, 36, 67, 97) have been well documented. Studies which have examined the effect of physical activity patterns on the cardiovascular system of the older adult indicate that cardiovascular adaptation to physical training is possible (9, 24, 31, 105). Yet while numerous studies have examined the effects of age and physical activity patterns on the physiological responses of women to exercise (1, 30, 61, 125), there is limited information on what role lifelong patterns of physical activity play in delaying or offsetting the decline in cardiovascular function associated with advancing age (90, 116).

It is possible that the alterations seen in cardiovascular function in middle-aged and older women may be related to factors other than age and physical activity patterns. Part of the normal aging process and a period of physiological change for most women between the ages of 45-55 is menopause. The question arises about the extent to which the alterations seen in cardiovascular function are inevitable consequences of aging and menopause or to decrements seen in physical activity patterns in the postmenopausal woman. In their work done with women, Drinkwater, Horvath ,and Wells (36) and Plowman, Drinkwater, and Horvath (90) speculated that the sudden increase in the rate of decline in aerobic capacity seen in women over fifty may be related to changes in hormonal levels associated with menopause. Since the hormonal status of the female is altered during the menopausal period, these hormonal changes may in some way be associated with alterations seen in cardiovascular function. Cowan and Gregory (27) examined whether or not the ability to improve cardiorespiratory endurance and body composition was compromised by menopause. Their study revealed no evidence to suggest that menopause affected the trainability of the postmenopausal woman. Further research is warranted in the following areas to: (a) develop an understanding of the physiological effects of the ovarian hormone estrogen on central circulatory responses to exercise in postmenopausal women, and (b) determine the extent to which the loss of this ovarian hormone alters those responses.

Statement of the Problem

The purpose of this study was to determine the relationships between age, physical activity patterns, estrogen levels, estrogen supplement, and central circulatory responses of postmenopausal women to acute submaximal exercise. In addition, the research sought to determine the relative influence of these four variables on central circulatory responses to acute submaximal exercise in postmenopausal women.

Definition of Terms

Terminology used in this investigation were operationally defined as follows:

1. Acute Exercise : refers to a single bout of exercise, 55% of maximal oxygen uptake ($\dot{V}O_2$ max) for 30 minutes in duration.

2. Central Circulatory Responses to Submaximal Exercise : refers to changes in cardiac output, heart rate, stroke volume, cardiac contractility, and mean arterial blood pressure during acute submaximal exercise.

3. Estrogen Supplement : exogenous (synthetic) hormone often prescribed to postmenopausal women.

4. Physical Activity Patterns : refers to physical activity by occupation, lifespan physical activity, and physical activity by

decade.

a. Physical Activity by Occupation: occupational patterns

b. Lifespan Physical Activity: summation of physical activity patterns across all age-groups

c. Physical Activity by Decade: physical activity pattern in a particular age-group.

5. Postmenopause : a period of time beginning at least one year after the cessation of menstruation.

Hypotheses

For the purpose of this study, the following null hypotheses were tested:

1. There is no relationship between age and physical activity patterns in postmenopausal women.

2. There is no relationship between physical activity patterns and estrogen levels in postmenopausal women.

3. There is no relationship between physical activity patterns and central circulatory responses to acute submaximal exercise in postmenopausal women.

4. There is no relationship between age and central circulatory responses to acute submaximal exercise in postmenopausal women.

5. There is no relationship between estrogen levels and central circulatory responses to acute submaximal exercise in postmenopausal women.

6. There are no differences in the relative contribution of age, physical activity patterns, estrogen levels, and estrogen

supplement in explaining the variation in central circulatory responses to acute submaximal exercise in postmenopausal women.

Limitations of the Study

This study was limited by the following factors:

1. The subjects for this study were not randomly selected but recruited from volunteers meeting specified criteria.

2. Differences in central circulatory responses to exercise may have been influenced by parameters other than age, physical activity patterns, and estrogen levels.

Significance of the Study

Both the aging process and the level of physical activity have accounted for differences seen in central circulatory responses to exercise. Although the changes in the physiological responses to exercise as a consequence of aging and physical activity are relatively well-known, there is a paucity of research addressing what effect changes in hormonal status associated with menopause have on cardiovascular function (27, 95, 122). With the increasing number of middle-aged and older women now exercising, it becomes increasingly important to investigate the effects of menopause on their physiological responses to exercise. No study to date has specifically examined menopause and its related hormonal changes on central circulatory responses. The proposed research will investigate the relationship between estrogen and central circulatory responses to exercise, and what effect the loss of this ovarian hormone has on these physiological responses. Should such a relationship exist, then further insight is provided on the physiological changes associated with menopause. In addition, information will be obtained on the effect of estrogen on central circulatory responses to exercise beyond that which may result from differences in age and physical activity patterns.

CHAPTER II

REVIEW OF THE LITERATURE

In this chapter, four topics are reviewed: (1) effects of age on central circulatory responses to exercise, (2) effects of physical activity/training on central circulatory responses to exercise, (3) effects of estrogen on central circulatory responses to exercise in women, and (4) impedance cardiography as a measure for assessing cardiac function.

Effects of Age on Central Circulatory Responses to Exercise

Observations have shown that there are differences in the rate in which the various physiological systems change with age. Findings cited in the literature associated with the aging process and related cardiovascular changes allude to the diverse degrees in which individuals age. Although present knowledge does not allow us to draw conclusions about a general aging process, the most general pattern of aging is represented by a linear decrement in function beginning at about the age of 30. The linear decrements in cardiovascular response to exercise proceed at different rates and vary from individual to individual.

This section of the review of literature will discuss the effects of aging on selected cardiovascular parameters measured at rest and during exercise.

Heart Rate

Resting heart rate does not vary much with age (110, 119). During submaximal exercise, the effect of age has been reported to be associated with an increase (6), decrease (26) or no change (14, 26, 43, 44, 57, 86, 87, 105) in exercise heart rate. In their work with women aged 21 to 61 years, VanHandel, Costill, and Getchell (119) found that the women in the oldest group (53-61 years) had the lowest heart rate at any given submaximal level. Becklace, Frank, Dagenais, Ostiguy, and Guzman (14) measured heart rate in women 20-85 years of age during submaximal bicycle exercise at work loads of 150, 350, and 550 $kg \cdot m \cdot min^{-1}$. The authors found no age-apparent decline in heart rate with successive decades. During submaximal bicycle work with women 20-65 years of age, Astrand (4) found small variation in heart rates between age groups. However, circulatory responses to both maximal and submaximal exercise showed large individual variation.

The animal model is many times used to explore the mechanisms associated with the decline in cardiovascular performance observed with advancing age. The effect of aging on heart rate in 50 12-month-old and 45 24-month-old unanesthetized male Witser rats was examined by Rothbaum, Shaw, Angell, and Shock (98). At rest the mean rate was higher in the 24-month-old rat as compared to the 12-month-old rat. The authors stated that a greater increase in sympathetic tone may have accounted for the higher heart rate in the senescent animal. Heart rate determination was also made after the administration of beta-adrenergic blockade (propranolol 1 mg/kg). The beta-adrenergic blockade caused a significant fall in the heart rate of both the young and old animals abolishing the age-related difference. Similiar effects of beta-adrenergic blockade with propranolol on hemodynamic changes in man have been reported (38).

It is generally accepted that maximal heart rate during exhaustive work declines with age (16, 35, 57, 86, 90, 92). One explanation given for this decline is a greater stiffness (reduced compliance) of the chest wall which could hamper filling and increase the time required for filling of the ventricles (102, 103). Another cited reason for the decrease in maximum heart rate with age is that the sympathetic drive to the cardiac pacemaker cells may be diminished (25, 102, 103). Gernstenblith, Lakatta, and Weisfeldt (1976) stated that:

> The lower heart rate probably reflects an alteration in the neurohumoral perception or response to stress, the sensitivity of the pacemaker cells to the neurohumoral influences controlling rate or an inability of the conducting systems to generate very rapid impulses (p. 5).

Cardiac Output

On the average, resting cardiac output falls progressively with age (20, 44, 57, 61, 110). Harris (1982) stated that "cardiac output at rest diminishes with advancing age as a result of age-related changes in filling volume, vascular input, vascular impedance and intrinsic muscle performance" (p. 288). Invasive studies have shown a small decrease in stroke volume at rest which would account for the decrease in cardiac output as resting heart rate changes little with age (43). Julius, Amery, Whitlock, and Conway (57) and others (44, 70) have found the mean cardiac output, measured during supine and seated rest, to be lower in the older subject. Age-related changes in cardiac output in men and women, 20 to 89 years of age, was examined by Luisada, Bhat, and Knighten (78). Resting cardiac output, determined by the impedance cardiograph, dropped from 5.80 $l \cdot min^{-1}$ in the 20-39 age group to 3.99 $l \cdot min^{-1}$ in the 80-89 age group. Not all studies have reported a decline in resting cardiac output with age. In a study conducted with 61 moderately active individuals, 25 to 79 years of age, a decline in resting cardiac output was not observed with advancing age (97).

To examine the effect of age on resting cardiac output, 12- and 24-month old unanesthetized male Witser rats were examined by Rothbaum et al. (98). Values for resting cardiac output ($ml \cdot min^{-1}$), determined by the indicator dye-dilution technique, were significantly reduced with age. Resting cardiac output ($ml \cdot min^{-1}$) was 127 ± 5.0 in the 12-month old animal and 106 ± 5.2 in the 24-month old animal. Significant age-related differences in cardiac output still remained after the administration of beta-adrenergic blockage with propranolol (1 mg/kg) suggesting that the decline seen in cardiac output was not related to differences in sympathetic nervous tone.

During light exercise, cardiac output in the older subject is almost identical to that of younger individuals working at the same relative work load (102). In order to determine whether or not there were age and sex differences in exercise cardiac output, Becklace et al. (14) measured exercise cardiac output in 94 subjects, 20 to 85 years of age, using the indirect Fick method. Measurements were taken during steady state exercise on the bicycle ergometer at work loads of 150, 350, and 550 $kg \cdot min^{-1}$. At a given submaximal work load, cardiac output tended to be higher with increasing age for both men and women. Sex-related differences in exercise cardiac output were found between the ages of 20-39 years with the women having consistently higher values despite their lower body surface area. Exercise cardiac output in the older decades (40-69 years) was similiar for both sexes indicating an apparent sex difference in exercise cardiac output only during the woman's childbearing years (20-39 years).

As mentioned earlier, the sympathetic nervous system plays an important role in the response of the body to exercise. Conway, Wheeler, and Sonnerstedlt (25) examined the sympathetic activity during progressive bicycle ergometer exercise in young (20-35) and old (50-65) men and women. Age-group comparisons were made before and after the administration of propranolol. Before the administration of propranolol, resting and exercise cardiac outputs were lower in the older subjects. With the administration of propranolol, exercise cardiac output at a given work rate was almost identical in both age groups. The authors concluded that the sympathetic drive to the heart, which appears to be reduced with age, may be the result of changes in the responsiveness of the cardiac tissue to catecholamines or to an age-associated reduction in sympathetic stimulation. Therefore, the sympathetic response to stress may account for some of the differences seen in cardiovascular performance in older adult.

Maximum cardiac output has been found to decrease with age (43, 57). This has been attributed to both a decrease in maximal heart rate and stroke volume. Shephard (102) stated that the maximal cardiac output is 20-30% lower in a 65 year old as compared to a younger individual. Comparison of changes in cardiac function asssociated with aging was investigated by Hossack and Bruce (54) in men and women 20 to 70 years of age. Cardiac output was obtained by the Fick method. The change in cardiac index with age was much less for the women in comparison to the men due to a lower reduction in maximal heart rate. Rodeheffer, Gernstenblith, Becker, Fleg, Weisfeldt, and Lakatta (97) found no significant decline in cardiac output during progressive bicycle ergometer exercise in active men and women between 21 and 79 years of age. On the basis of their findings, the authors concluded that aging did not limit cardiac output during exercise for these particular individuals. Although there was no significant decline in cardiac output with age, the mechanisms by which cardiac output were maintained was altered by the aging process. The authors stated that "with advancing age there is a shift from a catecholamine-mediated increase in heart rate and reduction in ESV to a greater reliance on the Frank-Starling mechanism" (p. 212).

Stroke Volume

Resting stroke volume has been reported to diminish with age (20,57,110). Changes in stroke volume with age may be associated with higher systolic blood pressure, aortic impedance and intrinsic changes in the myocardium (20). Resting cardiovascular measurements taken on young and old unanesthetized male Witser rats showed a decline in stroke volume with age (98). This age difference was preserved after the administration of a beta-adrenergic blockade (propranolol 1 mg/kg), indicating that the decline seen in stroke volume with age could not be explained by differences in sympathetic nervous tone. Similiar hemodynamic changes in man have been reported after the administration of beta-adreneric blockade wih propranolol (38).

During submaximal work, stroke volume changes little with age (14, 45). The influence of age and sex on exercise cardiac output, was examined by Becklace et al. (14). Women, aged 20-39 years, had a higher stroke volume and heart rate than men of similar age during submaximal bicycle ergometer exercise. In the older decades, (40-59 years of age), the women showed a decrease in stroke volume with age. In contrast to the men, a decrease in heart rate with successive decades was not apparent in the women.

In the older subject, stroke volume diminishes with age as maximum effort is approached (14, 44, 45, 87). There has been a reported 11 to 20% decrease in maximum stroke volume with advancing age (6, 46, 61, 62, 110). Shephard (1978) stated that the decrease in stroke volume during maximal work "... may reflect poorer myocardial perfusion, lesser cardiac compliance, or poorer contractility" (p. 78). The tendency for stroke volume to plateau at a lower percentage of maximal oxygen intake may be related to these factors (44, 45). However, in a study conducted by Rodeheffer et al. (97), an age-related increase in stroke volume with age was noted during bicycle ergometer work in healthy adults between the ages of 25 and 79 years. The increase in exercise stroke volume with age was due to an increase in end diastolic volume as end systolic volume increased as a function of age.

Blood Pressure

Numerous studies which have examined the relationship between aging and associated changes in blood pressure have indicated a gradual rise in both systolic and diastolic pressure with advancing age. Kannel and Gordon (1977) stated that:

> Because blood pressures increase with age, some appear to contend that this is either a physiological sign of progressive increase in arterial rigidity or a compensatory change to ensure tissue perfusion through the narrowed vessels (pp. 67-68).

The majority of the animal studies exploring the effects of aging on cardiac function have used the rat as a model. An intra-arterial catheter was used to measure systolic and diastolic blood pressure in unanesthetized male Witser rats (98). At rest, mean systolic blood pressure (mm Hg) was 135 ± 3.0 and 125 ± 3.5 in the

12- and 24-month old rats respectively. The administration of beta adrenergic blockade (propranolol 1 ml/kg) did not produce a significant change in blood pressure in either age group but did abolish the slight age difference in resting blood pressure.

Julius et al. (57) examined the effect of age on resting and exercise blood pressure in men and women 18 to 69 years of age. Systolic pressure measured during supine rest was the highest in women 50 to 69 years of age while diastolic pressure remained the same for all three age groups. While seated on the bicycle ergometer, the rise in both the systolic and diastolic pressure was the highest in the oldest group. With exercise, the older group had the greatest rise in systolic pressure with the small increase in diastolic pressure being the same for all three groups. Similiar findings have been cited by other investigators (44, 45, 59). An age-related effect on systolic pressure, noted during rest in subjects participating in the Baltimore Longitudinal Study of Aging (97), was not evident during exercise.

Myocardial Contractility

Kubicek et al. (1974) have defined myocardial contractility "as the rate of shortening or contraction of the heart muscle fibres" (p. 412). Smith and Kampine (1980) have defined contractility as the "... basic ability of the heart muscle to generate power" (p. 107). Both the duration of the systole and the volume of blood expelled from the ventricle may be influenced by the contractility of the heart (102).

There is limited literature on the use of impedance cardiograph to evaluate myocardial contractility. The more common method used is the timing of the systolic time intervals (STI) involving the simultaneous recording of the electrocardiogram, phonocardiogram, and the carotid pulse wave (17, 93). Measurements include: (a) total period of ventricular systole (QS2); (b) ejection period (LVET), and (c) pre-ejection period (PEP) which equals QS2-LVET. The measurements are often expressed in milliseconds.

Some measurements of heart function appear to change with advancing aging. Resting pre-ejection period (PEP) has been found to increase with age. The PEP phase of the cardiac cycle represents both the electrical and mechanical activity within the ventricle. At age 25, resting PEP was 80 mmsec increasing to 95-100 mmsec in a 65 year old individual (50, 86). Montoye et al. (86) found that the age difference in resting PEP still existed when corrected for heart rate. In this same study, left ventricular ejection time was independent of age yet higher in the females as was total time of systole.

The age-related increase in PEP has been attributed to: (a) electrical changes associated with a decrease in sympathetic tonus (103), (b) a decline in the ATPase activity of the myofibrils with a mechanical slowing of the tension development in cardiac muscle fibres (2), and/or (c) a general loss of co-ordination of the contractile process (108).

Central Circulatory Responses to Exercise in the Physically Active Female

Research exploring the role that exercise plays in delaying the decline in bodily functions often associated with aging has produced conflicting results. Differences seen in the cardiovascular adaptation of the older adult to training involve more than just the affect of age. There has been difficulty in standardizing the procedures and/or controlling for the many intrinsic and extrinsic factors which may affect the adaptation to training in the older adult. These concerns have led to divergent conclusions regarding the effect of training on the older adult or the trainability of that particular individual.

Literature dealing with the physiological responses of women to exercise have addressed two main issues: the physiological effects of aging and physical activity levels on the aging female. This section of the review of literature will examine the effects of physical activity on the central circulatory responses of women to exercise.

Heart Rate

Resting heart rate of women has been shown to decrease with training (1, 30, 34, 117). In addition, one of the more consistently reported findings of training on the physiological response to exercise has been a decrease in heart rate at a given submaximal work load (1, 39, 49, 61, 62).

No change in maximal heart rate after training was noted by

Kilbom and Astrand (62) although Dowdy, Cureton, DuVal,and Ouzts (34) reported a small decrease in maximal heart rate in women 25 to 44 years after 10 weeks of aerobic dance. Drinkwater et al. (36) examined the effect of age and physical activity patterns on the physiological responses of women 10 to 69 years of age. Maximal heart rate was found to decrease with age with no significant difference in mean maximal heart rate among age groups after the age of thirty. Plowman et al.(90) retested thirty-six women from the original cross-sectional study (36) to determine the longitudinal effects of aging on their physiological response to maximal exercise. The longitudinal data produced a similar aging pattern in the rate of decline in HRmax, but the pattern was not consistent over time. The rate of decline in HRmax was -0.565 beats per year for women 20 to 29 years of age with the decline more than doubling (-1.169 beats per year) for women in their fifties. In a study conducted by Profant, Early, Nilson, Kusumi, Hofer, and Bruce (92), HRmax declined steadily from the fourth to the seventh decade in active women 20-70 years of age. For women (29-59 years of age) the decline was approximately three beats per year increasing to seventeen beats per year for women over sixty.

Cardiac Output

There is little published data on the effect of physical training on cardiac output in middle-aged women (30, 62, 87, 119). After seven weeks of interval training on the bicycle ergometer, Kilbom and Astrand (62) found no significant difference in cardiac output at rest or at a given submaximal work load in women 21-61 years of age. The women in the oldest group (53-61 years) had a lower cardiac output both at rest and during submaximal exercise compared to the other two age groups (21-28 age group; 46-48 age group). The women in the oldest group had a lower hemoglobin concentration which the authors concluded may partially explain the difference seen in cardiac output between the groups. Cunningham and Hill (30) studied the effect of a supervised training program on the cardiovascular response to exercise in women aged 21-48 years. Cardiac output, determined by the Fick principle, increased significantly after nine weeks of training. Little change in this value was found in six subjects who underwent 52 weeks of additional training. Niinimaa and Shephard (87) found no difference in exercise cardiac output in women 60-76 years of age after an 11 week endurance training program.

Maximal cardiac output in women, 21 to 61 years of age, increased after seven weeks of training (62). Mean cardiac output values increased from 14.3 l/min before training to 15.8 l/min after training with an 8.7% increase (11.5 to 12.5 l/min) in the oldest group.

Stroke Volume

Kilbom and Astrand (62) examined the effects of a seven week training program on the circulatory responses of sedentary women aged 21-61 years. Training at 70% of their maximal aerobic capacity, an increase in stroke volume with no change in the arterio-venous oxygen difference was observed. An increased central circulatory capacity was the primary adaptation to training seen in these women.

These results were supported in a study conducted by Cunningham and Hill (30) with women 21-48 years of age. After nine weeks of training, the authors observed an increase in stroke volume with no change in arterio-venous difference at submaximal work levels. Six subjects trained for an additional 52 weeks. With the additional weeks of training, the initial gain seen in stroke volume was reduced with a subsequent increase in the arterio-venous difference. The longer training period brought about a peripheral adaptation reflected by the increase in arterio-venous difference.

Blood Pressure

A lower resting blood pressure after training has been reported in some studies (61, 62) but not in others (1, 34, 39). Flint, Drinkwater, and Horvath (39) reported that neither resting nor immediate post-exercise blood pressure was affected by six weeks of training in seven women, ages 23 to 49. Seventeen women, 52-79 years of age, participated in a three month conditioning program which included calisthenics, a jog-walk phase, and static stretching for one hour, three times a week (1). At the end of the three months, there was no significant difference between the experimental and control group in resting blood pressure. Blood pressure response to submaximal exercise was lower after seven weeks of training in women 43 to 61 years of age (62). No significant change in blood pressure was observed during maximal work. Profant et al. (92) examined the circulatory responses to maximal exercise in middle-aged women. Systolic blood pressure, which was measured immediate post-exercise, increased with advancing age. The change in systolic blood pressure, noted with increasing age, was attributed to a decrease in the elasticity of the peripheral vascular bed. Little variation in diastolic pressure occurred with exercise.

Myocardial Contractility

The overall effects of physical training on cardiac contractility remain unclear. A large number of studies, involving both animals and humans, have not demonstrated any training effect that can be attributed to an improved contractile process (17). Echocardiographic data obtained from longitudinal and cross-sectional studies conducted by Personnet, Ferguson, Ricci, and Lajoie (89) provided no significant evidence that training effected contractile performance.

In contrast, studies conducted by Scheuer and Tipton (100) have shown an improvement in the myocardial function in trained rats with concommitant changes in the myocardial myosin-ATPase and calcium handling. Brooks and Fahey (21) have stated that one of the major adaptations resulting from endurance training in humans is an increased contractility. The availability of the calcium ion, its rate of delivery to the contractile site, and rate of binding to troponin affects the contractile state of the myocardium (107). Contraction is enhanced with an increase in the myocardial calcium myosin-ATPase activity. Endurance training effects the calcium myosin-ATPase activity of the heart thus increasing contractility (21).

The effect of training on the myocardial performance in humans was studied by Winters, Leaman, and Anderson (126). Systolic time intervals were simultaneously measured using the electrocardiogram, phonocardiogram and carotid arterial pulse wave. LVET was not effected by training, but PEP and QS2 were significantly decreased. Metzger, Chough, Kroetz, and Leonard (80) have stated that a decrease in PEP reflects an increase in dp/dt (rate of rise in ventricular pressure). The left ventricular dp/dtmax varies to some extent with preload and heart rate, yet is responsive to changes in the inotropic or contractile state of the myocardium (1070. Therefore, the dpt/dtmax has been used to assess the contractile ability of the myocardium.

The Effects of Estrogen on Central Circulatory Responses to Exercise in Women

The endocrinological changes associated with menopause have been defined by an alteration in the serum concentrations of most sex hormones. Alterations in two of those sex hormones, estradiol and estrone, will be discussed here.

The principal circulating estrogen in the premenopausal female is 17-βestradiol. Most of the circulating estradiol in the premenopausal women is secreted directly by the ovary (11) with five percent being produced from the peripheral conversion of estrone to estradiol (75). The normal range for estradiol varies from 35-500 pg/ml. Estradiol levels fluctuate during the menstrual cycle with the highest levels reached just prior to ovulation (10, 83).

In the postmenopausal woman, the amount of circulating estradiol is reduced. One year after menopause, the plasma concentration of estradiol is about 20% of the premenopausal value (23). Some investigators have found the mean level to be approximately 13 pg/ml (10, 94). The value found for estradiol in a study conducted by Chakravarti, Collins, Forecast, Newton, Oram, and Studd (23) remained low for the first ten years after menopause with a reported increase 10 to 20 years later.

Estrone is produced by the extraglandular conversion of androstenedione to estrone. Estrone levels in the premenopausal woman varies from 30-200 pg/ml (10, 112). Estrone becomes the principal estrogen during the postmenopausal years with circulating levels higher than those of estradiol. The mean level of estrone in the postmenopausal woman is approximately 30 pg/ml (94) with most of the estrone derived from the peripheral conversion of androstenedione in adipose tissue (47, 76, 88). The peripheral conversion of androstenedione to estrone is twice that which is found in the premenopausal woman (55) and correlates with increasing body weight (55, 88, 120) and advancing age (47, 53). In later studies conducted by Longcope (77) and Vermulen (120) the correlation with age was not confirmed.

Heart Rate

The use of exogenous estrogen has produced changes in central hemodynamics. After one month of estradiol-17β substitution, resting heart rate in normotensive postmenopausal women decreased by an average of 2 beats/minute and 5 beats/minute with daily dosages of 2 and 4 mg respectively (79). A decrease in resting heart rate in postmenopausal women using estradiol valerate and conjugated equine estrogens for six months has been reported (74). Several investigators have examined the effect of oral contraceptives on heart rate response in premenopausal women (8, 71, 73, 123). Results indicated that heart rate was not altered in premenopausal women receiving oral contraceptives.

Three months of estradiol-17β substitution did not produce any significant effect on exercise heart rate in postmenopausal women (79). Backman, Sandstrom, and Solheim (8) reported similar results in postmenopausal women receiving estrogen-progestin. Lehtovirta, Kuikka, and Pyorala (72) found in their study that the use of oral contraceptives by premenopausal women did not significantly effect exercising heart rate.

Cardiac Output and Stroke Volume

There is a paucity of literature dealing with the effects of estrogen substitution on central circulatory responses in women. An increase in resting cardiac output (0.5-1.2 l/min) in women using oral contraceptives has been reported (71, 123). Luotola (79) reported an increase in cardiac output in postmenopausal women receiving estradiol-17β treatment. No significant correlation was found between serum estrogen concentration and cardiac output. Lehovirta et al. (72) observed an increase in exercise cardiac output in women (mean age 21.5 years) who were using a combined oral contraceptive.

In postmenopausal women, Luotola (79) observed an increase in resting stroke volume during estradiol-17β substitution. When estradiol-17β substitution was given in 4 mg daily doses, there was a significant correlation betweeen the increase seen in stroke volume and serum concentrations of estradiol (79). In the premenopausal years, an increase in resting and exercise stroke volume has been demonstrated in women using oral contraceptives (71, 72, 123).

Blood Pressure

Research on the relationship between arterial hypertension and oral contraceptives is quite extensive. Weir, Briggs, Mack, Naismith, Taylor, and Wilson (124) examined the effect of estrogen-progestogen oral contraceptives on blood pressure in premenopausal women (mean age 23 ± 3.4 years). After four years, the mean systolic blood pressure showed a significant rise of 14.2 mm Hg with a mean rise of 8.5 mm Hg in diastolic pressure. The central circulatory responses of premenopausal women (41 to 51 years) who were using an estradiol/norgestrel combination for one year was investigated by Backman et al. (8). The systolic and diastolic pressures, which were recorded after 10 minutes of exercise, showed a slight increase after six months of therapy, but returned to original values by the end of the year. Utian (115) found that the administration of conjugated estrogens to postmenopausal women caused a slight rise in blood pressure. Similar findings on the effect of conjugated estrogens on blood pressure have been reported (28, 109).

The results of a study conducted by vonEiff, Plotz, Beck, and Czernik (121) showed a distinct correlation between the degree of endogenous estrogen activity and blood pressure response in women. At rest and under stress women who had undergone physiological menopause had higher systolic and diastolic blood pressures than those of normal menstruating women. Ovariectomized women, who were being treated with long-acting estrogen and progestin, showed a decrease in diastolic pressure at rest and a smaller rise in both systolic and diastolic pressure compared to similar women who served as controls. Four weeks of estradiol-17β substitution caused a decrease in both systolic and diastolic blood pressure in both normotensive and hypertensive postmenopausal women (79). Blood pressure returned to initial levels after the discontinuation of therapy. Hemodynamic changes in premenopausal women receiving a combined estrogen/progestogen oral contraceptive were studied by Walters and Lim (123). A significant increase in systolic pressure was observed with no significant change in the diastolic pressure. The results suggested that central rather than peripheral circulation was the site effected by the use of oral contraceptives. There was no observed change in blood pressure, measured during exercise, in premenopausal women using oral contraceptives (72).

Myocardial Contractility

The effect of estrogen on myocardial contractility is still under investigation. Few investigators have examined the possible effect of this ovarian hormone on myocardial contractility (63, 123). The effect of estrogen on the composition and function of the cardiac muscle in ovariectomized albino rats was examined by King, Whitehorn, Reeves, and Kubota (63). Myocardial contractility and actomyosin content were reduced. Administration of estradiol in dosage of 0.1 ug/day produced an increase in the actomyosin concentration and in tension development. The authors concluded that the contractile system of the cardiac muscle is dependent on estrogen and may have important implications as to the role that this female hormone plays in myocardial function.

Impedance Cardiography as a Measure for Assessing Cardiac Function

Impedance cardiography is a simple noninvasive technique used for obtaining information about the mechanical activity of the heart. Due to its noninvasive nature, impedance cardiography has been used by investigators in the field of physiology to examine the response of the cardiovascular system to stress. This section of the review of literature will discuss the use of the impedance cardiograph in assessing cardiac response.

Electrical impedance data is obtained using an impedance cardiograph with four Mylar tape electrodes. The electrodes, numbered one through four from the neck down, are positioned as described by Kubicek, Karnegis, Patterson, Witsoe, and Mattson (67). The electrodes encircle the body at the following sites: (a) two on neck, and (b) two around the upper abdomen, one at the level of the xiphoid and the other approximately 3 centimeters lower. The two outer electrodes provide an electrical field through which passes a constant sinusoidal current (4mA r.m.s.) with a frequency of 100 KHz. The two inner electrodes are attached to a high impedance amplifier and measure impedance changes due to the cardiac cycle. The impedance wave form (ΔZ) and the first time derivative (dZ/dt) are recorded.

Stroke volume is calculated using the equation of Kubicek et al (67):

$$\Delta V = p * (L/Zo)2 * (dZ/dt)T$$

where ΔV is stroke volume (ml); p is rho, resistivity of blood (ohms-cm); L is the mean distance between the two inner electrodes (cm); Zo is the mean thoracic impedance between the two inner electrodes (ohms); (dZ/dt)min is the minimum value for dZ/dt occurring during the cardiac cycle (ohms/sec), and T is the ventricular ejection time (sec).

The equation used to calcuate cardiac output is:

$$Q = SV * HR/1000$$

in which Q is cardiac output (1/min); HR is heart rate (min.), and SV is stroke volume (ml).

When calculating stroke volume by the impedance method, knowledge of the electrical resistivity of the blood is needed. A constant value of 150 ohms-cm is often used to represent the resistivity of human blood (67). Kobayashi, Andoh, Tujinamij, Nakayama, Takada, Takeuchi, and Okamato (65) have stated that some of reported differences in cardiac output values obtained by the electrical impedance and invasive methods may be due to the use of the constant value for rho in the calculation of stroke volume. Mathematical equations, which correct for the estimate of blood resistivity by considering individual hematocrit values, have been developed by several investigators (42, 84, 111). Kobayashi et al. (65) calculated stroke volume using the standard equation of Kubicek et al. (67) and compared the results with those determined from hematocrit. The maximal value obtained for cardiac output using the constant averaged 27% lower than the value determined by hematocrit. Similar results were reported by Denniston, Maher, Reeves, Cruz, Cyerman, and Grover (32) who reported a 27% increase in cardiac output values obtained at rest and during exercise on the bicycle ergometer when rho was derived from hematocrit. In a study conducted by Fujinami, Nakana, Nakayama, and Takada (41), stroke volume was calculated using of the equation of Tanaka, Kanai, Nakayama, and Ono (111) and where rho equaled 135 ohms-cm. Maximal cardiac output values were 38.7% higher when rho was based on actual hematocrit.

Electrode distance (L) was one of the factors used in the stroke volume equation derived by Kubicek et al. (67). The lower correlation found between cardiac output values obtained from the impedance method and invasive methods may be related to the effects of varying the total distance between the inner electrodes on calculated stroke volume (19, 32). Denniston et al. (32) found that cardiac output measured by the impedance method was significantly correlated with values obtained from the dye dilution technique when the mean distance (cm) between the inner electrodes at the anterior and posterior midlines was used to determine L. Boer, Roos, Geyskes, and Mees (19) examined what effect varying the mean electrode length would have on peak height (dZ/dt), thoracic impedance (Zo), and calculated stroke volume. The authors stated that dZ/dt varied with length and Zo increased linearly with inceasing distance. Since both L and Zo are raised to the second power in the equation used to calculate stroke volume, any change in these two parameters would affect the determination of stroke volume. The authors concluded that to estimate intrasubject variations in stroke volume, the distance between the inner electrodes must be kept constant for that individual.

To test the validity of the impedance cardiography as a method for determining cardiac output, comparisons have been made with other traditional methods. Boer et al. (19) found a moderate correlation (r =.61) between cardiac values measured by impedance and thermodilution techniques. A significant correlation between cardiac output values measured by the impedance and dye dilution technique was found when rho was determined from individual hematocrit values and L was the anterior midsternal distance (cm) between the inner electrodes (32). When rho was derived from hematocrit, Miles, Sawka, Wilde, Doerr, Frey, and Glaser (81) found similar values for cardiac output measured during rest and arm exercise for the impedance and CO2 rebreathing method. Smith, Bush, Wiedmeier, and Tristani (106) investigated the usefulness of the impedance method in studying the response to postural stress. The correlation coefficents for stroke volume and cardiac output determined by the impedance and dye dilution technique were 0.87 and 0.83 respectively. The absolute values for cardiac output assessed from the impedance cardiography were found to be greater than values obtained by the dye dilution technique (67) and radioisotope dilution (12, 56). In an early study, Kubicek et al. (67) examined the ability of the impedance and dye dilution technique to reproduce cardiac output values. The authors stated:

> ... reproducibility of single impedance observations of cardiac output is greater than for a similar value obtained by the dye dilution technique. Likewise, the results indicate that the ratio of two cardiac output values obtained by the impedance method is more accurate than a similar ratio obtained by the dye dilution technique in predicting true dye cardiac output values (p. 1212).

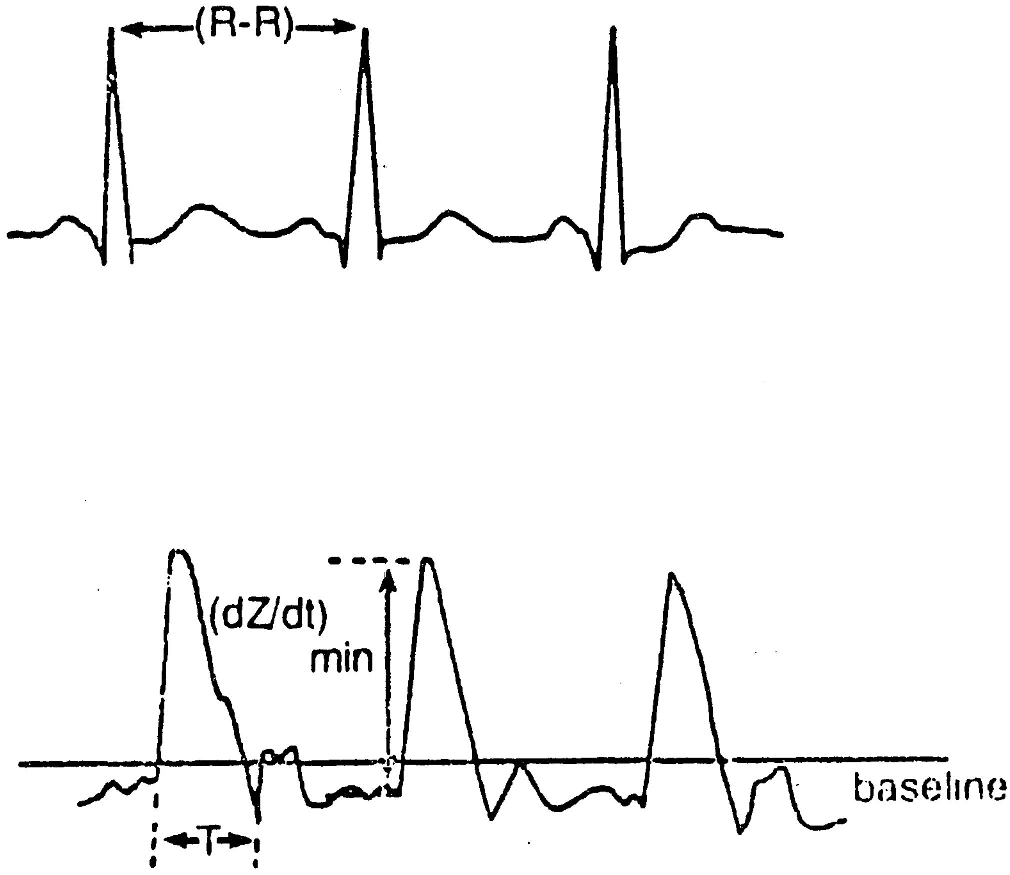
Similar observations have been made by other investigators (12, 64). Impedance cardiography may therefore be a better measure of relative rather than absolute changes in cardiac output (19, 32, 67, 82, 106).

The interpretation of impedance data has often been hindered by respiratory and movement artifacts associated with moderate to heavy exercise (32, 81). Several researchers (33, 65, 81) have investigated alternative methods for estimating cardiac output using the impedance cardiograph. The use of the impedance method to estimate cardiac performance in women during arm ergometer work was examined by Miles et al. (81). By having the subject pause briefly during exercise, the authors found that impedance distortion was minimized without affecting the stroke volume value. However, heart rate fell immediately during the pause. The authors concluded that it would be necessary to multiply the stroke volume value obtained during the pause with exercise heart rate to avoid underestimating cardiac output obtained during exercise. Respiration, especially during exercise, has been found to vary the height of the (dZ/dt)min and cause oscillations above and below a specified baseline (69). In a study conducted by Denniston et al. (32), respiratory and movement artifacts during moderate and heavy exercise performed on the bicycle ergometer distorted the dZ/dt waveform and prevented the calculation of cardiac output by the impedance method. Kobayashi et al. (65) minimized the effects of respiration on the dZ/dt waveform by having the subjects stop pedaling and hold their breath while five cardiac cycles were recorded. The standard method used for calculating stroke volume when using the impedance cardiograph has been to use those impedance beats which fall on a specified baseline. Doerr, Miles, and Frey (33) evaluated an alternative method for the calculation of stroke volume. All impedance beats that occurred during the respiratory cycle and which were independent of a specified baseline were used in the calculation of stroke volume. Results of their study indicated that the values for stroke volume, which were calculated independent of the baseline, were in agreement with those values obtained using the conventional method.

The evaluation of myocardial contractility has been assessed with the impedance cardiograph. The Heather Index, which has been used as an index of heart contractility, can be determined from the impedance cardiograph. The Heather Index is represented by the ratio (dZ/dt)/R-Z interval. The dZ/dt occurs during the rapid ejection phase of the ventricles and increases in the normal individual with exercise. The R (R spike of the ECG) represents the maximal electrical stimulation of the myocardium. The peak value of the dZ/dt (Z spike of the dZ/dt) occurs at the time of maximum ventricular ejection. The interval between the R spike of the ECG and the peak value of the dZ/dt (Z) has been termed the R-Z interval (Figure 1). In the normal heart, the R-Z interval shortens with exercise.

In a study conducted by VanFraechem (118), cardiac output, stroke volume, heart rate, Heather Index, and systolic time intervals were studied in 17 male university students. The purpose of the study was to obtain information about the adjustment of these parameters during bicycle ergometer work. The average R-Z intervals at rest were 95-120 ms which decreased to 60 ms at a workload representing 75% $\dot{V}O_2$ max. A high correlation ($r = .90$) was found between HI and heart rate at 75% workload which demonstrated the importance of the role that heart rate played in the stress response.

Figure 1. Simultaneous recordings of ECG and cardiac impedance (dZ/dt) min.



*Taken from: Doerr, B.M., Miles, D.S., and Frey, M.A.B. (1981). Influence of respiration on stroke volume determined by impedance cardiography. Aviation Space Environmental Medicine, 52 (7), 394-398.

CHAPTER III

METHODS, PROCEDURES, AND STATISTICAL ANALYSES

The purpose of this investigation was to determine the relationships between age, physical activity patterns, estrogen levels and central circulatory responses of post-menopausal women subjected to acute submaximal exercise. This chapter begins with a short introduction and then details the five procedures used in this investigation: (1) selection of subjects, (2) pilot study, (3) maximal stress test, (4) submaximal test, and (5) statistical analyses. These procedures underwent a Human Subject's Committee review with subsequent approval.

Introduction

Due to the complexity of investigating the topic of this study and the lack of documented research in this area, the content is more extensive than the stated research problem. Total central circulatory profiles of postmenopausal women are presented to extend the existing knowledge base of women's physiology. For this reason also information is given about the impedance cardiograph. In summary, the data on rest and recovery as well as exercise are provided for clarity and should not draw attention away from a description of how the stated problem was investigated.

Selection of Subjects

Postmenopausal women were recruited, through campus and newspaper advertisements and contacts made with local physicians, to voluntarily participate in the study. Subjects were between the ages of 44-63 with no known cardiorespiratory disease. Subjects were one to 20 years postmenopausal; had not menstruated for the past year, and had both ovaries intact. Due to the reported low levels of endogenous estrogen in postmenopausal women, women taking estrogen replacement for at least six months preceding data collection were also included in the study to investigate varying levels of estrogen on central circulatory response to submaximal exercise.

Prior to the study each subject underwent a complete physical examination and received physician approval to participate in the study. All were asked to complete a medical history and activity questionnaire. Each subject was informed verbally and in writing of the purpose and nature of the study and gave their informed consent to participate. See Appendix A for these forms.

Pilot Study

Five pre- and postmenopausal women participated in a pilot study conducted during the fall of 1985. Subjects completed both the maximal and submaximal bicycle ergometer tests. Procedures and instrumentation used during the tests are discussed in the following sections. Maximal stress test data were utilized to set each individual submaximal work intensity. During the submaximal test, blood samples were drawn at rest and immediately upon completion of the 30-minute exercise bout to determine hematocrit and estrogen levels. Central circulatory responses to submaximal exercise were assessed by the impedance cardiograph.

The pilot study was conducted to: (1) determine the adequacy of the proposed protocol in assessing central circulatory responses to exercise in middle-aged women, (2) evaluate the proposed pedal cadence, and (3) determine if cardiac response could be assessed during submaximal exercise.

Maximal Stress Test

During the first session, subjects reported to the Student Health Center on the campus of the University of North Carolina at Greensboro. All subjects were asked to refrain from caffeine consumption, cigarette smoking, and eating a large meal three hours prior to each exercise testing session. Subjects were asked to refrain from any physical activity on the day of testing.

Each subject was familiarized with the metabolic and cardiac assessment procedures to be used in the study. The test protocol and pedal cadence were explained to each subject.

The subject's height in centimeters (cm) to the nearest mm without shoes was measured. Body weight was recorded in kilograms (kg) to the nearest decigram.

Maximum voluntary ventilation (MVV) was measured using the pneumoscan S-301 spirometer. Any subject not reaching 70% of the predicted values for maximum voluntary ventilation (Cotton Dust Standards) was excluded from the study.

Baseline data was taken after 5 minutes in the supine position and again after 5 minutes of seated rest on the bicycle ergometer. Resting heart rate and electrocardiogram (ECG) were monitored on the Quinton S-3000 (Leads I,II, and III) and recorded. Blood pressure was measured using the first and fifth sounds of Kortokoff.

The bicycle ergometer stress test was conducted under medical supervision. The maximal graded exercise test was given to determine each subject's maximal aerobic capacity ($\dot{V}O_2$ max) and to eliminate those subjects for whom exercise might be contraindicated. The subject performed a 1-minute warm-up period at zero resistance with a pedaling frequency of 60 rpm. A metronome was used to guide the subject's pedaling cadence. Beginning with a work load of 30 watts, the work intensity was increased by 30 watts every 2 minutes until the subject reached volitional exhaustion. Criterion for determination of $\dot{V}O_2$ max included a plateau (values equal to or less than .15 L 02/min) in oxygen uptake during the last 2 minutes of work or a respiratory exchange ratio (R) greater than 1.00 (Plowman et al. 1979).

Continuous monitoring of the subject's physiological responses was conducted during the stress test. ECG and exercise heart rate were monitored on the Quinton-3000 (Leads I, II, and III) and recorded the last 10 seconds of each workbout. Blood pressure was measured during the first 30 seconds of the last minute of each workbout by asculation using the first and fifth sounds of Kortokoff. A standard open-circuit indirect caliorimetric system was used at 1-

minute intervals to measure pulmonary ventilation ($\dot{V}E$), volume of oxygen consumed ($\dot{V}O_2$), volume of expired carbon dioxide ($\dot{V}CO_2$), and respiratory exchange ratio (R). Ventilation volumes were obtained from expired air using a Pneumoscan S-301 spirometer. Fractions of expired oxygen and carbon dioxide were measured by the Beckman OM-11 and LB CO2 gas analyzers. Calibration of the analyzers was conducted prior to each testing session with gases previously analyzed with a gas chromatograph.

At the completion of the test, the subject continued to pedal at zero resistance for 5 minutes followed by 5 minutes of seated rest. Heart rate, ECG, and blood pressure were recorded immediate post-exercise and during minutes 5 and 10 of recovery. No subject was permitted to leave the Student Health Center until heart rate and blood pressure were near pre-exercise levels.

Submaximal Test

During the second session, each subject reported to the Rosenthal Human Performance Laboratory. Baseline data was taken after 10 minutes of supine rest and after ten minutes of seated rest on the bicycle ergometer. Resting ECG and blood pressure were measured and recorded following the same procedures outlined for the maximal test. Stroke volume, heart rate, cardiac output, and cardiac contractility were assessed with the subject in the supine position and after ten minutes of seated rest on the bicycle ergometer.

Impedance data were obtained using the Minnesota Impedance Cardiograph and four Mylar tape electrodes. The electrodes were numbered one through four from the neck down. Two electrodes encircled the neck and two the upper abdomen, one at the level of the xiphisternal joint and the other approximately 5 centimeters lower around the abdomen. A constant sinusoidal current of 4 milliamperes with a frequency of 100 kilohertz passed through electrodes 1 and 4. The two inner electrodes measured impedance changes during the cardiac cycle. The electrocardiogram and the derivative of impedance (dZ/dt)min were recorded at 50 mm/sec on an Astromed 4000 recorder. The average of six heart beats was used to calculate impedance stroke volume.

Stroke volume was determined using the formula set down by Kubicek, Karnegis, Paterson, Witsoe, and Mattson (67):

$$\Delta V = p * (L/Zo)2 * (dZ/dt)T$$

where ΔV is stroke volume (ml); p is rho, resistivity of blood (ohms-cm); L is the mean distance between the two inner electrodes measured at the anterior and posterior midsternal line (cm); Zo is the basic impedance read from the digital display on the cardiograph (ohms); (dZ/dt)min is the minimum value for dZ/dt occurring during the cardiac cycle (ohms/s); and T is the ventricular ejection period (seconds).

The dZ/dt was measured from the notch in the upstroke of the impedance cardiography. Ventricular ejection time (T) was calculated from the upstroke point defined in (dZ/dt)min to the maximum positive peak.

The resistivity of blood at body temperature was calculated using the equation of Tanaka et al. (1970):

$$p= 66(3 + 1.9\ Hct)/\ (3-3.8\ Hct)$$

where Hct is the individual hematocrit. Hematocrit was determined after 10 minutes of seated rest on the bicycle ergometer.

Cardiac output (Q) in liters per minute was calculated from stroke volume (SV) times heart rate (HR):

$$Q = SV * HR /1000$$

Cardiac contractility was calculated using the Heather Index:

$$(dZ/dt)min\ /\ RZ\ interval$$

where (dZ/dt)min is the minimum value of dZ/dt occuring during the cardiac cycle (ohms/s) and RZ is the time interval in seconds separating the R-wave from the (dZ/dt)min.

A 10.0 ml and 5.0 ml blood sample were drawn by a technican from the antecubital vein after 10 minutes of seated rest on the bicycle ergometer. The blood samples were analyzed for estrogen levels and CBC profile respectively. Estrogen levels were determined by standardized radioimmunoassay. CBC was analyzed on a Coulter S plus II (Appendix B).

The subject completed a 30-minute submaximal bicycle ergometer test. The submaximal protocol consisted of a 1-minute warm-up period at zero resistance followed by a gradual increase in work load over the next 3 minutes. The work load was held constant when the VO_2, expressed in $ml\cdot kg\cdot min^{-1}$, corresponded to 55% of the subject's VO_2 max determined by the maximal graded exercise test. Samples of expiratory gases were collected for 30-second intervals during minutes 6-8, 12-14, and 22-24 to determine if the subject was working within the prescribed intensity ($\pm$ 3.5 $ml \cdot kg \cdot min^{-1}$). If the calculated $\dot{V}O_2$ was not within the intensity range, the work load was adjusted to elicit a response within the prescribed range.

Throughout the submaximal test, heart rate and ECG were monitored continuously. Heart rate was recorded every minute. An ECG tracing was recorded at five minute intervals. Blood pressure was obtained every five minutes.

Impedance data was recorded during minutes 10, 15, 20, 25 and 29 of exercise. Six cardiac cycles were recorded and averaged. For each sampling period, the average of six heart beats was used in the calculation of stroke volume.

At the immediate completion of the submaximal test, impedance, ECG, heart rate and blood pressure data were recorded. A 10.0 ml post-exercise blood sample was then drawn and analyzed for estrogen levels. Heart rate, ECG, blood pressure, and impedance data were recorded during minutes 5 and 10 of recovery.

Statistical Analyses

Statistical procedures were used to determine sample means and standard deviations for each of the variables under investigation (age, physical activity patterns, estrogen levels, mean arterial blood pressure, heart rate, stroke volume, cardiac output, and myocardial contractility). A matrix of Pearson correlation coefficients was generated to determine bivariate relationships between each pair of variables. Stepwise multiple regression procedures using age, physical activity patterns, estrogen levels, and estrogen supplement as the independent variables were computed, one for each of the five dependent variables (stroke volume, heart rate, cardiac output, mean arterial blood pressure, and myocardial contractility), to determine the relative influence of each of the independent variables. An alpha level of .05 was used for all tests of statistical significance.

The values used in the statistical analysis for the independent variable physical activity patterns were computed in two ways from the Physical Activity Questionnaire responses. The physical activity score by decade was the activity level reported by the individual for her age-group. The physical activity by occupation and lifespan physical activity scores were weighted. It was decided to use a weighted average in order to assign more importance to the most recent activity levels. The weights used were: (a) .5 for the 20-30 age-group, (b) 1.0 for the 30-40 age-group, (c) 1.5 for the 40-50 age-group, (d) 2.0 for the 50-60 age-group, and (e) 2.5 for the over 60 age-group. This method of weighting was decided upon resulting from meetings with dissertation committee member and statistical consultant.

CHAPTER IV

RESULTS

The subjects for this study were 19 postmenopausal women ranging in age from 44 to 63 years. Characteristics of the subjects and individual hematocrit values are presented in Table 1. It was intended that only those women who had gone through physiological menopause would be included in this study. However, there was one exception. Subject 14 had her uterus removed at the age of 36, but since both ovaries were intact, she was included in the study.

Results of the bicycle ergometer stress test to maximal exertion are summarized in Table 2. The subjects had a mean age of 54.47 $\pm$ 4.94 years. The group mean $\dot{V}O_2$ max ($ml \cdot kg \cdot min^{-1}$) was 21.74 $\pm$ 5.60. The mean value for maximal heart rate was 153.47 $\pm$ 23.40.

The Physical Activity Questionnaire (Appendix A) was completed by each subject to assess past and present occupational and spare-time physical activity patterns. Table 3 shows number of women who responded to each assessment question by age-group. The majority of responses fell into Group II on both occupational and spare-time physical activity. The responses for occupation and lifespan physical activity were weighted for each subject by age (Methods and Procedures). The group means for these weighted scores are presented in Figure 2. The mean for physical activity by decade was not

Table 1

Baseline Data

No.	Age (Yr)	Yrs. Past Menopause	Ht. (cm)	Wt. (cm)	HR (BPM)	SBP (mm Hg)	DBP	Hct. %
1	54	2	168.91	75.68	85	120	80	37.1
2	52	3	168.91	53.86	50	106	80	41.8
3	56	13	168.28	66.36	85	122	70	41.2
4	56	1	160.02	75.57	54	121	72	47.1
5	50	1	167.64	65.00	57	106	74	37.4
6	55	3.5	162.56	60.91	73	128	76	41.1
7	50	5.5	165.10	52.05	65	128	78	41.4
8	55	5	175.26	58.86	56	105	65	43.4
9	54	1.5	175.26	83.18	65	118	74	36.6
10	52	6	160.02	55.45	86	164	80	36.5
11	52	1	168.91	62.27	78	138	70	40.8
12	63	13	160.02	54.55	60	146	74	42.6
13	58	5	152.40	48.18	74	118	78	39.9
14	59	26	162.56	51.82	54	108	60	42.3
15	63	15	177.80	91.59	69	149	88	40.4
16	48	5	157.48	57.73	63	110	70	41.2
17	44	4	167.64	47.27	59	108	72	43.3
18	61	20	170.18	68.18	78	124	78	40.1
19	53	1	157.48	62.73	64	112	70	41.2
X=	54.47	6.92	165.60	62.70	67.11	122.73	74.16	38.76
SD=	±4.94	±7.14	±6.76	±11.92	±11.39	±16.35	±6.26	±8.72

Table 2

Maximal Data

No.	Age (Yr)	$\dot{V}E$ $(l \cdot min^{-1})$	$\dot{V}O2$ $(ml \cdot kg^{-1} \cdot min^{-1})$	R	HR (BPM)	SBP (mm Hg)	DBP (mm Hg)
1	54	33.04	17.79	1.09	187	180	90
2	52	46.63	31.00	1.23	176	140	84
3	56	25.22	13.79	1.16	166	190	85
4	56	37.75	20.37	1.09	132	182	85
5	50	60.86	32.01	1.04	167	182	80
6	55	50.58	20.88	1.07	150	194	80
7	50	39.74	25.40	1.18	167	168	76
8	55	49.90	27.13	1.07	145	200	80
9	54	66.50	19.80	1.14	150	180	94
10	52	26.57	13.23	.98	118	170	86
11	52	54.60	27.58	1.01	160	200	98
12	63	22.76	18.24	.76	120	170	85
13	58	47.14	20.52	1.34	175	180	92
14	59	28.13	19.51	1.07	145	170	75
15	63	37.25	13.67	.98	96	160	90
16	48	56.73	25.76	1.05	175	150	90
17	44	39.11	27.11	1.10	160	168	88
18	61	59.83	18.94	1.20	173	162	100
19	53	49.30	20.40	1.10	154	170	80
X =	54.47	43.77	21.74	1.09	153.47	174.53	86.21
SD =	±4.94	±13.00	±5.60	±.12	±23.40	±15.72	±6.92

Table 3

Physical Activity Questionnaire Results *

Occupational Activity

Group I	Group II	Group III	Group IV
Predominantly sedentary, sitting: desk worker, watch maker, sitting assembly-line worker (light goods)	Sitting or standing, some walking: cashier, general office worker, light tool and machinery worker, foreman	Walking, some handling of material: mailman, waiter, construction worker, heavy tool and machinery worker	Heavy manual work: lumberjack, dock worker, stone mason, farm worker, ditch digger

Occupation corresponded most closely to group:

Age	I	II	III	IV
20-30	4	11	2	1
30-40	3	12	3	1
40-50	4	11	4	-
50-60	2	8	3	-
Over 60	1	2	-	-

Spare-Time Physical Activity

Group I	Group II	Group III	Group IV
Almost completely inactive: reading, TV watching, movies, etc.	Some physical activity during at least 4 hours per week: riding a bicycle or walking to work, walking or skiing with the family, gardening.	Regular activity: such as heavy gardening, running, calisthenics, tennis, etc.	Regular hard physical training for competition in running events, soccer, racing, European handball, etc. Several times per week.

Activity during at least 7 mo/yr corresponding to group:

Age	I	II	III	IV
20-30	2	14	2	1
30-40	2	14	2	1
40-50	2	13	4	-
50-60	3	8	3	-
Over 60	-	3	-	-

* Taken from: Saltin, B., and Grimby, G. (1968). Physiological analysis of middle-aged and older former athletes. Comparison with still active athletes of the same ages. Circulation, 38, 11044-1115.

weighted (Figure 2).

There was a significant correlation ($r = .90$, $p = .0001$) between lifespan physical activity and physical activity by decade as shown in Table 4. Physical activity patterns and Agel were not significantly related.

In Table 5 are presented the group means and standard deviations for the dependent variables (cardiac output, stroke volume, Heather Index, mean arterial blood pressure, and heart rate) during submaximal exercise. Each variable was measured during: (a) supine rest, (b) seated rest, (c) exercise, (d) immediate post-exercise (IPE), and (e) after 10 minutes of seated recovery. All 19 subjects completed the submaximal exercise and the measurements taken immediately after exercise. Recovery data was unattainable on one subject.

The data in Table 5 shows that mean values for cardiac output and stroke volume decreased when the subject moved from a supine to seated position. As expected, exercise values were higher than resting values for all variables. There was little change in mean values during exercise. In each variable, the IPE mean was lower than the mean measured during minute 29 of exercise. The Heather Index showed slight variation from minute 29 of exercise to IPE. The group means for each of the variables ($\pm$ SE) are presented in Figures 3 through 7.

In Table 6 are the values for the serum concentration of total estrogen (pg/ml) measured at rest and immediately after submaximal

Figure 2. Weighted mean occupational (PAO) and lifespan physical activity scores (LSPA) and mean physical activity by decade (PAD). Lines, SE.

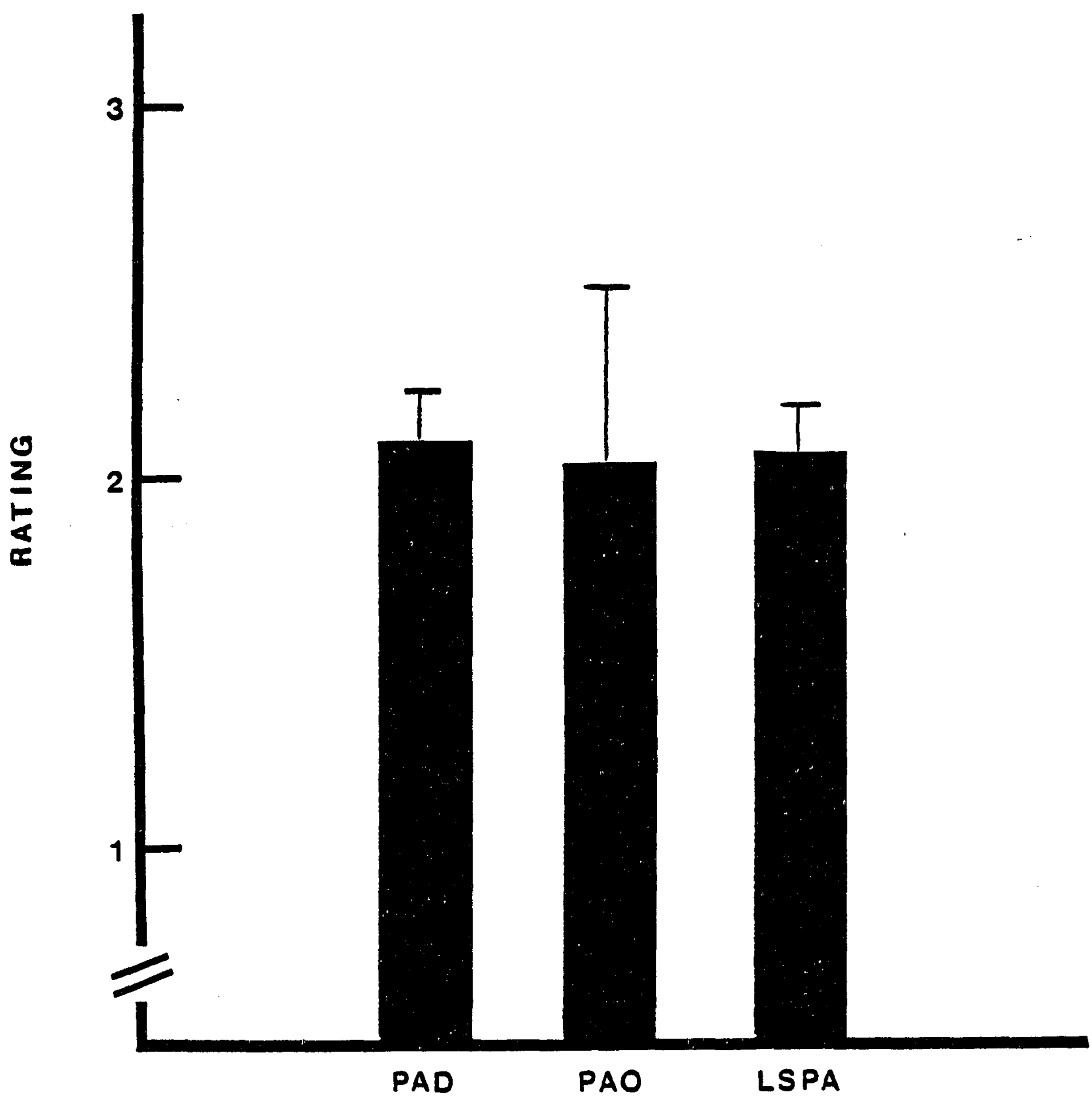


Table 4

Correlation Matrix of Physical Activity Patterns and Age

	PAO	LSPA	PAD	AGE
Physical Activity by Occupation (PAO)	1.000	___		
Life-Span Physical Activity (LSPA)	.754	1.000	___	
Physical Activity by Decade (PAD)	.617	.900	1.000	___
Age	-.294	.009	-.014	1.000

Table 5

Group Means and Standard Deviations of Submaximal

Rest, Exercise, and Recovery Data

Variable	Rest		Exercise				Recovery	
	10 Supine	20 Seated	15	20	25	29	IPE	10 Seated
Cardiac Output (l/min)								
X	5.95	4.32	9.69	10.37	10.29	10.23	9.16	4.55
SD	2.17	1.30	2.92	2.39	3.14	2.99	3.06	1.49
Stroke Volume (ml)								
X	100.49	62.56	95.21	98.65	97.55	97.37	91.41	57.26
SD	35.65	19.58	29.06	22.30	28.01	27.55	28.69	19.76
Heart Rate (BPM)								
X	61.11	70.26	103.16	106.63	106.84	106.68	101.37	80.28
SD	10.54	10.83	16.84	18.85	20.51	19.56	20.08	10.87
Mean Arterial Blood Pressure (mm/hg)								
X	88.18	91.40	100.08	100.53	100.65	100.42	93.35	90.76
SD	9.18	10.17	8.73	10.35	10.31	10.92	10.12	9.77
Heather Index								
X	25.34	19.51	55.73	55.29	52.47	53.41	52.74	21.18
SD	12.39	7.58	15.27	12.49	14.84	15.27	16.85	8.40

Figure 3. Group means for cardiac output measured at rest, exercise, and recovery. Lines, SE.

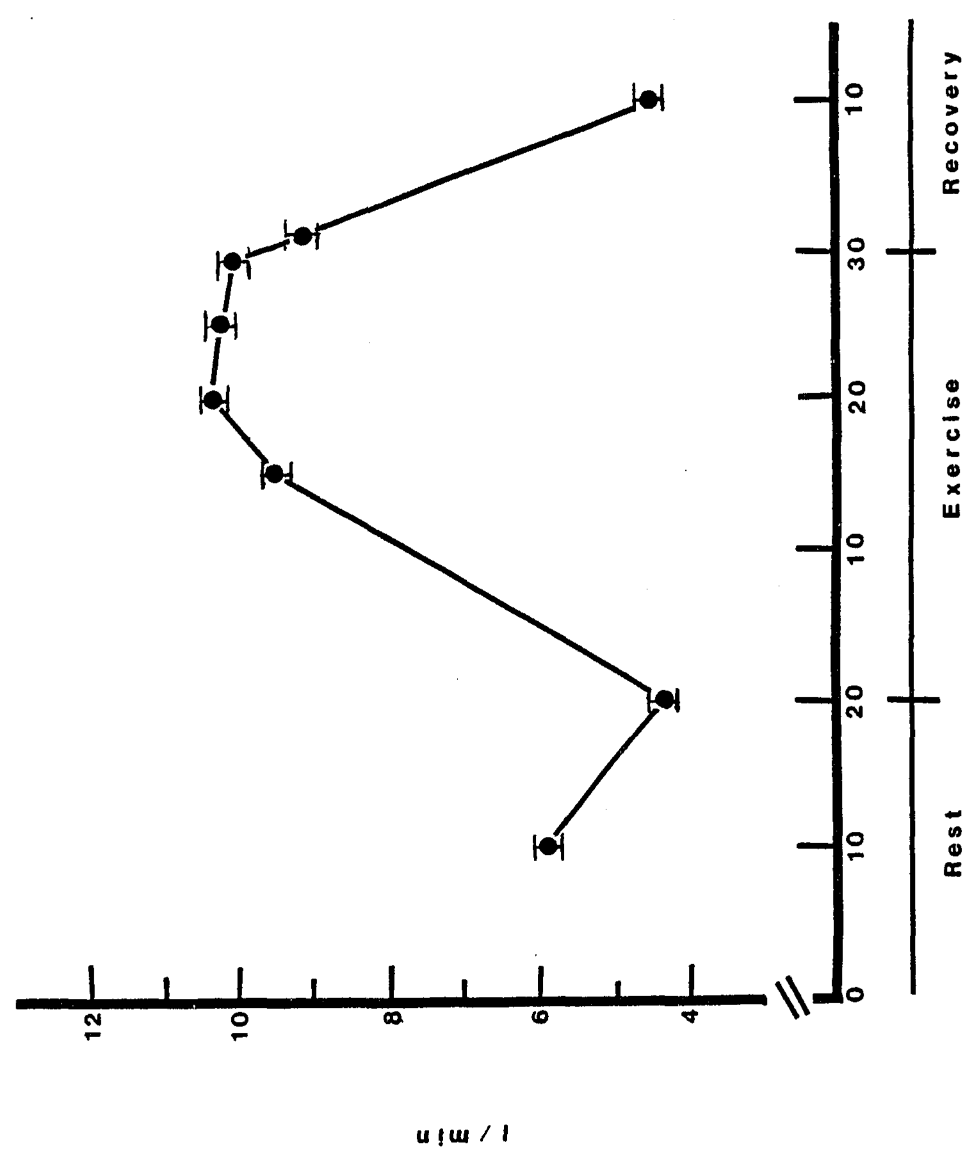


Figure 4. Group means for stroke volume measured at rest, exercise, and recovery. Lines, SE.

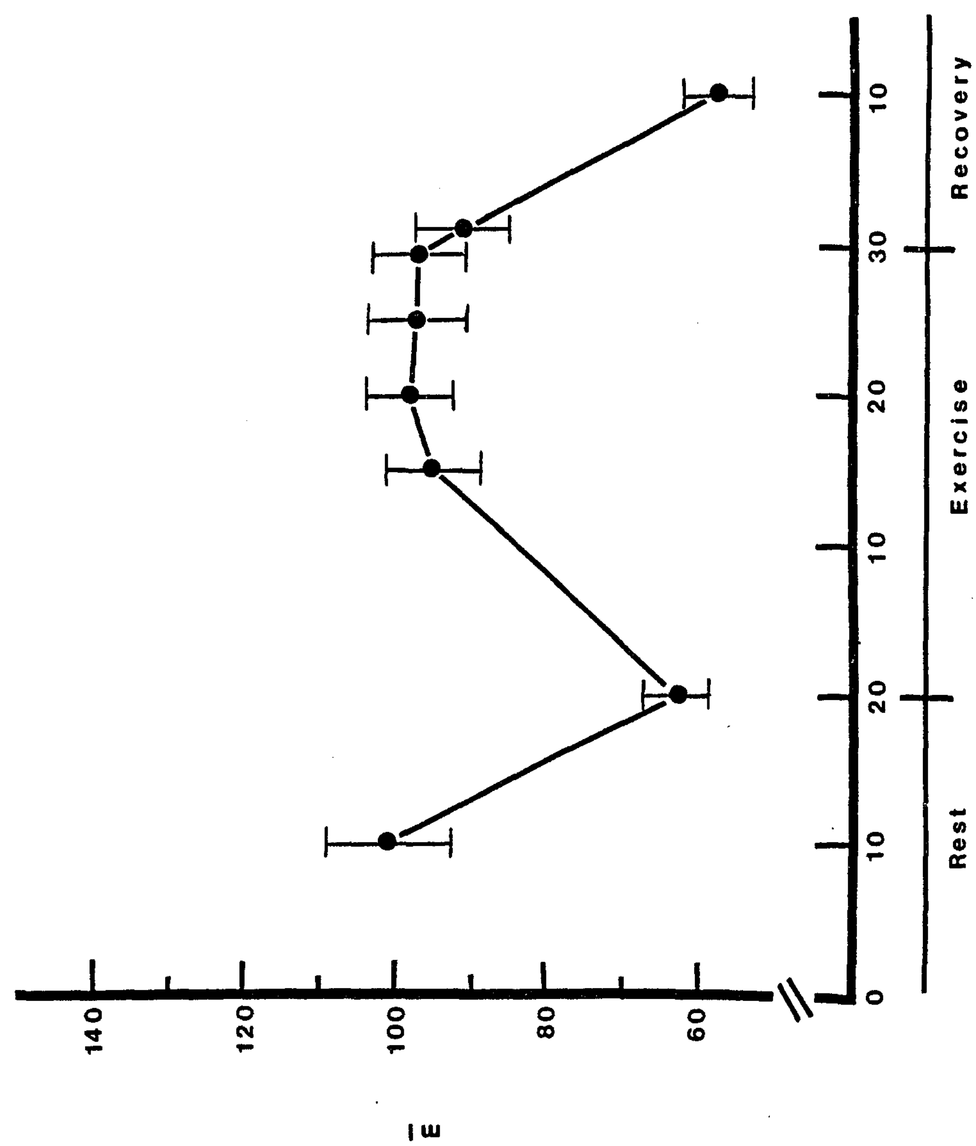


Figure 5. Group means for the Heather Index measured at rest, exercise, and recovery. Lines, SE.

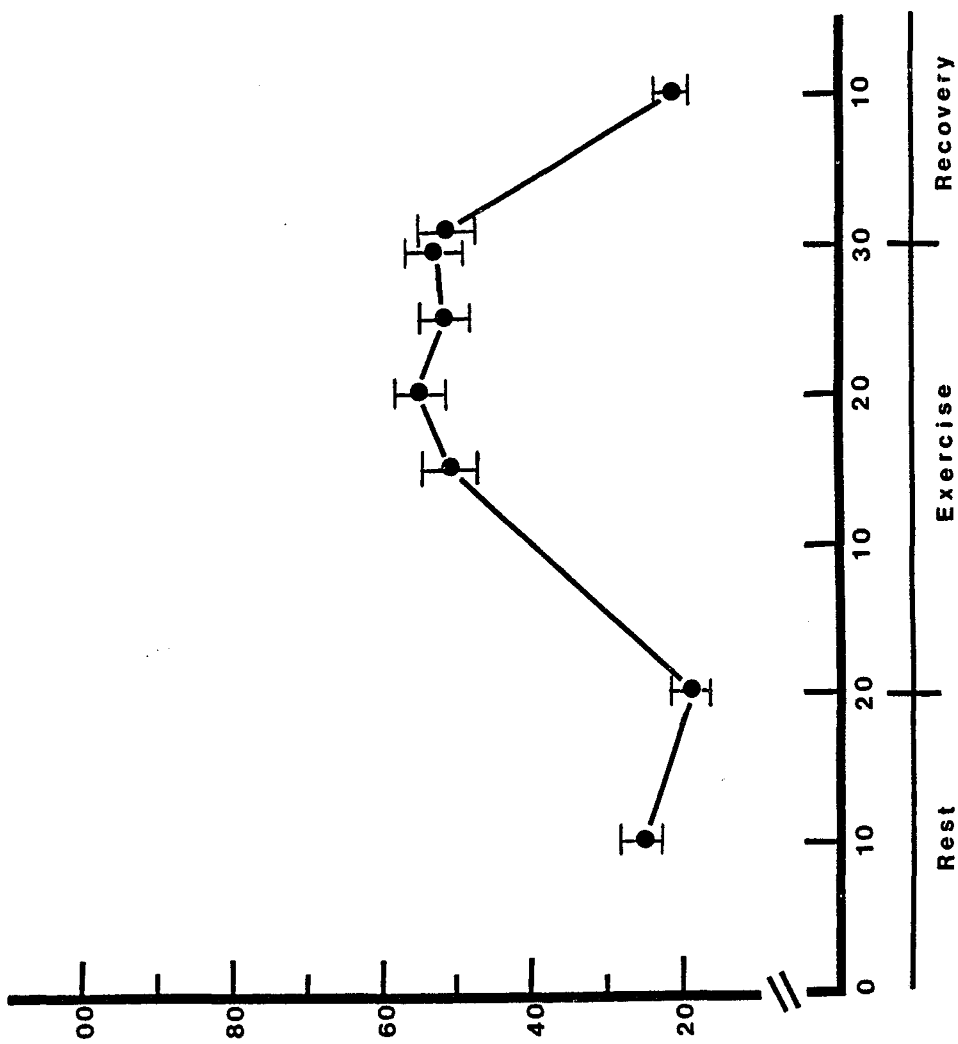


Figure 6. Group means for mean arterial blood pressure measured at rest, exercise, and recovery. Lines, SE.

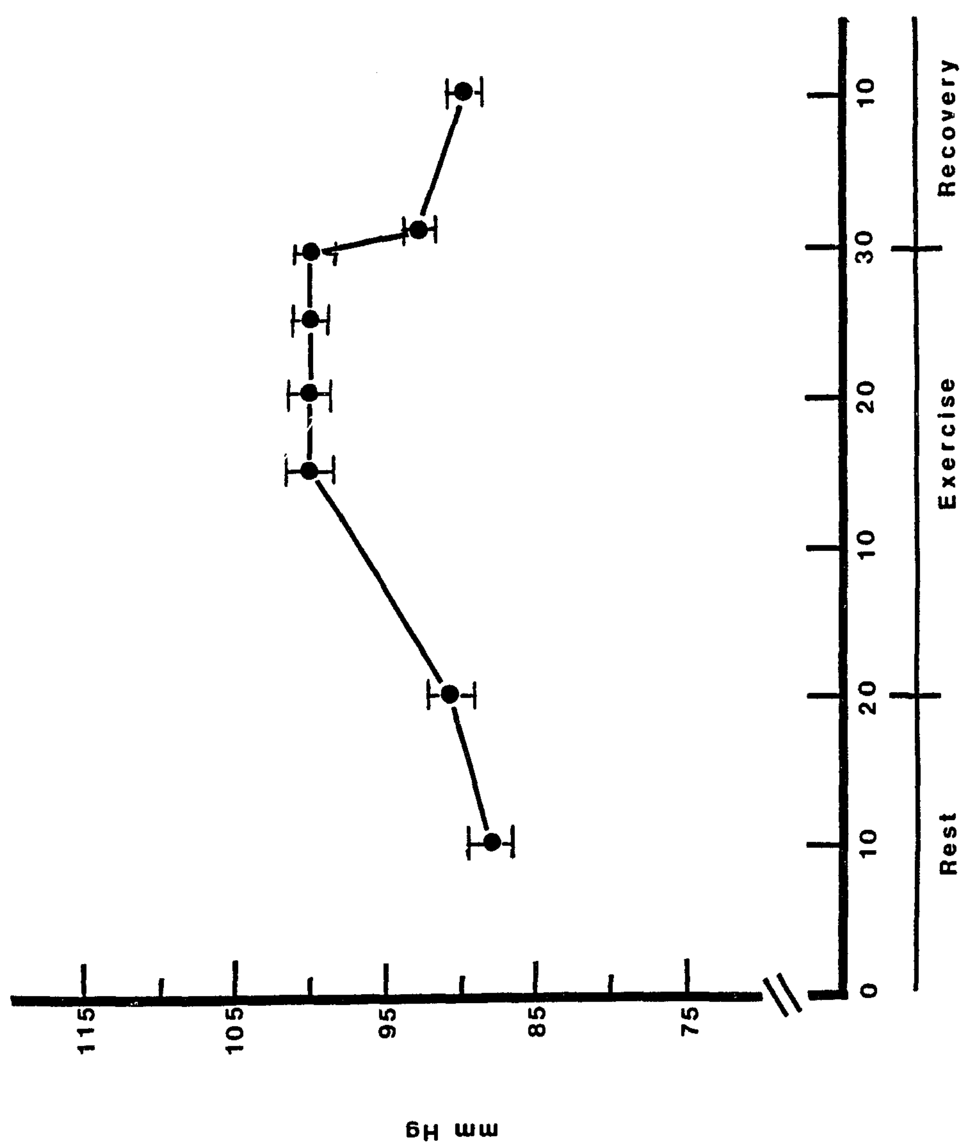
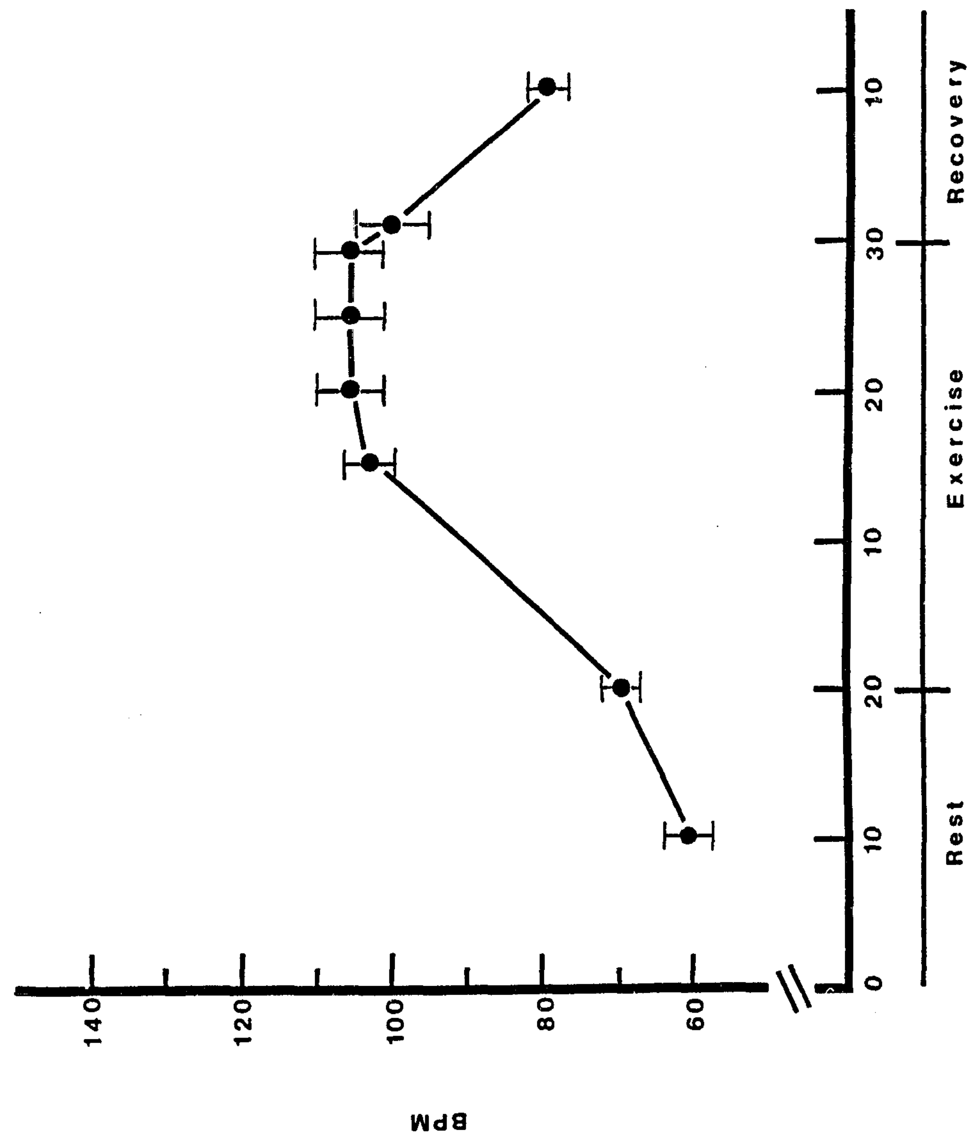


Figure 7. Group means for heart rate measured at rest, exercise, and recovery. Lines, SE.



exercise (IPE). The four women receiving estrogen supplement had higher serum concentration of total estrogen at rest. The IPE values for total estrogen exceeded resting values in all but two subjects (subjects 11 and 17). Subject 9 at the time of the study was taking two forms of estrogen supplement (Appendix C). As seen in Table 6, this subject had the highest levels of total estrogen at rest and IPE. The relationships of both estrogen levels to physical activity patterns were not significant (Table 7).

Pearson product moment correlations were determined for all independent variables (physical activity patterns, age, estrogen levels, and estrogen supplement) with each of the dependent variables (Tables 8 through 12). In Tables 8 through 12 the independent variables are represented by:

PAO = physical activity by occupation
LSPA = lifespan physical activity
PAD = physical activity by decade
Age1 = age
Est1 = serum concentration of estrogen measured at rest
Est2 = serum concentration of estrogen measured immediate post-exercise
Sup = estrogen supplement

The dependent variables in Tables 8 through 12 are represented by:

Q = cardiac output
SV = stroke volume
HI = Heather Index
MAP = mean arterial blood pressure
HR = heart rate

The sampling periods in Tables 8 through 12 are represented by:

1 = supine rest
2 = seated rest
3 = minute 15 of exercise
6 = minute 29 of exercise

Table 6

Serum Concentration of Total Estrogen at Rest and Immediate Post-Exercise (IPE)

Subject	Rest (Est1) (pg/ml)	IPE (Est2)
1	68.7	77.2
2	60.1	95.2
3+	181	393
4	265	288
5	90.0	131
6	80.4	97.4
7	63.4	65.5
8	56.0	68.1
9+	352	398
10	49.1	79.4
11	112	56.2
12+	45.4	48.9
13	39	51.9
14	77.8	87.2
15+	255	280
16	37.3	42.3
17	82.1	72.5
18	53.5	70.6
19	73.3	116

+ = estrogen supplement.

Table 7

Correlation Matrix of Total Estrogen Levels and Physical Activity Patterns

	PAO	LSPA	PAD
Estrogen/Rest	.158 p=.516	-.009 p=.969	-.034 p=.888
Estrogen/Immediate Post-Exercise	.004 p=.988	-.128 p=.600	-.121 p=.621

PAO = occupational patterns
LSPA = lifespan physical activity patterns
PAD = physical activity patterns by decade

7 = immediate post-exercise (IPE)
8 = recovery

The immediate post-exercise value (IPE) was obtained during the first ten seconds of recovery. In the discussion of the results, the symbols used for the dependent variables and the sampling periods are combined.

In Table 8 are presented the Pearson correlation coefficients between cardiac output and the independent variables. At rest, PAO (r =.25, p =.293) LSPA (r =.26, p =.916) and PAD (r =.01, p =.983) were not significantly correlated with cardiac output. Measurements taken during minute 15 of exercise showed Q3 to be significantly correlated to LSPA (r =.51, p =.027) and to PAD (r = .47, p =.043). As can be seen in Table 8, Q6 was significantly correlated to PAO (r =.57, p =.011), LSPA (r =.57, p =.011) and PAD (r =.52, p =.022). Significant relationships were found with Q7 and LSPA (r =.51, p =.025) and with Q7 and PAD (r =.54, p =.017). During recovery, physical activity patterns and cardiac output were not significantly related.

The relationships of Age1 to Q1, Q2 and exercise Q3 were not significant (Table 8). Cardiac output, measured during minute 29 of exercise, was negatively related to Age1 (r = -.57, p =.017). Age1 and Q7 showed a significant negative relationship (r = -.47, p =.040).

Estrogen levels at rest showed no significant correlation with Q1 or Q2. Coefficients for Est1 (r = -.51, p =.029) and Est2 (r = -.50, p =.033) were significantly related to Q8.

Table 8

Correlation Matrix of Cardiac Output and Physical Activity Patterns, Age, Estrogen Levels, and Supplement

	Q1	Q2
PAO	0.25433 0.2934	0.27319 0.2578
LSPA	0.02588 0.9162	0.24765 0.3067
PAD	0.00535 0.9827	0.12299 0.6159
AGE1	-0.08788 0.7205	-0.28172 0.2426
EST1	0.31151 0.1942	-0.28803 0.2318
SUP	0.39964 0.0900	-0.27744 0.2502

	Q3	Q6	Q7	Q8
PAO	0.38053 0.1080 19	0.56957 0.0109 19	0.36785 0.1213 19	0.33353 0.1762 18
LSPA	0.50653 0.0269 19	0.56658 0.0114 19	0.51275 0.0248 19	0.23861 0.3403 18
PAD	0.46774 0.0434 19	0.52152 0.0220 19	0.54130 0.0167 19	0.24917 0.3187 18
AGE1	-0.38326 0.1053 19	-0.56576 0.0116 19	-0.47468 0.0400 19	-0.44494 0.0643 18
EST1	-0.04217 0.8639 19	-0.14650 0.5495 19	-0.38584 0.1028 19	-0.51336 0.0293 18
EST2	-0.14744 0.5469 19	-0.24789 0.3062 19	-0.41640 0.0762 19	-0.50368 0.0331 18
SUP	-0.51628 0.0236 19	-0.42015 0.0733 19	-0.48565 0.0350 19	-0.36302 0.1387 18

The relationships between physical activity patterns and stroke volume are presented in Table 9. Physical activity patterns by occupation (r =.46, p =.049) and LSPA (r =.47, p =.042) were significantly correlated to SV2. Stroke volume, measured during minute 15 of exercise, was significantly related to LSPA (r =.45, p =.055) and to PAD (r =.52, p =.024). The relationships of SV6 and SV7 to PAO, LSPA, and PAD were all significant. The correlation between stroke volume obtained during minute 29 of exercise and PAO was .67 (p =.002). Physical activity by decade and SV8 showed a correlation of .60 (p =.007). Age1, Est1 or Est2 were not significantly related to stroke volume measurements made at rest, exercise, or during recovery.

The Heather Index, measured in the supine position (HI1), had a strong but not significant relationship with PAD (r = - .45, p =.054) (Table 10). Physical activity patterns and the HI, measured during exercise, IPE, and recovery, were not significantly correlated. Heather Index measurements made during minute 15 (r = -.59, p =.008) and 29 (r = -.56, p =.013) of exercise and IPE (r = -.53, p =.021) were significantly related to Age1.

In Table 10 the relationships between Est1, Est2 and the HI are presented. A significant negative relationship was found between Est1, and HI7 (r = -.51, p =.024) and between Est1 and HI8 (r = -.56, p =.017). No significant relationships were found between Est2 and the HI measured during exercise, IPE, or recovery.

The correlation matrix between MAP and the independent variables

Table 9

Correlation Matrix of Stroke Volume and Physical Activity Patterns, Age, Estrogen Levels, and Supplement

	SV1	SV2
PAO	0.33733 0.1578	0.45657 0.0494
LSPA	0.24586 0.3103	0.47037 0.0421
PAD	0.28006 0.2455	0.34945 0.1425
AGE1	-0.06898 0.7790	-0.26581 0.2714
EST1	0.31454 0.1897	-0.17536 0.4727
SUP	0.30648 0.2019	-0.15342 0.5306

	SV3	SV6	SV7	SV8
PAO	0.37496 0.1137 19	0.67020 0.0017 19	0.49662 0.0305 19	0.48394 0.0419 18
LSPA	0.44714 0.0549 19	0.58046 0.0092 19	0.53755 0.0176 19	0.36825 0.1327 18
PAD	0.51638 0.0236 19	0.56881 0.0110 19	0.59600 0.0071 19	0.35825 0.1443 18
AGE1	-0.04524 0.8541 19	-0.27898 0.2474 19	-0.26452 0.2738 19	-0.33757 0.1707 18
EST1	0.23582 0.3311 19	0.22193 0.3612 19	-0.08525 0.7286 19	-0.28555 0.2507 18
EST2	0.14063 0.5658 19	0.07567 0.7582 19	-0.13683 0.5765 19	-0.29243 0.2390 18
SUP	-0.25345 0.2951 19	-0.12181 0.6194 19	-0.20925 0.3899 19	-0.13436 0.5950 18

Table 10

Correlation Matrix of Heather Index and Physical Activity Patterns, Age, Estrogen Levels, and Supplement

	HI1	HI2
PAO	-0.14154 0.5633	-0.17468 0.4744
LSPA	-0.38977 0.0990	-0.16678 0.4950
PAD	-0.44797 0.0544	-0.21594 0.3746
AGE1	-0.03221 0.8958	-0.00847 0.9726
EST1	-0.06048 0.8057	-0.40585 0.0847
SUP	0.18064 0.4593	-0.20517 0.3994

	HI3	HI6	HI7	HI8
PAO	0.26396 0.2748 19	0.29405 0.2217 19	0.10330 0.6739 19	-0.02153 0.9324 18
LSPA	0.06982 0.7764 19	0.09177 0.7087 19	0.07159 0.7709 19	-0.18836 0.4541 18
PAD	0.01585 0.9487 19	0.09014 0.7136 19	0.13831 0.5723 19	-0.17630 0.4841 18
AGE1	-0.59130 0.0077 19	-0.55787 0.0131 19	-0.52631 0.0206 19	-0.31087 0.2093 18
EST1	-0.25895 0.2844 19	-0.40248 0.0876 19	-0.51400 0.0244 19	-0.55590 0.0166 18
EST2	-0.26572 0.2715 19	-0.37708 0.1115 19	-0.43854 0.0604 19	-0.44533 0.0640 18
SUP	-0.50635 0.0270 19	-0.52021 0.0224 19	-0.60791 0.0058 19	-0.28516 0.2514 18

is presented in Table 11. Physical activity patterns and all MAP measurements were not significantly related. Estrogen levels (Est1 and Est2) and MAP were not significantly related. Age1 was significantly related to MAP1 (r = .46, p =.047) and to MAP8 (r =.57, p =.014).

Table 12 presents the resulting Pearson correlation coefficients between heart rate and the independent variables. Heart rate measured at rest (HR1) was significantly related to LSPA (r = -.50, p =.031) and to PAD (r = -.59, p =.008). Physical activity patterns were negatively correlated with HR2.

Heart rate measurements taken during exercise or IPE were not significantly related to physical activity patterns. A significant negative correlation was found between PAO and HR8 (r = -.48, p =.046).

No significant relationships were found between Age1 and heart rate measured at rest in the supine (HR1) or seated position (HR2). Age1 was significantly related to HR3 (r = -.57, p =.011) and to HR6 (r = -.49, p =.073).

Resting levels of estrogen were not significantly related to HR1 or HR2. However, as can be seen in Table 12, both Est1 and Est2 were significantly negatively correlated with heart rate measurements taken during exercise, IPE, and recovery.

A stepwise multiple regression procedure (maximum R-square) was used to determine the relative influence of age, physical activity patterns, estrogen levels, and estrogen supplement in explaining the

Table 11

Correlation Matrix of Mean Arterial Blood Pressure and

Physical Activity Patterns, Age, Estrogen Levels and Supplement

	MAP1	MAP2
PAO	-0.06621 0.7877	-0.17394 0.4764
LSPA	0.05656 0.8181	0.00326 0.9894
PAD	-0.02956 0.9044	-0.05415 0.8257
AGE1	0.46122 0.0469	0.41411 0.0780
EST1	0.16355 0.5035	0.04385 0.8585
SUP	0.39639 0.0929	0.31567 0.1880

	MAP3	MAP6	MAP7	MAP8
PAO	0.03116 0.8992 19	0.00649 0.9790 19	-0.25303 0.2959 19	-0.06689 0.7920 18
LSPA	0.31952 0.1824 19	0.32034 0.1812 19	0.06679 0.7859 19	0.22089 0.3784 18
PAD	0.12599 0.6073 19	0.20590 0.3977 19	0.08311 0.7352 19	0.22856 0.3616 18
AGE1	0.28043 0.2449 19	0.35403 0.1370 19	0.40238 0.0876 19	0.56619 0.0143 18
EST1	0.11524 0.6385 19	0.15844 0.5171 19	0.10752 0.6613 19	0.26751 0.2832 18
EST2	0.08177 0.7393 19	0.11708 0.6331 19	0.14705 0.5480 19	0.22880 0.3611 18
SUP	0.24442 0.3132 19	0.24731 0.3074 19	0.31323 0.1916 19	0.38943 0.1102 18

Table 12

Correlation Matrix of Heart Rate and Physical Activity

Patterns, Age, Estrogen Levels, and Supplement

	HR1	HR2
PAO	-0.36983	-0.52049
	0.1191	0.0223
LSPA	-0.49446	-0.59458
	0.0314	0.0073
PAD	-0.58658	-0.55796
	0.0083	0.0130
AGE1	0.10148	-0.01286
	0.6793	0.9583
EST1	-0.08397	-0.20378
	0.7325	0.4027
SUP	0.05762	-0.24568
	0.8147	0.3107

	HR3	HR6	HR7	HR8
PAO	-0.07562	-0.18998	-0.22083	-0.47646
	0.7583	0.4360	0.3636	0.0456
	19	19	19	18
LSPA	0.04463	-0.03813	-0.04027	-0.42976
	0.8560	0.8768	0.8700	0.0751
	19	19	19	18
PAD	-0.08184	-0.09225	-0.08722	-0.35788
	0.7391	0.7072	0.7225	0.1448
	19	19	19	18
AGE1	-0.57105	-0.48847	-0.41995	-0.19782
	0.0107	0.0338	0.0734	0.4314
	19	19	19	18
EST1	-0.46076	-0.57874	-0.56991	-0.57942
	0.0471	0.0094	0.0109	0.0117
	19	19	19	18
EST2	-0.47714	-0.50276	-0.51458	-0.53556
	0.0389	0.0282	0.0242	0.0220
	19	19	19	18
SUP	-0.54067	-0.54742	-0.53161	-0.54522
	0.0168	0.0153	0.0192	0.0193
	19	19	19	18

variation in central circulatory responses measured during acute submaximal exercise. In Tables 13 through 17 are presented the best estimative models for each of dependent variables measured at rest, submaximal exercise, and recovery.

In Table 13 are presented the best estimative models for explaining the variation in cardiac output measured during rest, exercise, and recovery. The models for Q1 and Q2 were able to explain 27% and 25% of the variability in cardiac output measured at rest. The four variables, (Sup, LSPA, PAD, and Est2) accounted for 71% of the variability in Q3. Supplement, LSPA, and Age1 accounted for 66% of the variance in Q6 with LSPA ($p = .002$) and Age1 ($p = .017$) being the significant variables. The three variables, PAD, Age1, and Est1, were able to explain 60% of the variance in Q7. Age1 ($p = .023$) and PAD ($p = .005$) were significant. Resting estrogen levels (Est1) were significant ($p = .021$) in the regression equation with PAD and Age1 which explained 48% of the variability in Q8.

As shown in Table 14, a large proportion of the variation in resting stroke volume was not accounted for by the independent variables. Supplement ($p = .001$), PAO ($p = .002$), Age1 ($p = .016$) and Est2 ($p = .003$) were significant contributors to the explanation of the variation in SV3 ($R^2 = .67$). Physical activity by decade ($p = .001$) and Sup ($p = .052$) were significant variables in the regression equation used to explain 59% of the variance in SV6. Physical activity by decade and Age1 accounted for 43% of the variation in SV7 with PAO being significant ($p = .006$). The explanatory power of the

Table 13

Best Estimative Models for Cardiac Output Measured During Rest, Submaximal Exercise, and Recovery

Variable	Best Model Variables	R^2 (Best Model)	R^2 (Full Model)	p
REST SUPINE	Sup	.27	.29	.058
	PAO			.736
	Age1			.253
REST SEATED	Sup	.25	.27	.144
	PAO			.572
	LSPA			.317
	PAD			.260
EXERCISE (min. 15)	Sup	.71	.71	.0004
	LSPA			.015
	PAD			.245
	Est2			.013
EXERCISE (min. 29)	Sup	.66	.68	.246
	LSPA			.002
	Age1			.017
EXERCISE (IPE)	PAD	.60	.62	.005
	Age1			.023
	Est1			.105
RECOVERY	PAO	.48	.51	.118
	Est1			.021
	Age1			.337

Table 14

Best Estimative Models for Stroke Volume Measured

During Rest, Submaximal Exercise, and Recovery

Variable	Best Model Variables	R^2 (Best Model)	R^2 (Full Model)	p
REST SUPINE	Sup			.080
	PAO	.26	.29	.171
	Age1			.252
REST SEATED	LSPA			.042
	Age1	.29	.34	.237
EXERCISE (min. 15)	Sup			.0006
	PAO	.65	.67	.002
	Age1			.016
	Est2			.003
EXERCISE (min. 29)	Sup			.053
	PAO	.59	.62	.001
	Est1			.090
EXERCISE (IPE)	PAD			.006
	Age1	.43	.45	.181
RECOVERY	PAO			.021
	Est1	.39	.41	.256
	Est2			.614

full regression model was not able to explain a significant portion of the variance in either SV7 or SV8. The variables, PAO, Estl and EST2, accounted for only 39% of the variability in SV8. The variable, PAO, was significant (p =.021).

In Table 15 are presented the best estimative models for explaining the variation seen in the Heather Index measured during rest, exercise, and recovery. As seen with cardiac output and stroke volume, the independent variables were not able to explain a significant portion of the variance in the Heather Index measured at rest. However, Sup, PAO, PAD, Estl, and Est2 explained 55% of the variation in HI3. Supplement (p =.009) and PAO (p =.015) were significant variables. A significant portion of the variation in HI6 (R^2 =.60) was explained by Sup, PAO, PAD, Estl and EST2. The variables Sup (p =.009) and PAO (p = .015) were significant. Fifty-seven percent of the variance in HI7 was explained by Sup, PAO, Estl and Est2 with the variables Sup (p =.013) and Estl (p =.038) being the significant. A significant portion of the variance in HI8 was explained by Estl (p =.007).

A significant portion of the variation in resting mean arterial blood pressure was not explained by the independent variables (Table 16). Supplement, PAO, LSPA, and PAD explained only 46% of the variance in MAP3 and accounted for a small portion of the variance in MAP6 (R^2 =.38). Lifespan physical activity was a significant variable in the regression equation for MAP3 (p =.009) and MAP6 (p =.04). Physical activity by decade, Agel and Estl explained 42% of

Table 15

Best Estimative Models for the Heather Index Measured

During Rest, Submaximal Exercise, and Recovery

Variable	Best Model Variables	R^2 (Best Model)	R^2 (Full Model)	p
REST SUPINE	Sup			.248
	PAO	.30	.31	.292
	LSPA			.068
	Est1			.264
REST SEATED	PAD			.313
	Est1	.22	.23	.080
EXERCISE (min. 15)	Sup			.009
	PAO			.015
	PAD	.55	.55	.100
	Est1			.206
	Est2			.149
EXERCISE (min. 29)	Sup			.022
	PAO			.010
	LSPA	.60	.60	.124
	Est1			.074
	Est2			.131
EXERCISE (IPE)	Sup			.013
	PAO	.57	.59	.087
	Est1			.038
	Est2			.070
RECOVERY	PAO			.111
	LSPA	.46	.49	.077
	Est1			.007

Table 16

Best Estimative Models for Mean Arterial Blood Pressure Measured During Rest, Submaximal Exercise, and Recovery

Variable	Best Model Variables	R^2 (Best Model)	R^2 (Full Model)	p
REST SUPINE	Sup			.376
	Age1	.25	.29	.175
REST SEATED	Sup			.426
	Age1	.21	.25	.250
	Est1			.552
EXERCISE (min. 15)	Sup			.284
	PAO	.46	.47	.044
	LSPA			.009
	PAD			.062
EXERCISE (min. 29)	Sup			.229
	PAO			.054
	LSPA	.38	.41	.046
	PAD			.323
EXERCISE (IPE)	Sup			.065
	PAO	.38	.41	.020
	LSPA			.046
RECOVERY	PAD			.203
	Age1	.42	.46	.019
	Est1			.482

the variation in MAP8. Age1 explained a significant portion of the variance in MAP8 (p =.019)

In Table 17 are presented the best estimative models for explaining the variation in heart rate during rest, exercise, and recovery. The amount of variation in resting heart rate explained by the independent variables was less than 45%. However, 73% of the variance in the dependent variable, HR3, was explained by PAO, LSPA, PAD, Age1 and Est1. All the variables were significant except Est1 (p =.127). These same variables (PAO, LSPA, PAD, Age1 and Est1) accounted for 66% and 61% of the variance in HR6 and HR7 respectively. Physical activity by decade and Age1 were significant variables in both equations. The variable, LSPA, explained a significant portion of the variance in HR8 (p =.031).

Table 17

Best Estimative Models for Heart Rate Measured

During Rest, Submaximal Exercise, and Recovery

Variable	Best Model Variables	R^2 (Best Model)	R^2 (Full Model)	p
REST SUPINE	PAD			.011
	Age1	.37	.38	.554
	Est1			.548
REST SEATED	Sup			.214
	PAD	.42	.44	.448
	PAO			.587
EXERCISE (min. 15)	PAO			.008
	LSPA			.006
	PAD	.73	.74	.024
	Age1			.008
	Est1			.127
EXERCISE (min. 29)	PAO			.032
	LSPA			.060
	PAD	.66	.66	.176
	Age1			.007
	Est1			.068
EXERCISE (IPE)	PAO			.038
	LSPA			.078
	PAD	.61	.61	.225
	Age1			.018
	Est1			.088
RECOVERY	Sup			.206
	LSPA	.57	.59	.031
	Est1			.083

CHAPTER FIVE

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to determine the relationships between age, physical activity patterns, estrogen levels, estrogen supplement and central circulatory responses of postmenopausal women to acute submaximal exercise. In addition, the research sought to determine the relative influence of these four variables in explaining the variation in central circulatory responses to acute submaximal exercise in postmenopausal women.

The women in this study were not randomly selected but recruited from volunteers who met the specified criteria. Also, the sample size was smaller than hoped for when the investigation was initially undertaken. Twenty additional women had volunteered for the study but were not recruited due to surgical intervention. The major worth of this investigation is in generating hypotheses for future research as opposed to being able to generalize findings to a greater population of postmenopausal women. Therefore, no attempt was made to generalize these findings.

To study the influence of aging on the cardiovascular system, a basic cardiovascular profile is necessary. In Chapter 4 a resting, exercise, and recovery profile was given for each of the variables. When the data was plotted by time (Figures 3-7), all cardiovascular changes from rest through recovery were typical of a healthy individual. Little difference between exercise means was noted. However, in each variable, the measurement taken immediate post-exercise (IPE) had a mean value which was lower than that obtained during minute 29 of exercise. Therefore, those central circulatory responses measured during minute 29 of exercise and IPE were thought to be representative of acute responses to submaximal exercise and were considered in the null hypotheses.

Presently there is a lack of published information regarding the impedance cardiograph and its use with women. The potential usefulness of this noninvasive technique with postmenopausal women was assessed in this study. Cardiovascular data and other relevant information obtained using the impedance cardiograph can be found in Appendix E.

<u>Age, Physical Activity Patterns and Central Circulatory Responses to Submaximal Exercise</u>

Both the aging process and the level of physical activity might account for differences seen in central circulatory responses to acute submaximal exercise. In the present study the variable age was operationally defined as chronological aging. In Tables 8-13 are presented the correlations between age and each of the dependent variables. These data imply that age and central circulatory responses to exercise are related, but also allude to the fact that chronological aging may reveal only a small portion of a synergistic effect which may exist between aging and other factors, possibly those of a behavioral or psychophysiological origin.

Cardiovascular changes associated with the aging process may be explained in part by behavioral patterns. The societal notion has been that as one ages, patterns of activity change and become more sedentary. However, it is difficult to objectively evaluate lifetime physical activity patterns. The Physical Activity Questionnaire, designed by Saltin and Grimby (99), surveyed both past and present occupational and spare-time physical activities of the women in this study. The questionnaire was easy to administer and the subjects merely had to select one of several descriptive categories which best mirrored their past and present occupational and spare-time physical activities. The selections made by the subjects were very subjective and dependent on recall. The physical activity patterns of the women in this study fell mostly in Group II (Table 3) with little variation in these patterns over a lifespan. This questionnaire has been used by its authors to assess lifetime physical activity, occupational and recreational, in middle-aged and old male former athletes. Data from other settings in which this questionnaire has been used have not been published to this investigator's knowledge.

Age and physical activity patterns (occupational, lifespan physical activity, and physical activity by decade) were not significantly related in these postmenopausal women. The reliability and validity estimates of this questionnaire have not been reported to date. It is very possible that the instrumentation used to assess physical activity patterns, as defined in this study, did not accurately portray the activity patterns of these women. However, after reviewing many instruments which measure physical activity patterns in adults, the instrument used in this study still seemed to be the best choice when comparing it to others, most of which were extremely weak from a measurement perspective.

The majority of the studies examining the effects of physical activity patterns on selected circulatory responses to submaximal exercise in women have considered physical training rather than occupational and leisure-time physical activity. Because of the paucity of literature employing retrospective measures of habitual physical activity in women, the results of this study are compared with previously cited training studies.

An increase in stroke volume in women after training has been reported by some investigators (30, 62) but not by all (31, 87). In the present study, stroke volume measurements at minute 29 of exercise and IPE were significantly correlated to all three physical activity patterns. These results might be indicative of chronic changes associated with physical training. Little change in stroke volume measured during submaximal exercise has been found with advancing age (14, 45) which concur with the results found in this study.

Previously cited investigators have reported an increase (30), decrease (119), or no change (30, 62) in cardiac output after training. The relationships between physical activity patterns and exercise cardiac output in this study were all significant which may be reflective of the chronic effects of physical activity. The results of this study indicated that age and cardiac output measured during exercise and IPE were significantly negatively related. These data are not in agreement with either Shephard (102) who reported that cardiac output in the older subject is almost identical to that of younger individuals working at the same relative work load, or Becklace (14) who reported an increase in cardiac output with age.

Heart rate measurements and physical activity patterns were not significantly related in this study. These findings were surprising considering the reported decrease in heart rate during exercise in women after training (1, 39, 49, 61, 62). It is very possible that the physical activity patterns of the women in this study did not provide an adequate training stimulus. It is well-known that heart rate achieved during maximal exertion is limited by chronological age. During submaximal exercise, the effect of age has been reported to be associated with an increase (6), decrease (26), or no change (14, 43, 44, 57, 86, 87) in heart rate. In the present study, heart rate during minute 29 of exercise was a significant inverse function of age with no significant relationship found between age and IPE heart rate.

Cardiac output, stroke volume, and heart rate are interdependent. Cardiac output is the product of stroke volume and heart rate. Stroke volume measurements were significantly related to physical activity patterns yet showed no correlation with age. Heart rate during exercise was negatively related to age but not significantly related to physical activity patterns. These results suggest that variations seen in cardiac output in this study may be explained by the influence of physical activity patterns on stroke volume measurements. With reference to that finding, it is interesting to note that all the mean physical activity pattern scores for the women in this study fell into Group II: some physical activity for at least 4 hours per week. This is considered a low frequency of activity for healthy adults. In addition, the mean maximal aerobic capacity for these women was 21.74 ± 5.60 $ml \cdot kg \cdot min^{-1}$ an average value for middle-aged women. Yet, even at these low levels of physical activity, significant relationships were shown to exist between physical activity patterns and cardiovascular parameters during exercise.

Another important measure of cardiovascular response to acute submaximal exercise is mean arterial blood pressure. A decrease in blood pressure response to submaximal exercise has been reported by some (13, 62) but not by all (1). Mean arterial blood pressure in this study was not significantly related to physical activity patterns (Table 12). The nonsignificant relationship found between age and mean arterial blood pressure was not in agreement with previously cited studies which reported both an increase in systolic and diastolic pressure with advancing age (44, 45, 57, 59).

The influence of physical training on cardiac contractility remains unclear. Kubicek et al. (1974) defined myocardial contractility "as the rate of shortening or contraction of the heart muscle fibres" (p.412). Brooks and Fahey (21) have stated that an improved contractile process is one of the major adaptations resulting from training, while other investigators have not demonstrated any improvement in myocardial function with training (17,89). In the present study, the relationships between physical activity patterns and the Heather Index were nonsignificant. However, the significant negative correlations found between age and the Heather Index in this study concur with findings from previous studies (2, 103, 108). It is very possible that the patterns of physical activity demonstrated by the women in this study did not reach the threshold necessary to demonstrate any chronic change in myocardial contractility or that the influence of age overshadowed any effect which might have occurred from physical activity.

Serum Concentration of Total Estrogen and Central Circulatory Responses to Acute Submaximal Exercise

Part of the endocrine changes associated with menopause is a decrease in the production rate of endogenous estrogens. In order to investigate the influence of varying levels of estrogen on central circulatory responses to submaximal exercise, women on estrogen supplement were also included in this study. The effects of both endogenous and exogenous estrogens on cardiovascular function in postmenopausal women is not fully understood (74, 79, 115, 124).

Serum concentration of resting total estrogen in this study showed wide individual variability in circulating hormone levels. Subject 4, who was not on estrogen supplement, had very high levels of total estrogen both at rest and immediate post-exercise. The high estrogen levels may indicate that this subject was perimenopausal and not postmenopausal as thought. Also interesting was the very low levels of total estrogen in subject 12 (63 years of age) who was taking estrogen supplement (Premarin .625 mg). The reason for these low levels is uncertain.

Total estrogen levels were measured at rest and immediate post-exercise. There was a trend which showed an increase in total estrogen levels after acute submaximal exercise in all but two women. Although not measured in this study, the changes in the serum concentration of total estrogen after acute exercise may be attributed to an increase in hormone production or to a decrease in metabolic clearance. A further discussion of this group's changes would be highly speculative. Serum concentration of total estrogen at rest and immediate post-exercise were not related to physical activity patterns.

Resting and immediate post-exercise levels of total estrogen were not significantly related to cardiac output and stroke volume measurements made at rest. These results infer that chronic levels of circulating estrogens are not related to cardiac output or stroke volume at rest. These findings are surprising considering the fact that Luotola (79) reported an increase in both resting cardiac output and stroke volume in postmenopausal women on estrogen supplement. In addition, resting and immediate post-exercise levels of total estrogen were not significantly related to cardiac output or to stroke volume during exercise. Perhaps the physiological effects of estrogen take place at a cellular level and would not be evident in central circulatory output measurements. The effect of both endogenous and exogenous levels of estrogen on central circulatory responses to exercise in postmenopausal women have not been reported to this investigator's knowledge.

The influence of estrogen replacement on exercising heart rate in postmenopausal women has been investigated (72, 79). In both studies, estrogen replacement and heart rate response were not significantly related; the data in this study contrasted those findings. In this study, there were significant negative relationships found between resting and immediate post-exercise levels of total estrogen and heart rate measurements taken during minute 29 of exercise and IPE. Although not a significant variable, resting levels of total estrogen appeared in the best estimative models used to explain the variation in heart rate during exercise and IPE. This suggests that the influence of circulating estrogen on heart rate during exercise is of relative minor importance.

A study conducted by von Eiff et al. (121) showed a distinct correlation between the circulating levels of endogenous estrogen and blood pressure response in postmenopausal women. Women who had gone through menopause had higher blood pressure responses at rest and during stress which does not concurr with the results found in this study. Mean arterial blood pressure and resting and immediate post-exercise levels of total estrogen were not significantly related. In addition, examination of the best estimative models used to explain the variance in mean arterial blood pressure indicate that circulating levels of estrogen were not important influences on blood pressure responses.

Using the animal model, King (63) found that the contractile system of the cardiac muscle was dependent on estrogen and from his findings suggested that this ovarian hormone may have important implications in myocardial function. In their work done with premenopausal women, Walters and Lim (123) suggested that the effects of estrogen may directly or indirectly influence resting myocardial contractility. These data are not in agreement with the results found in this study. A significant negative relationship was found between resting estrogen levels and the Heather Index measured immediate post-exercise. This significant negative relationship suggests that, as estrogen levels increased, myocardial contractility decreased. Examination of the best estimative models for the Heather Index during exercise and IPE showed that estrogen supplement was a significant variable. Resting estrogen levels were also significant in the regression equation used to explain the variance in the Heather taken immediate-post-exercise. It is possible that estrogen may facilitate or inhibit physiological mechanisms at the cellular level.

The hypothesis that there would be no differences in the relative contribution of age, physical activity patterns, estrogen levels, and estrogen supplement in explaining the variation in central circulatory responses measured during acute submaximal exercise was investigated. A stepwise multiple regression was computed for each variable. Consideration was given to the very low reported values for subject 12 (supplement) and the very high values for subject 3 (nonsupplement). A second stepwise analysis was later computed excluding the estrogen data from these two women. The exclusion of those extreme values did not significantly effect the results or R^2.

The results of the stepwise multiple regression analysis implied that these four variables did not account equally for the variation in central circulatory responses to submaximal exercise in postmenopausal women. The best estimative models used in this study only accounted for 38 to 66% of the variability in any dependent variable measured during minute 29 of exercise and IPE (Tables 13-17). All of the best estimative models used to explain the variation in central circulatory responses to submaximal exercise in postmenopausal women had at least one physical activity index in the model, and in all but one model, the Heather Index measured during IPE, a physical activity index was significant. This supports the contention that physical activity patterns are important to the cardiovascular response to stress. These results also suggest that chronological aging, the subjective recall of physical activity patterns, and circulating levels of estrogen do not fully nor equally explain the variation in central circulatory responses to submaximal exercise in postmenopausal women. Additional variables may need to be identified.

Conclusions

Based on the data provided in this investigation, and within the limits of this study, the following conclusions seem justified:

1. There were no significant relationships between age and physical activity patterns.

2. There were no significant relationships between estrogen levels and physical activity patterns.

3. There were significant relationships between physical activity patterns and cardiac output and stroke volume measurements.

4. There were significant negative relationships between age and cardiac output, stroke volume, and the Heather Index.

5. There were significant negative relationships between resting and immediate post-exercise estrogen levels and heart rate and the Heather Index.

6. There was a difference in the relative influence of age, physical activity patterns, estrogen levels, and estrogen supplement in explaining the variation in central circulatory response to submaximal exercise in postmenopausal women.

Recommendations for Future Research

This study examined the relative contribution of age, physical activity patterns, and circulating levels of estrogen on central circulatory responses to acute submaximal exercise in postmenopausal women. The results of this study answered some research questions and gave rise to some future concerns. Future research needs to identify additional variables which may explain more of the variation in central circulatory responses to acute submaximal exercise in postmenopausal women. One variable which might be explored is the psychological aspect of aging. Longitudinal study of all of the above variables needs to be conducted to add depth to the existing knowledge base concerning women's physiological response to exercise. The development of a more objective and reliable questionnaire which will provide assessment of lifespan physical activity patterns will enable the researcher to assess the influence of habitual levels of physical activity on the physiological response to exercise in the aging female.

BIBLIOGRAPHY

1. Adams, G.M., & de Vries, H.A. (1973). Physiological effects of an exercise regimen upon women aged 52 to 79. Journal of Gerontology, 28 (2), 50-5.

2. Albert, N.R., Gale, H.H., & Taylor, A. (1967). The effect of age on contractile protein ATPase activity and the velocity of shortening. In R.D. Tanz, F. Kavalee, & J. Roberts (Eds.), Factors influencing myocardial contractility. New York: Academic Press.

3. Andrew, G.M., Guzman, C.A., & Becklace, M.R. (1966). Effect of athletic training on exercise cardiac output. Journal of Applied Physiology, 21 (2), 603-608.

4. Astrand, I. (1960). Aerobic capacity in men and women with special references to age. Acta Physiologica Scandinavia, 49 (Suppl. 169), 7-92.

5. Astrand, I., Astrand, P.O., Hallback, I., & Kilbom, A. (1973). Reduction in maximal oxygen uptake with age. Journal of Applied Physiology, 35 (5), 649-654.

6. Astrand, P.O. (1968). Physical performance as a function of age. Journal of American Medical Association, 205 (11), 105-109.

7. Astrand, P.O., Cuddy, T.E., Saltin, B., & Stenberg, J. (1964). Cardiac output during submaximal and maximal work. Journal of Applied Physiology, 19, 268-274.

8. Backman, C. Sandstrom, B. & Solheim, F. (1982). Changes in central circulation in premenopausal women during application of an estradiol valerate-norgestrel combination (cycladil). Acta Obstetrics Scandinavia, (Suppl. 106), 47-50.

9. Badenhop, D., Cleary, P.A., Schaal, S.F., Fox, E.L., & Bartels, R.L. (1983). Physiological adjustments to higher-or-lower-intensity exercise in elders. Medicine and Science in Sports, 15 (6), 496-502.

10. Baird, D.T. & Guevara, A. (1969). Concentration of unconjugated estrone and estradiol in peripheral plasma in non-pregnant women throughout the menstrual cycle, castrate and postmenopausal women and men. Journal of Clinical

Endocrinology and Metabolism, 29:149-156.

11. Baird, D.T. & Fraser, I.S. (1974). Blood production and ovarian secretion rates of estradiol-17 and estrone in women throughout the menstrual cycle. Journal of Clinical Endocrinology and Metabolism, 38, 1009-1017.

12. Baker, L.E., Judy, W.V., Geddes, L.E., Langley, F.M., & Hill, D.W. (1970). The measurement of cardiac output by means of electrical impedance. Cardiovascular Research Center Bulletin, 9, 135-145.

13. Barry, A.J., Daly, J.W., Pruett, E.D.R., Steinmetz, J.R., Page, H.F., Birkhead, N.E., & Rodahl, K. (1966). The effects of physical conditioning on older individuals. I. Work capacity, circulatory-respiratory function and work electrocardiogram. Journal of Gerontology, 21, 182-191.

14. Becklace, M.R., Frank, H., Dagenais, G.R., Ostiguy, G.L., & Guzman, C.Q. (1965). Influence of age and sex on cardiac output. Journal of Applied Physiology, 20, 938-947.

15. Bevegard, S., Holmgren, K., & Jonsson, B.J. (1960). The effect of body position on the circulation at rest and during exercise, with special reference to the influence of stroke volume. Acta Physiologica Scandinavia, 49, 279-298.

16. Blair, S.N., Lavey, R.S., Goodyear, N., Gibbons, L.W., & Cooper, K.H. (1984). Physiological responses to maximal graded exercise testing in apparently healthy white women aged 18 to 75 years. Journal Cardiac Rehabilitation, 4, 459-468.

17. Blomquist, C.G., & Saltin, B. (1983). Cardiovascular adaptations to physical training. Annual Review of Physiology, 45, 169-189.

18. Blumberger, K.J., & Sigisbert, M. (1959). Studies of cardiac dynamics. In A.A. Luisada (Ed.), Cardiology, an encyclopedia of the cardiovascular system: Vol. II. New York: McGraw-Hill.

19. Boer, P., Roos, J.C., Geyskes, G.G., & Mees, E.J.D. (1979). Measurement of cardiac output by impedence cardiography under various conditions. American Journal of Physiology: Heart Circulation Physiology, 6 (4), H 491-496.

20. Brandfonbrener, M., Landowne, M., & Shock, N.W. (1955). Changes in cardiac output with age. Circulation, 12, 557-566.

21. Brooks, G.A., & Fahey, T.D. (1984). Exercise physiology: Human bioenergetics and its applications. New York: John Wiley & Sons.

22. Caspersen, C.J., Powell, K., & Christenson, G.M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Reports, 100 (2), 126-131.

23. Chakravarti, S. Collins, W.P., Forecast, J.D., Newton, J.R., Oram, D.H., & Studd, J.W.W. (1976). Hormonal profiles after the menopause. British Medical Journal, 2, 784-786.

24. Clausen, J.P. (1977). Effect of physical training on cardiovascular adjustments to exercise in man. Physiological Reviews, 57 (4), 779-810.

25. Conway, J., Wheeler, R., & Sonnerstedt, R. (1971). Sympathetic nervous activity during exercise in relation to age. Cardiovascular Research, 5, 577-581.

26. Cotes, J.E., Hall, A.M., Johnson, G.R., Jones, P.R.M., & Knibbs, A.V. (1973). Decline with age of cardiac frequency during submaximal exercise on healthy women. Journal of Physiology, 238, 24-25.

27. Cowan, M.M., & Gregory, L.W. (1985). Responses of pre- and post-menopausal females to aerobic conditioning. Medicine and Science in Sports and Exercise, 17, 138-143.

28. Crane, M.G., Harris, J.J., & Winsor, W. (1971). Hypertension, oral contraceptive agents and conjugated estrogens. Annals of Internal Medicine, 74, 13-21.

29. Csapo, A. (1950). Actomyosin formation by estrogen action. American Journal of Physiology, 162, 406-410.

30. Cunningham, D., & Hill, S. (1975). Effect of training on cardiovascular response to exercise in women. Journal of Applied Physiology, 39 (6), 891-895.

31. de Vries, H. (1970). Physiological effects of an exercise training regimen upon men aged 52-88. Journal of Gerontology, 25 (4), 325-336.

32. Denniston, J.C., Maher, J.T., Reeves, J.T., Cruz, J.C., Cyerman, A., & Grover, R.F. (1976). Measurement of cardiac output by electrical impedance at rest and during exercise. Journal of Applied Physiology, 40 (1), 91-95.

33. Doerr, B.M., Miles, D.S., & Frey, M.A.B. (1981). Influence of respiration on stroke volume determined by impedance cardiography. Aviation Space Environmental Medicine, 52 (7), 394-398.

34. Dowdy, D.B., Cureton, K.J., Duval, H.P., & Ouzts, H.G. (1985). Effects of aerobic dance on physical work capacity, cardiovascular function and body composition of middle aged women. Research Quarterly for Exercise and Sport, 56 (3), 227-233.

35. Drinkwater, B. (1973). Physiological responses of women to exercise. In J.H. Wilmore (Ed.), Exercise and sport sciences reviews (Vol.1) (pp. 126-150). New York: Academic Press.

36. Drinkwater, B.L., Horvath, S., & Wells, C. (1975). Aerobic power of females, ages 10 to 68. Journal of Gerontology, 30 (4), 385-394.

37. Emes, C. (1979). The effects of a regular program of light exercise on seniors. Journal of Sports Medicine, 19, 185-190.

38. Epstein, W.E., Robinson, B.F., Kahler, R.L., & Braunwald, E. (1965). Effects of beta-adrenergic blockade on the cardiac response to maximal and submaximal exercise in man. Journal of Clinical Investigation, 44, 1745-1753.

39. Flint, M.M., Drinkwater, B., & Horvath, S. (1974). Effects of training on women's response to submaximal exercise. Medicine and Science in Sports, 6 (2), 89-94.

40. Frick, M. Konttinen, A., & Sarajas, H.S.S. (1963). Effects of physical training on circulation at rest and during exercise. American Journal of Cardiology, 12, 142-147.

41. Fujinami, T. Nakano, S. Nakayama, K., & Takada, K. (1979). Impedance cardiography for the assessment of cardiac function during exercise. Japanese Circulation Journal, 43, 214-223.

42. Geddes, L.A., & Sadler, C. (1973). The specific resistance of blood at body temperature. Medical Biological Engineering, 11, 336-339.

43. Gerstenblith, G., Lakatta, E.G., & Weisfeldt, L. (1976). Age changes in myocardial function and exercise response. Progress in Cardiovascular Disease, 19 (1), 1-21.

44. Granath, A., Jonsson, B., & Strandell, T. (1964). Circulation in healthy old men, studied by right heart catherization at rest & during exercise in the supine and sitting position. Acta Medica Scandinavia, 176 (14), 425-446.

45. Grimby, G., Nilsson, N.J., & Saltin, B. (1966). Cardiac output during submaximal and maximal exercise in active middle-aged athletes. Journal of Applied Physiology, 21 (4), 1150-1156.

46. Grimby, G. & Saltin, B. (1966). Physiological analysis of physically well trained middle aged and older athletes. Acta Medica Scandinavia, 179 513-526.

47. Grodin, J.M., Siiteri, P.K., & McDonald, P.C. (1973). Source of estrogen production in the postmenopausal women. Journal of Clinical Endocrinology and Metabolism, 36, 207-214.

48. Harris, R. (1982). Aging of the cardiovascular system. In A. Viidik (Ed.), Lectures on gerontology. Vol. I: On biology of aging, Part B, (275-304). London: Academic Press.

49. Hanson, J.S., & Needle, W.H. (1974). Long-term physical training effect in sedentary females. Journal of Applied Physiology, 37, 112-116.

50. Harrison, T.R., Dixon, K., Russell, R.O., Bidwai, P.S., & Coleman, H.N. (1964). The relation of age to the duration of contraction ejection and relaxation of the normal heart. American Heart Journal, 67, 189-199.

51. Hartley, L.H., Grimby, G., Kilbom, A., Nilsson, N.J., Astrand, I., Bjure, J., Ekblom, B., & Saltin, B. (1969). Physical training in sedentary middle-aged and older men. III. Cardiac output and gas exchange at submaximal and maximal exercise. Scandinavian Journal of Clinical & Laboratory Investigation, 24, 335-344.

52. Heath, G.W., Hagberg, J.M., Ehsani, A.A., & Holloszy, J.O. (1981). A physiological comparison of young and older endurance athletes. Journal of Applied Physiology: Respiratory Environmental Exercise Physiology, 51 (3), 634-640.

53. Hemsell, D.L., Grocliv, M., Brenner, P.F., Siiteri, P.K., & McDonald, P.C. (1974). Plasma precursors of estrogen. II. Correlation of the extent of conversion of plasma androstenedione with age. Journal of Clinical Endocrinology and Metabolism, 38, 476-479.

54. Hossack, K.F., & Bruce, R.A. (1982). Maximal cardiac function in sedentary normal men and women: Comparison of age-related changes. Journal of Applied Physiology, 53 (4), 799-804.

55. Judd, N. (1980). Reproductive hormone metabolism in postmenopausal women. In B. Eskin (Ed.), The menopause: Comprehensive management (pp. 55-72). New York: Masson Publishing USA Inc.

56. Judy, W.V., Langley, F.M., McCowen, K.D., Stinett, D.M., Barer, L.E., & Johnson, P.C. (1969). Comparative evaluation of the thoracic impedance and isotope dilution methods for measuring cardiac output. Aerospace Medicine, 40, 532-536.

57. Julius, S., Amery, A., Whitlock, L.S., & Conway, J. (1967). Influence of age on the hemodynamic response to exercise. Circulation, 36, 222-230.

58. Kannel, W.B., & Gordon, T. (1977). Cardiovascular risk factors in the aged: The Framingham Study. In S.G. Haynes & M. Feinlein (Eds.), Proceedings of the 2nd Conference on the Epidemiology of Aging, 65-89.

59. Kanstrup, I., & Ekblum, B. (1978). Influence of age and physical activity on central hemodynamics and lung function in active adults. Journal of Applied Physiology, 45 (5), 709-717.

60. Kavanagh, T., & Shephard, R.J. (1978). The effects of continued training on the aging process. Annals of New York Academy Science, 301, 656-667.

61. Kilbom, A. (1971). Physical training in women. Scandinavian Journal of Clinical and Laboratory Investigation, 28 (Suppl. 119), 5-34.

62. Kilbom, A., & Astrand, I. (1971). Physical training with submaximal intensities in women. II. Effect of cardiac output. Scandinavian Journal of Clinical and Laboratory Investigation, 28, 163-175.

63. King, T.M., Whitehorn, W.V., Reeves, B., & Kubota, R. (1959). Effects of estrogen on composition and function of cardiac muscle. American Journal of Physiology, 196 (6), 1282-1285.

64. Kinnen, E. (1970). Cardiac output from trans-thoracic impedance variations. Annals of New York Academy Science, 170, 747-756.

65. Kobayashi, Y., Andoh, Y., Fujinami, T., Nakayama, K., Takada, K., Takeuchi, T., & Okamoto, M. (1978). Impedence cardiography for estimating cardiac output during submaximal and maximal work. Journal of Applied Physiology, 45 (3), 459-462.

66. Kollias, J., Bartlett, H.L., Mendez, J., & Franklin, B. (1978). Hemodynamic responses of well-trained women athletes to graded treadmill exercise. Journal of Sports Medicine, 18, 365-372.

67. Kubicek, W.G., Karnegis, J.N., Patterson, R.P., Witsoe, D.A., & Mattson, R.H. (1966). Development and evaluation of an impedance cardiac output system. Aerospace Medicine, 37, 1208-1212.

68. Kubicek, W.G., Kottke, F.J., Ramos, M.U., Patterson, R.P., Witsoe, D.A., Labree, J.W., Remole, W., Layman, T.E., Schoening, H., & Garamella, J.T. (1974). The Minnesota impedance cardiograph theory and applications. Reprinted from Biomedical Engineering, 9 (9), 410-416.

69. Lababidi, Z., Ehmke, D.A., Duraia, R.E., Leaverton, P.E., & Laver, R.M. (1971). Evaluation of impedance cardiac output in children. Pediatrics, 47, 870-879.

70. Landowne, M., Brandfonbrener, M., & Shuck, N. (1955). The relation of age to certain measures of performance of the heart and the circulation. Circulation, 12, 567-576.

71. Lehtovirta, P. (1974). Haemodynamic effects of combined oestrogen/progestrogen oral contraceptives. British Journal of Obstetrics & Gynecology, 81, 517-525.

72. Lehtovirta, P., Kuikka, J., & Pyorala, T. (1977). Hemodynamic effects of oral contraceptives during exercise. International Journal of Gynecology & Obstetrics, 15, 35-37.

73. Lim, Y.L., Lumbers, E.R., & Whelan, R.F. (1970). Effects of oestrogen on the human circulation. Journal of Obstetrics & Gynecology, 23 (6),422-427.

74. Lind, T., Cameron, E.C., Hunter, W.M., Leon, C., Moran, P.F., Oxley, A., Gerrard, J., & Lind, U.C.G. (1979). A prospective controlled trial of six forms of hormone replacement therapy given to postmenopausal women. British Journal of Obstetrics & Gynecology, (Suppl. 86), 1-29.

75. Lloyd, C.W., Lobotsky, J. Baird, D.T., McCracken, J.A., Weiss, J., Pupkin, M., Zanartu, J., & Puga, J. (1971). Concentration of unconjugated estrogens, androgens, and gestagens in ovarian and peripheral venous plasma of women: The normal menstrual cycle. Journal of Clinical Endocrinology, 32, 155-166.

76. Longcope, C. (1971). Metabolic clearance and blood production rates of estrogens in postmenopausal women. American Journal of Obstetrics & Gynecology, 111, 778-781.

77. Longcope, C. (1980). Androgen and estrogen conversion ratio in aging women. Maturitas, 2, 13-17.

78. Luisada, A.A., Bhat, P.K., & Knighten, V. (1980). Changes in cardiac output caused by aging: An impedance cardiograph study. Angiology, 31 (2), 75-81.

79. Luotola, H. (1983). Blood pressure and hemodynamics in postmenopausal women during estradiol-17 beta substitution. Annals of Clinical Research, 15 (Suppl. 38), 1-121.

80. Metzger, C.C., Chough, C.B., Kroetz, F.U., & Leonard, J.J. (1970). True isovolumic contraction time, its correlation with two external indexes of ventricular performance. American Journal of Cardiology, 25, 434-442.

81. Miles, D.S., Sawka, M.N., Wilde, S.W., Doerr, B.M., Frey, M.A.B., & Glaser, R.M. (1981). Estimation of cardiac output by electrical impedance during arm exercise in women. Journal of Applied Physiology, 51 (6), 1488-1492.

82. Miller, J.C., & Horvath, S.M. (1978). Impedance cardiography. Psychophysiology, 15, 80-91.

83. Mishell, D.R.Jr., Nakamura, R.M., Crosignan, P.G., Stone, S., Kharma, K., Nagata, Y., & Thorneycroft, I.H. (1971). Serum gonadotropin and steroid patterns during the normal menstrual cycle. American Journal of Obstetrics & Gynecology, 111, 60-65.

84. Mohapatra, S.N., Costeloe, K.L., & Hill, D.W. (1977). Blood resistivity and its implications for the calculation of cardiac output by the thoracic electrical impedance technique. Intensive Care Medicine, 3, 63-67.

85. Montoye, H.J., Willis, P.W., & Cunningham, D.A. (1968). Heart rate response to submaximal exercise: Relation to age and sex. Journal of Gerontology, 23, 127-133.

86. Montoye, H., Willis, P.W., Howard, G.E., & Keller, J.B. (1971). Cardiac preejection period: Age and sex comparisons. Journal of Gerontology, 26 (2), 208-216.

87. Niinimaa, V., & Shephard, R.J. (1978). Training and oxygen conductance in the elderly. II. The cardiovascular system. Journal of Gerontology, 33, 362-367.

88. Nimrod, A., & Ryan, K.J. (1975). Acromatization of androgens by human abdominal and breast fat tissue. Journal of Clinical Endocrinology and Metabolism, 40, 367-372.

89. Personnet, F., Ferguson, R.J., Perrault, H., Ricci, G., & Lajoie, D. (1981). Echocardiography and the athlete's heart. Physician & Sports Medicine, 9, 102-112.

90. Plowman, S.A., Drinkwater, B., & Horvath, S. (1979). Age and aerobic power in women: A longitudinal study. Journal of Gerontology, 34 (4), 512-520.

91. Pollack, M.L. (1973). The quantification of endurance training programs. In J.H. Wilmore (Ed.), Exercise & Sport Science Reviews, Vol. I, (pp. 155-188). New York: Academic Press.

92. Profant, G.R., Early, R.G., Nilson, K.L., Kusumi, F., Hofer, V., & Bruce, R.A. (1972). Response to maximal exercise in healthy middle-aged women. Journal of Applied Physiology, 33 (5), 595-599.

93. Raab, W. (1966). Training, physical activity and the cardiac dynamic cycle. Journal of Sports Medicine & Physical Fitness, 6, 38-47.

94. Rader, M.D., Flickinger, G.L., DeVilla, G.O.Jr., Mikuta, J.J., & Mikhail, G. (1973). Plasma estrogens in postmenopausal women. Americal Journal of Obstetrics & Gynecology, 116, 1069-1073.

95. Richardson-Lehnhard, H.J. (1984). The effects of training on selected steroid hormones: Response to exercise in postmenopausal women. Dissertation Abstracts International, 45, 2442-A. (University Microfilms No. 8426462)

96. Robinson, S., Dill, D.B., Robinson, R.D., Tzankoff, S.P., & Wagner, J.A. (1976). Physiological aging of champion runners. Journal of Applied Physiology, 41 (1), 46-51.

97. Rodeheffer, R.J., Gerstenblith, G., Becker, L., Fleg, J.L., Weisfeldt, M.L., & Lakatta, E.G. (1984). Exercise cardiac output is maintained with advancing age in healthy human subjects: cardiac dilatation and increased stroke volume compensate for a diminished heart rate. Circulation, 69 (2), 203-213.

98. Rothbaum, D.A., Shaw, D., Angell, C.S., & Shock, N.M. (1971). Cardiac performance in the unanesthetized senescent male rat. Journal of Gerontology, 28 (3), 287-292.

99. Saltin, B., & Grimby, G. (1968). Physiological analysis of middle-aged and old former athletes. Comparison with still active athletes of the same ages. Circulation, 38, 1104-1115.

100. Scheuer, J., & Tipton, C. (1977). Cardiovascular adaptation to physical training. Annal Review of Physiology, 39, 221-251.

101. Schmidt, M.N., & Wrenn, J.P. (1978). Selected physical and cardiorespiratory parameters of active males aged 40-59. Journal of Sports Medicine, 18, 183-188.

102. Shephard, R.J. (1978a). Physical activity and aging. Chicago: Year Book Medical Publishers, Inc.

103. Shephard, R.J. (1978b). Exercise and aging. In J.A. Behnke, C.E. Finch, & G.B. Moment (Eds.), The biology of aging (pp. 131-149). New York: Plenum Press.

104. Shock, N.W. (1976). Cardiac performance and age. In H.I. Russek (Ed.), Cardiovascular problems (pp. 3-24). Baltimore: University Park Press.

105. Sidney, K.H., & Shephard, R.J. (1978). Frequency and intensity of exercise training for elderly subjects. Medicine and Science in Sports, 10 (2), 125-131.

106. Smith, J.J., Bush, J.E., Wiedmeier, V.T., & Tristani, F.E. (1970). Application of impedance cardiography to study postural stress. Journal of Applied Physiology, 29 (1), 133-137.

107. Smith, J.J., & Kampine, J.P. (1980). Circulatory physiology - The essentials. Baltimore: Williams & Wilkins.

108. Starr, I. (1964). An essay on the strength of the heart and on the effect of aging upon it. American Journal of Cardiology, 14, 771-783.

109. Stern, M.P., Brown, B.W.Jr., Haskell, W.L., Farquhar, J.W., Wehrle, C.L., & Woods, P.D.S. (1976). Cardiovascular risk and use of estrogens or estrogen - progestagen combinations. Journal of the American Medical Association, 255, 811-815.

110. Strandell, T. (1964). Circulatory studies on healthy old men. Acta Medica Scandinavia, 175 (Suppl. 414), 1-44.

111. Tanaka, K., Kanai, H., Nakayama K., & Ono, N. (1970). The impedance of blood: The effects of red cell orientation and application. Japan Journal Medical Engineering, 8, 436-443.

112. Tulchinsky, D. & Korenman, S.G. (1970). A radio-ligand assay for plasma estrone; normal values and variations during the menstrual cycle. Journal of Clinical Endocrinology & Metabolism, 31, 76-80.

113. Tzankoff, S.P. Robinson, S., Pyke, F.S., & Brown, C.A. (1972). Physiological adjustments to work in older men as affected by physical training. Journal of Applied Physiology, 33 (3), 346-350.

114. Upton, S.J., Hagan, R.D., Lease, B., Rosentswieg,J., Gettman, L.J., & Duncan, J.J. (1984). Comparative physiological profiles among young and middle-aged female distance runners. Medicine and Science in Sports & Exercise, 16 (1), 67-71.

115. Utian, W.H. (1978). Effect of postmenopausal estrogen therapy on diastolic blood pressure and body weight. Maturitas, 1, 3-8.

116. Vaccaro, P., Dummer, G., & Clarke, D.H. (1981) Physiological characteristics of female master swimmers. The Physician and Sports Medicine, 9 (12), 75-78.

117. Vaccaro, P., Ostrove, S.M., Vandervelden, L., Goldfarb, A., Clarke, D.H., & Dummer, G. (1984). Body composition and physiological responses of master female swimmers 20 to 70 years of age. Research Quarterly for Exercise and Sport, 55 (3), 278-284.

118. Vanfraechem, J.H.P. (1979). Stroke volume and systolic time interval adjustments during bicycle exercise. Journal of Applied Physiology: Respiratory, Environmental, Exercise Physiology, 46, 588-592.

119. VanHandel, P.J., Castill, D.L., & Getchell, L.H. (1976). Central circulatory adaptations to physical training. Research Quarterly, 47 (4), 815-823.

120. Vermulen, A. (1980). Sex hormone status of the postmenopausal woman. Maturitas, 2, 81-89.

121. VonEiff, A.W., Plotz, E.J., Beck, K.J., & Czernik, A. (1971). The effect of estrogens and progestins on blood pressure regulation of normotensive women. American Journal of Obstetrics and Gynecology, 109 (6), 887-892.

122. Wallace, J.P. (1981). Serum concentrations of sex hormones during exercise in pre-, peri-, and post-menopausal women. Dissertation Abstract International, 42, 3624-B. (University Microfilms No. DA 8129232)

123. Walters, W. & Lim, Y.L. (1970). Haemodynamic changes in women taking oral contraceptives. The Journal of Obstetrics and Gynaecology of the British Commonwealth, 77, 1007-1012.

124. Weir, J. Briggs, E., Mack, A., Naismith, L., Taylor, L., & Wilson, E. (1974). Blood pressure in women taking oral contraceptives. British Medical Journal, 1, 533-535.

125. Wessel, J.A., & Van Huss, W.D. (1969). The influence of physical activity and age on exercise adaptation of women, 20-69 years. Journal of Sports Medicine, 9, 173-180.

126. Winters, W.G., Leaman, D.M., & Anderson, R.A. (1973). The effect of exercise on intrinsic myocardial performance. Circulation, 48, 50-55.

APPENDIX A

THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

SCHOOL OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

SCHOOL REVIEW COMMITTEE

INFORMED CONSENT FORM

I understand the purpose of this study. I have been informed of the procedures that will be used in the project and understand what will be required of me as a subject. The benefits that may be expected from the project have been explained to me. I have been informed of the possible risks and discomforts associated with the project.

I confirm that my participation is entirely voluntary. No coercion of any kind has been used to obtain my cooperation.

I understand that I may withdraw my consent and terminate my participation at any time during the project without explanation or penalty.

I understand that my individual contributions to this study will remain confidential.

I understand that my test results will be made available to me upon request.

I wish to give my voluntary cooperation as a participant.

____________________ Witness

____________________ Signature

____________________ Date

____________________ Address

____

____________________ Date

AGE, PHYSICAL ACTIVITY PATTERNS, ESTROGEN LEVELS AND CENTRAL CIRCULATORY RESPONSES OF POST-MENOPAUSAL WOMEN TO SUBMAXIMAL EXERCISE

I understand that my medical history has been reviewed and that I am judged medically fit to participate in this study. Prior to any testing, I will be asked to complete a Self-Administered Medical Questionnaire and describe my current level of physical activity.

The purpose of the study and the procedures to be used have been explained to me and I understand them to be:

The purpose of this study is to determine the relationship between age, physical activity patterns, estrogen levels and central circulatory responses of post-menopausal women to submaximal exercise.

I understand that my participation in this study will require two separate visits to the University of North Carolina at Greensboro campus. On the first visit, I will report to the Student Health Center. I will be asked to refrain from caffeine, cigarette smoking, and eating a large meal three hours prior to each exercise testing session and to refrain from any physical activity on the day of testing. At the beginning of the session, there will be a short orientation which will familiarize me with the metabolic and cardiac assessment procedures to be used in the study. The pulmonary function test will require me to breathe deeply into a spirometer. I will be asked to inhale and exhale maximally into a mouthpiece while wearing a noseclip. My height and weight will also be record. I understand that I will be asked to perform a bicycle ergometer test to maximal effort. I understand that I am free to terminate the test at any time because of any reason. I understand that this test will be conducted under medical supervision. To continuously monitor my physiological responses during the stress test, I will be asked to wear four electrodes on my chest, a blood pressure cuff on one arm, and wear a headgear with a breathing valve and a noseclip. Measurements of heart rate, blood pressure, and expired air will be obtained.

I understand that the second visit will be conducted in the Human Performance Laboratory. I will be asked to complete a 30-minute submaximal bicycle test. The test will be similiar to the one performed during the second session, but the submaximal workload will correspond to 60% of my maximal capacity as determined by the initial stress test. I understand that during rest a venous blood sample will be drawn from my arm by qualified personnel. The sample taken will be approximately 10 ml. I will be asked to wear four electrodes to monitor ECG and heart rate; four aluminum strips, two placed around the neck and two around the abdomen for cardiac assessment, and a blood pressure cuff on one arm. Resting data will be recorded.

I understand that heart rate and ECG will be monitored continuously during the submaximal test. Blood pressure will be recorded every five minutes and on three separate occasions, cardiac assessments will be made. Twice during the 30-minute test, I will be asked to wear a headgear with a breathing valve and a noseclip to collect expired air which will be used to determine whether or not I am working up to 60% of my maximal capacity. Immediately at the completion of the submaximal test, a cardiac assessment will be made and approximately a 10 ml blood sample will be drawn.

I understand that the tests have been designed to minimize all possible risks. I understand that some muscular fatigue, discomfort, or soreness may be associated with the bicycle ergometer tests. In addition, some discomfort in breathing, a sensation of light-headedness, dizziness, or nausea is possible. There is a slight risk of cardiac incident. I understand that the stress test will be performed under medical supervision and that the submaximal test will be conducted under the supervision of the UNC-G Human Performance Laboratory staff.

The benefits to be expected from my participation will be a better understanding of my level of physical fitness. From my participation in this study, the data collected may provide greater insight into the effect of menopause on the central circulatory responses of post-menopausal women to exercise.

I understand that the results of this study may be published but that my privacy will be protected. Any questions that I had regarding any facet of the study and my participation have been answered to my satisfaction.

Based on the above considerations, I understand the procedures to be used, any risks involved, and what will be required of me. I volunteer and agree to participate in this study. My consent is freely given and I understand that I may withdraw this consent at any time.

____

Signature

Name of Physician ____________________

(Print)

Address: ____________________

____

____

Telephone: ____________________

DATE:

TO: Primary Physician

FROM: Kathy Morocco
Rosenthal Human Performance Laboratory
Stone Building
The University of North Carolina at Greensboro
Greensboro, North Carolina 27412

____________________, a patient of yours, would like to participate in a health-related physical fitness evaluation to be performed on the campus at the University of North Carolina at Greensboro. The purpose of the testing is to determine the relationship between age, physical activity patterns, estrogen levels and central circulatory responses of post-menopausal women to submaximal exercise. The evaluation would include a bicycle ergometer stress test to be conducted according to the Guidelines for Graded Exercise Testing and Prescription (ACSM, 1981). The exercise stress test will be conducted at the Student Health Center under medical supervision. During a second testing session, a submaximal bicycle test will be conducted in the Human Performance Laboratory. The test will be thirty minutes in length with the workload set to correspond to 60% of the individual's maximal capacity as determined during the stress test. The test will be conducted under the supervision of the UNC-G Human Performance Laboratory staff. Emergency Medical Services will be notified of all test sessions. Pulmonary function will be assessed by measurement of vital capacity and maximum voluntary ventilation (full inhalation and exhalation and timed expiration volume).

Your cooperation in completing the attached form is appreciated. By completing the enclosed form, I acknowledge that you are not assuming any responsibility for the administration of the evaluation. However, if you know of any medical or other reasons why this evaluation would not be in the best interest of this individual, I would appreciate your indication on the referral form. A copy of the results may be forwarded to you, if you so desire. Please feel free to contact me at 379-3039 or at home, 282-6524, if you have any questions or concerns.

PHYSICIANS REFERRAL FORM

Patient's Name: ____________ Date: ____________

Address: ____________ Age: ______ Ht ____ Wt _

____

For the patient to sign:

I, ______________________, hereby authorize the release of any aspect of my medical history which may be necessary for my evaluation for participation in the graduate research study on adult fitness at the University of North Carolina at Greensboro.

The following information is to be filled out by the physician :

Date of last complete physical examination: ____________

Present Medication(s): ____________

Please fill in the information below if it is available:

1. Complete blood count: Hbg. ____ Hct. ____ WBC ____
   Diff. _____
2. Cholesterol ________ mg% Triglyceride ______ mg%
3. Glucose ____________
4. Blood Pressure: Systolic ______ Diastolic ________
5. Resting Heart rate: ______
6. ECG (if available, enclose): Resting: normal _____
   abnormal ____

   explain ____________

   Exercise: normal _____ abnormal ______

   explain ____________

Please respond "Yes" or "No" to the following health data:

History of		Presently Has
____________	High Blood Pressure	____________
____________	Low Blood Pressure	____________
____________	Heart Disease	____________
____________	Diabetes	____________
____________	Hypoglycemia	____________
____________	Pulmonary Disease	____________
____________	Arthritis	____________
____________	Asthma or Allergies	____________
____________	Musculoskeltal Problems	____________
____________	Gastrointestinal Problems	____________

Are there any other medical data, medications, or abnormalities in this person's medical history which should be considered prior to the fitness evaluation?

____

The above listed person is capable of participation in a bicycle ergometer stress and submaximal test and related laboratory tests (pulmonary function assessment) to be conducted on campus at the University of North Carolina at Greensboro.

Signed: __________________________ (Physician) Date: ______________

I would like a copy of the results of the test sessions sent to my office for my patient's file: Yes ________ No ________

Please return to patient listed or directly to me at the address below:

Kathy Morocco
Forney Building
The University of North Carolina at Greensboro
Greensboro, North Carolina 27412

SELF-ADMINISTERED PRE-EXERCISE MEDICAL HISTORY FORM

Name ____________________ Date __________

Address ____________________ Phone (work) ____________

____________________ (home) ____________

Age _____ Sex _____ Ht _____ ft _____ inches Wt _____

PLEASE CHECK IF "YES"

Symptom	Past History	Present History	Family History
Coronary Heart Disease	______	______	______
Hypertension	______	______	______
Varicose Veins	______	______	______
Lung Disease	______	______	______
Rheumatic Fever	______	______	______
Obesity	______	______	______
Heart Attack(s)	______	______	______
Stroke	______	______	______
Heart Operation	______	______	______
Diabetes	______	______	______
Arthritis	______	______	______
Epilepsy	______	______	______

Kidney Disease	______	______	______
Other (specify)	______	______	______

Please give an explanation for those checked (include dates, family member, severity and any other pertinent information)

Have you ever been treated for or had any known indication of:
(Please check the appropriate box. If answered yes , please explain)

1. Dizziness, fainting, convulsions, paralysis or stroke
   Yes ____ No ____

   Explain: ______________________________

2. Shortness of breath at rest Yes ____ No ____

   Explain: ______________________________

3. Shortness of breath during exercise Yes ____ No ____

   Explain: ______________________________

4. Chest pain at rest Yes ____ No ____

   Explain: ______________________________

5. Chest pain during exercise Yes ____ No ____

   Explain: ______________________________

6. Heart attack, coronary artery disease or other disease or disorders of the heart or blood vessel Yes ______ No ___

Explain: ____

7. Heart palpitations Yes _____ No ______

Explain: ____

8. Heart murmur Yes _______ No _________

Explain: ____

9. Persistent hoarseness, cough, pleurisy, bronchitis, asthma, emphysema, tuberculosis, hay fever, or other chronic respiratory disease or disorder

Yes _____ No _____

Explain: ____

10. Thyroid or other endocrine disorder Yes ____ No ___

Explain: ____

11. Drug allergy or other known sensitivity or intolerance

Yes _______ No _______

Explain: ____

12. Frequent or severe headaches Yes ____ No _____

Explain: ____

13. Disease or injury of bones or joints Yes _____ No ___

Explain: ____

14. Anemia Yes ___ No ______

Explain: ______________________________

15. Do you have now any physical handicaps or disabilities that may limit or restrict in some way your physical activity? Yes ___ No

Explain: ______________________________

16. Medications: ______________________________

17. Rx Diets: ______________________________

18. Medical complaints ______________________________

____

19. Major illness or hospitalization in past year ______________

____

20. How many years have passed since menopause? (cessation of menstrual flow) ________

Smoking Status: Never ____ Stopped ______ years ago

Yes _____ Packs per day ____ for ___ years

Alcohol consumption: Never __________

Beer ______ per week

Wine ______ per week

Mixed Drink ______ per week

My weight now is ______ One year ago _____ at 25 ______

at 45 ________

Please circle one of the following to describe your activity level during:

a. Early childhood

seldom active quite active moderately active very active

b. Adolescence

seldom active quite active moderately active very active

c. Adult

seldom active quite active moderately active very active

Please list your CURRENT recreational pursuits and the TIME spent in each/wk.

	ACTIVITY	TIME SPENT/WEEK
1.	________	____________
2.	________	____________
3.	________	____________
4.	________	____________
5.	________	____________

In comparison to five years ago my:

a. general health has: 1) declined ____ ; 2) not changed ____

3) improved ____

I attribute this change to ______________________________

b. physical fitness has: 1) declined ____ ; 2) not changed ___
3) improved ____

I attribute this change to ______________________________

In comparison to individuals of the same age how do you perceive your current level of fitness. Please explain your answer. ____________

____

____

c. frequency of participation in physical/recreational activities has: (1) declined ____ ; 2) not changed _____ , 3) improved ______

I attribute this change to ____

If you are still employed, how would you classify the work you do:

1. Sedentary _______
2. Light activity ____
3. Moderately active _____
4. Very active ______
5. Heavy work _______

In what kind of work are (were) you employed: ________________

____

PHYSICAL ACTIVITY QUESTIONNAIRE *

The following two sections have been designed to allow an estimate of your lifetime physical activity, both occupational and recreational. The first section deals with physical activity within your occupation. We have classified all occupations in four groups, from sedentary to hard manual work. Please study the following table and then match your own occupation during various periods of your life with the table by checking the appropriate boxes below.

Occupational Activity

Group I	Group II	Group III	Group IV
Predominantly sedentary, sitting: desk worker, watch maker, sitting assembly-line worker (light goods)	Sitting or standing, some walking: cashier, general office worker, light tool and machinery worker, foreman	Walking, some handling of material: mailman, waiter, construction worker, heavy tool and machinery worker	Heavy manual work: lumberjack, dock worker, stone mason, farm worker, ditch digger

Occupation corresponded most closely to group:

Age	I	II	III	IV	Worked mostly: Outdoors	Indoors	Both
20-30	____	____	____	____	____	____	____
30-40	____	____	____	____	____	____	____
40-50	____	____	____	____	____	____	____
50-60	____	____	____	____	____	____	____
Over 60	____	____	____	____	____	____	____

The following section deals with your spare-time physical activity. The table outlines four different levels. Please read the table carefully and then check appropriate boxes below:

Spare-Time Physical Activity

Group I	Group II	Group III	Group IV
Almost completely inactive: reading, TV watching, movies, etc.	Some physical activity during at least 4 hours per week: riding a bicycle or walking to work, walking or skiing with the family, gardening.	Regular activity: such as heavy gardening, running, calisthenics, tennis, etc.	Regular hard physical training for competition in running events, soccer, racing, European handball, etc. Several times per week.

Age	Activity during at least 7 months per year corresponding to group: I	II	III	IV	Activity during 2 to 6 months corresponding to group: I	II	III	IV
20-30	____	____	____	____	____	____	____	____
30-40	____	____	____	____	____	____	____	____
40-50	____	____	____	____	____	____	____	____
50-60	____	____	____	____	____	____	____	____
Over 60	____	____	____	____	____	____	____	____

*Taken from: Saltin, B. & Grimby, G. (1968). Physiological analysis of middle-aged and old former athletes. Circulation, 38, 1104-1115.

APPENDIX B

Radioimmunoassay (RIA) Total Estrogen Procedures

A. Set up assay in duplicate, in consecutively numbered

10 x 75 mm disposable glass test tubes. (DO NOT USE PLASTIC TUBES). Refer to the Protocol (Section VIII) as a guide only. Pipet all reagents directly from shipping vials.

B. Extraction of serum or plasma sample:

1. Add 0.1 ml* or 0.6 ml of serum or plasma to an appropriate glass disposable tube.

Note:* This volume to be used only for HMG Ovulation Induction Control samples.

2. Add 6 ml of ethyl acetate: hexane (3:2) (Mallinckrodt catalog numbers 3432 and 4159) to the serum or plasma.

3. Shake or vortex mix vigorously for 60 seconds and allow the phases to separate.

4. Withdraw 5 ml of the organic phase (top phase) and evaporate under air or nitrogen.

5. Reconstitute the sample residue (4) with 2.5 ml of Diluent Buffer and incubate at room temperature for 30 minutes or longer. Swirl or gentle mix during this incubation period.

6. Withdraw duplicate 0.5 ml aliquots for assay.

Note: Each 0.5 ml is equivalent to 0.1 ml serum or plasma if 0.6 ml of sample was extracted, or 0.0166 ml if 0.1 ml of sample was extracted. The dilution factors are 10 and 60 respectively.

C. Assay Conditions:

1. Add 0.6 ml and 0.5 ml of Diluent Buffer to tube numbers 1, 2 and 3, 4 respectively

(see Protocol, Section VIII).

2. Add 0.5 ml (in duplicate) of Total Estrogens standard (2.5 - 100 pg) to tube numbers 5-16.

3. Add 0.5 ml (in duplicate) of reconstituted sample (see Section VII., B, (6) to tube numbers 17 to end of assay.

4. With the exception of tube numbers 1 and 2, add 0.1 ml of Anti-Total Estrogens to all the assay tubes.

5. Add 0.1 ml of Estradiol 17β-^{125}I to all the assay tubes.

6. Mix all the assay tubes, then incubate for 90 minutes at room temperature.

7. After incubation (6), add 0.1 ml of Second Antibody to all the assay tubes and incubate for 60 minutes.

8. After 60 minutes incubation (7), centrifuge all the assay tubes at 2300-2500 rpm (1000 x g) for 15 minutes. Aspirate or decant the supernatant (if decanting, blot the rim of the test tubes of absorbant paper before turning right side up).

9. Count the precipitate in a gamma counter.

Radioassay Systems Laboratories, Inc. (RSL)
20770 Leapwood Avenue
Carson, California 90746
(213) 537-2414
(800) 421-2112

PRINTED BY THE STANDARD REGISTER COMPANY, U.S.A. ZIPSET ®

HEMATOLOGY II

38-184 REV. (8/85)

REQ. BY	DATE TO BE DONE	☐ URGENT	☐ STAT	☐ PRE-OP

☐ CBC WITH DIFF	☐ CBC W/O DIFF	☐ WBC WITH DIFF	☐ WBC ONLY
☐ RBC ONLY	☐ HGB	☐ HCT	☐ PLATELET COUNT

/ /	TECH.	TEST NO.

SA	OP CODES	NORMAL VALUES
.	WBC x 10³	M F 7.8±3
.	RBC x 10⁶	M 4.8±0.7 F 4.3±0.8
.	Hgb g/dl	M 15.0±2 F 13.0±2
.	Hct %	M 43±5.5 F 38±6.0
.	MCV µm³	M 87±7 F 90±9
.	MCH pg	M F 29±2
.	MCHC g/dl	M F 34±2
.	RDW %	M F 12.5±1.5
.	PLT x 10³	M F 130-400
.	MPV µm³	M F 8.9±1.5
.	LYMPH %	M F 28±13
.	LYMPH x 10³	M F 2.0±1

WESLEY LONG COMMUNITY HOSPITAL, INC. GREENSBORO, N.C.

POLYS (SEGMENTED NEUTROPHILS) %		RBC MORPH	
BAND NEUTROPHILS %		ANISO-CYTOSIS	
LYMPHOCYTES %		POIKILO-CYTOSIS	
MONOCYTES %		MICRO-CYTOSIS	
EOSINOPHILS %		MACRO-CYTOSIS	
BASOPHILS %		POLY-CHROMASIA	
REACTIVE LYMPHOCYTES %		HYPO-CHROMIA	
PLASMA CELLS %		SPHERO-CYTOSIS	
METAMYELOCYTES %		TARGET CELLS	
MYELOCYTES %		BASOPHILIC STIPPLING	
PROMYELOCYTES %		TOXIC GRAN	
BLASTS %		HYPER SEG POLYS	
NUCLEATED RBC # /100 WBC			
WBC DIFF SAMPLE X 10		PLATELET SUFFIC	
RETICS %		RBC SIZE MEAN µ	
CALC. PLAT. PER CU MM X 10³		RBC SIZE S.D. µ	

COLLECTED BY: DATE TIME A.M. P.M.

DIFF. REPORTED BY

CODE
SL – SLIGHT/FEW
MO – MODERATE
MK – MARKED/MANY
HI – HIGH
NL – NORMAL
LO – LOW

COMMENTS

APPENDIX C

Table A

Estrogen Supplement

Supplement	Subject No.	Months	Contents
Provera 5 mg	3	8	Medroxyprogesterone
Provera 10 mg	9*	6	Medroxyprogesterone
Premarin .625 mg	3, 9, 12, 15+	7-180	Estrone, equilin, & 17 -dihydroequilin together with smaller amounts of 17 -estradial, equilenin, & 17 -dihydro-equilenin as salts of their sulfate esters.

*Dual medication

+Additional medication - Corgard

APPENDIX D

Table D-1

Best Estimative Models for Cardiac Output

During Minute 29 of Exercise and IPE

	B VALUE	STD ERROR	F	PROB>F
	- MINUTE 29 -			
INTERCEPT	1899.12317477			
SUP	-147.65321872	122.30750982	1.46	.246
LSPA	31.91911309	8.47212413	14.19	.002
AGE1	-27.72917510	10.37619058	7.14	.017
	- IPE -			
INTERCEPT	1921.55195152			
PAD	247.62631876	76.25783949	10.54	.005
AGE1	-26.09155531	10.34386891	6.36	.023
EST1	-0.09856352	0.05719855	2.97	.105

Table D-2

Best Estimative Models for Stroke Volume

During Minute 29 of Exercise and IPE

	B VALUE	STD ERROR	F	PROB>F
		- MINUTE 29 -		
INTERCEPT	2653.11594055			
SUP	-2876.79130100	1368.20009024	4.42	.053
PAO	313.61441020	79.11928813	15.71	.001
EST1	1.16566275	0.64393885	3.28	.093
		- IPE -		
INTERCEPT	12058.03566753			
PAD	2599.96625753	826.31982626	9.90	.006
AGE1	-154.00611399	110.10325996	1.96	.181

Table D-3

Best Estimative Models for the Heather Index

During Minute 29 of Exercise and IPE

	B VALUE	STD ERROR	F	PROB>F
		- MINUTE 29 -		
INTERCEPT	4189.32458935			
SUP	-2334.46434075	895.36680338	6.80	.022
PAO	222.80968401	74.17765667	9.02	.010
LSPA	-130.12530629	79.10371125	2.71	.124
EST1	-1.51489856	0.77807935	3.79	.074
EST2	-1.06286250	0.66000050	2.59	.131
		- IPE -		
INTERCEPT	3969.77847870			
SUP	-2798.11802522	989.05123590	8.00	.013
PAO	102.59673887	55.63988960	3.40	.087
EST1	-1.96430737	0.85882137	5.23	.038
EST2	1.43132269	0.72846352	3.86	.070

Table D-4

Best Estimative Models for Mean Arterial Blood Pressure During Minute 29 of Exercise and IPE

	B VALUE	STD ERROR	F	PROB>F
	- MINUTE 29 -			
INTERCEPT	8726.85591962			
SUP	718.69664736	570.98232994	1.58	.229
PAO	-129.99023493	61.91580299	4.41	.054
LSPA	270.72956121	123.51470547	4.80	.046
PAD	-859.91909199	839.89533087	1.05	.323
	- IPE -			
INTERCEPT	9315.33806127			
SUP	995.15122629	499.10556870	3.98	.065
PAO	-141.55970962	54.26592296	6.80	.020
LSPA	130.30115829	59.78226256	4.75	.046

Table D-5

Best Estimative Models for Heart Rate

During Minute 29 of Exercise and IPE

	B VALUE	STD ERROR	F	PROB>F
	- MINUTE 29 -			
INTERCEPT	256.41516202			
PAO	-2.41780338	1.00959855	5.74	.032
LSPA	3.66371275	1.77613210	4.25	.060
PAD	-16.24966274	11.35141935	2.05	.176
	- IPE -			
INTERCEPT	242.11258541			
PAO	-2.56806504	1.11124801	5.34	.038
LSPA	3.74479356	1.95495849	3.67	.078
PAD	-15.93494452	12.49431483	1.63	.225
AGE1	2.27649301	0.83659318	7.40	.018
EST1	-0.00793513	0.00429612	3.41	.088

APPENDIX E

Assessment of Cardiac Response using the Impedance Cardiograph

There is limited cardiovascular data on postmenopausal women. In addition, published data using the impedance cardiograph in assessing cardiac response in women has been limited (33, 64, 78, 81). Impedance cardiography is a simple, practical noninvasive method for obtaining information about cardiac function. This technique allows the investigator to assess cardiac response to exercise in a reliable manner without exposing the subject to undue pain or risk. The noninvasive nature of this technique broadens the research possibilities for studying the response of the cardiovascular system to stress with special populations. The potential usefulness of this noninvasive technique with postmenopausal women was assessed in this study.

Absolute values for cardiac output calculated from the impedance cardiograph have not always been in agreement with those obtained from invasive measures (12, 56, 67). This technique is considered to be a better measure of relative rather than absolute changes in cardiac output (19, 32, 67, 82, 106). The values obtained in this study for stroke volume and cardiac output were compared to those obtained invasively in other studies.

The value for stroke volume in the supine position obtained in this study (100.49 $\pm$ 35.65 ml) was larger than that obtained using the dye-dilution technique (62). After training, Kilbom and Astrand (62) reported a resting stroke volume ($\pm$ SE) of 67 $\pm$ 3 ml for women 53-61 years of age. During minute 29 of exercise mean stroke volume value obtained in the present study (97.37 $\pm$ 27.55 ml) was higher than that reported by Kilbom and Astrand (62) using the dye-dilution technique.

In the present study, resting cardiac output values obtained in the supine position (5.95 $\pm$ 2.17 $l \cdot min^{-1}$) and during minute 29 of exercise (10.23 $\pm$ 2.99 $l\ min^{-1}$) were higher than those obtained using the dye-dilution technique (62). Kilbom and Astrand (62) reported cardiac output values ($\pm$ SE) after training of 4.2 $\pm$ 0.2 $l \cdot min^{-1}$ in the supine position and 7.5 $\pm$ 0.4 $l \cdot min^{-1}$ during bicycle ergometer exercise (50 watts) in women 53-61 years of age.

Resting stroke volume values obtained in the present study in the supine (100.49 $\pm$ 35.65 ml) and seated (62.56 $\pm$ 19.58 ml) position compared relatively well with those reported by other investigators using the impedance cardiography (33, 78). Doerr et al. (33) reported stroke volume values ($\pm$ SD) of 118 $\pm$ 34.1 ml in the supine and of 72.1 $\pm$ 20.4 ml in the seated position for women 20-44 years of age. Luisada et al. (78) reported a resting stroke volume value ($\pm$ SD) of 77 $\pm$ 18.61 ml for women 40-59 years of age. The differences in resting stroke volume values obtained by impedance cardiography in these studies may be explained by the age of the subjects, the level of conditioning, and/or the values for L and Zo that were used in the calculation of stroke volume. In the stroke volume equation, both L and Zo are raised to the second power; thus, placing added significance on theses factors in the determination of stroke volume.

The resting cardiac output values reported in this study (Table

5) compared well to those reported by Luisada et al. (78) but were lower than those reported by Doerr et al. (33). Luisada et al. (78) reported cardiac output values (± SD) of 4.64 ± 1.27 $l \cdot min^{-1}$ for women in the seated position. Cardiac output values (± SD) of 7.36 ± 2.23 $l \cdot min^{-1}$ and of 5.29 ± 1.01 $l \cdot min^{-1}$ in supine and seated position were reported by Doerr et al. (33) for women 20-44 years of age. Exercise cardiac output values obtained by the electrical impedance method in this study (Table 5) were compared with those values measured noninvasively by the indirect Fick method during bicycle (14) and treadmill exercise (87). Becklace et al. (14) reported cardiac output values (± SD) during bicycle ergometer work of 11.8 ± 3.18 $l \cdot min^{-1}$ (150 kpm) and 17.1 ± 3.26 $l \cdot min^{-1}$ (350 kpm) in women 50 years of age. These values were slightly higher than those reported in this study during minute 29 of exercise (10.23 ± 2.99 $l \cdot min^{-1}$). Niinimaa and Shephard (87) reported cardiac output values (± SD) during treadmill exercise in women (mean age 66.6 years) of 10.3 ± 1.8 $l \cdot min^{-1}$. It should be noted that even though these values are comparable to the ones obtained in this study, the mode of exercise was different and the women in this study were much younger.

Some investigators feel that the reported differences in cardiac output values obtained by the impedance and invasive methods may be related to the use of a constant value for rho (resistivity of the blood) and to the effects of varying the total distance (L) between inner electrodes on the calculation of stroke volume (19, 32, 65). In the present study, these factors were accounted for by following the recommendations of Denniston (32): (a) rho was based on the actual hematocrit and (b) the mean distance (cm) between the inner electrodes at the anterior and posterior midlines was used to determine L. In addition, impedance beats recorded during all phases of the respiratory cycle, independent of a specified baseline, were used in the calculation of stroke volume (33). Heart rate, which is an important factor in the calculation of cardiac output, was calculated using the R-R interval. Respiratory and movement artifacts made the impedance recordings sometimes difficult to read. From the work done in a pilot study, it was decided that the impedance recordings would be taken while the subject continued to pedal with her hands resting on the handle bars. Although the distortion was minimized, respiratory and movement artifacts did interfere from time to time with the clarity of the dZ/dt waveform.

The cardiovascular data obtained in this study through the use of the impedance cardiograph were comparable to values measured noninvasively. The differences in the values reported in the present study compared with those in the literature might be attributed to: (a) the age of the subjects, (b) the mode of exercise, (c) the intensity of the exercise, (d) the level of conditioning, and (e) the uniqueness of the population under investigation.

APPENDIX F

Subject #1

REST SUPINE

.8	2.1	.34	.1	32.8	29.5	.37	153.77	75	88.81	6.66	21
.82	2.2	.33	.1	32.8	29.5	.37	153.77	73	90.3	6.59	22
.81	2.3	.32	.1	32.8	29.5	.37	153.77	74	91.55	6.77	23
.82	2.3	.32	.1	32.8	29.5	.37	153.77	73	91.55	6.68	23
.84	2.2	.33	.11	32.8	29.5	.37	153.77	71	90.3	6.41	20
.81	2.3	.33	.11	32.8	29.5	.37	153.77	74	94.41	6.99	20.91

MEANS FOR THIS SET OF OBSERVATIONS:

.82	2.23	.33	.1	32.8	29.5	.37	153.77	73.33	91.15	6.68	21.65

NAME FOR SET
REST SEATED

.62	1.4	.23	.16	38.2	29.5	.37	153.77	96	29.53	2.83	8.75
.6	1.4	.23	.15	38.2	29.5	.37	153.77	99	29.53	2.92	9.33
.61	1.8	.23	.13	38.2	29.5	.37	153.77	98	37.97	3.72	13.85
.61	1.5	.23	.14	38.2	29.5	.37	153.77	98	31.64	3.1	10.71
.62	1.4	.23	.13	38.2	29.5	.37	153.77	96	29.53	2.83	10.77
.6	1.5	.24	.16	38.2	29.5	.37	153.77	99	33.01	3.27	9.38

MEANS FOR THIS SET OF OBSERVATIONS:

.61	1.5	.23	.15	38.2	29.5	.37	153.77	97.67	31.87	3.11	10.46

NAME FOR SET 10 MINUTE EXERCISE

.53	4.4	.25	.09	38.4	29.5	.37	153.77	113	99.83	11.28	48.89
.54	3.3	.26	.09	38.4	29.5	.37	153.77	111	77.86	8.64	36.67
.54	3.4	.26	.08	38.4	29.5	.37	153.77	111	80.22	8.9	42.5
.54	4	.26	.08	38.4	29.5	.37	153.77	111	94.38	10.48	50
.55	3.5	.27	.08	38.4	29.5	.37	153.77	109	85.76	9.35	43.75
.54	4.1	.25	.09	38.4	29.5	.37	153.77	111	93.02	10.33	45.56

MEANS FOR THIS SET OF OBSERVATIONS:

.54	3.78	.26	.09	38.4	29.5	.37	153.77	111	88.51	9.83	44.56

NAME FOR SET 15 MINUTE EXERCISE

.54	2.9	.25	.08	38.1	29.5	.37	153.77	111	66.83	7.42	36.25
.54	3.2	.26	.08	38.1	29.5	.37	153.77	111	76.7	8.51	40
.53	2.9	.24	.07	38.1	29.5	.37	153.77	113	64.16	7.25	41.43
.52	3.7	.26	.07	38.1	29.5	.37	153.77	115	88.68	10.2	52.86
.53	3.1	.25	.07	38.1	29.5	.37	153.77	113	71.44	8.07	44.29
.51	3.4	.25	.08	38.1	29.5	.37	153.77	117	78.36	9.17	42.5

MEANS FOR THIS SET OF OBSERVATIONS:

.53	3.2	.25	.08	38.1	29.5	.37	153.77	113.33	74.36	8.44	42.89

NAME FOR SET 20 MINUTE EXERCISE

.51	3.7	.25	.07	36.8	29.5	.37	153.77	117	91.4	10.69	52.86
.51	3.4	.25	.07	36.8	29.5	.37	153.77	117	83.99	9.83	48.57
.51	3	.24	.08	36.8	29.5	.37	153.77	117	71.15	8.32	37.5
.52	3.8	.27	.08	36.8	29.5	.37	153.77	115	101.38	11.66	47.5
.51	3.2	.26	.07	36.8	29.5	.37	153.77	117	82.21	9.62	45.71
.52	3	.26	.07	36.8	29.5	.37	153.77	115	77.07	8.86	42.86

MEANS FOR THIS SET OF OBSERVATIONS:

.51	3.35	.26	.07	36.8	29.5	.37	153.77	116.33	84.54	9.83	45.83

Subject #1 (cont'd)

NAME FOR SET 25 MINUTE EXERCISE

.5	3.4	.25	.07	36.3	29.5	.37	153.77	120	86.32	10.36	48.57
.51	2.7	.26	.08	36.3	29.5	.37	153.77	117	71.29	8.34	33.75
.51	2.6	.24	.07	36.3	29.5	.37	153:77	117	63.37	7.41	37.14
.51	2.8	.24	.07	36.3	29.5	.37	153.77	117	68.24	7.98	40
.5	3.1	.24	.08	36.6	29.5	.37	153.77	120	74.32	8.92	38.75
.51	3.7	.24	.08	36.3	29.5	.37	153.77	117	90.18	10.55	46.25

MEANS FOR THIS SET OF OBSERVATIONS:

.51	3.05	.25	.08	36.35	29.5	.37	153.77	118	75.62	8.93	40.74

NAME FOR SET 29 MINUTE EXERCISE

.49	2.7	.25	.06	37.2	29.5	.37	153.77	122	65.27	7.96	45
.48	3.2	.23	.06	37.2	29.5	.37	153.77	124	71.17	8.83	53.33
.48	3.2	.23	.07	37.2	29.5	.37	153.77	124	71.17	8.83	45.71
.48	2.5	.24	.06	37.2	29.5	.37	153.77	124	58.02	7.19	41.67
.5	3	.24	.07	37.2	29.5	.37	153.77	120	69.62	8.35	42.86
.5	3.3	.25	.07	37.2	29.5	.37	153.77	120	79.78	9.57	47.14

MEANS FOR THIS SET OF OBSERVATIONS:

.49	2.98	.24	.07	37.2	29.5	.37	153.77	122.33	69.17	8.46	45.95

NAME FOR SET IPE

.5	2.8	.24	.06	37.3	29.5	.37	153.77	120	64.63	7.76	46.67
.5	2.9	.23	.07	37.3	29.5	.37	153.77	120	64.15	7.7	41.43
.51	3.1	.24	.07	37.3	29.5	.37	153.77	117	71.56	8.37	44.29
.52	3	.23	.07	37.3	29.5	.37	153.77	115	66.37	7.63	42.86
.51	3.2	.24	.08	37.3	29.5	.37	153.77	117	73.87	8.64	40
.54	3	.23	.07	37.3	29.5	.37	153.77	111	66.37	7.37	42.86

MEANS FOR THIS SET OF OBSERVATIONS:

.51	3	.24	.07	37.3	29.5	.37	153.77	116.67	67.82	7.91	43.02

NAME FOR SET 10 MINUTE RECOVERY

.59	1.6	.25	.1	37.3	29.5	.37	153.77	101	38.47	3.89	16
.6	1.5	.24	.11	37.3	29.5	.37	153.77	99	34.63	3.43	13.64
.58	1.5	.24	.1	37.3	29.5	.37	153.77	103	34.63	3.57	15
.58	1.4	.25	.11	37.3	29.5	.37	153.77	103	33.66	3.47	12.73
.58	1.8	.23	.11	37.3	29.5	.37	153.77	103	39.82	4.1	16.36
.59	2	.25	.11	37.3	29.5	.37	153.77	101	48.09	4.86	18.18

MEANS FOR THIS SET OF OBSERVATIONS:

.59	1.63	.24	.11	37.3	29.5	.37	153.77	101.67	38.22	3.88	15.32

Subject #2

EST SUPINE

1.37	2.9	.41	.12	32.2	25.25	.42	177.4	43	129.7	5.58	24.17
1.38	2.9	.39	.13	32.2	25.25	.42	177.4	43	123.37	5:31	22.31
1.39	2.7	.35	.13	32.2	25.25	.42	177.4	43	103.08	4.43	20.77
1.35	2.8	.33	.13	32.2	25.25	.42	177.4	44	100.79	4.43	21.54
1.44	2.7	.4	.13	32.2	25.25	.42	177.4	41	117.81	4.83	20.77
1.5	2.6	.4	.13	32.2	25.25	.42	177.4	40	113.45	4.54	20

MEANS FOR THIS SET OF OBSERVATIONS:

1.41	2.77	.38	.13	32.2	25.25	.42	177.4	42.33	114.7	4.85	21.59

NAME FOR SET REST SEATED

1.1	2.6	.35	.15	35.7	25.25	.42	177.4	54	80.76	4.36	17.33
1.08	2.8	.29	.14	35.7	25.25	.42	177.4	55	72.06	3.96	20
1.08	2.3	.34	.14	35.7	25.25	.42	177.4	55	69.4	3.82	16.43
1.1	2.3	.34	.14	35.7	25.25	.42	177.4	54	69.4	3.75	16.43
1.09	2.5	.34	.14	35.7	25.25	.42	177.4	55	75.43	4.15	17.86
1.06	2.8	.28	.14	35.7	25.25	.42	177.4	56	69.58	3.9	20

MEANS FOR THIS SET OF OBSERVATIONS:

1.09	2.55	.32	.14	35.7	25.25	.42	177.4	54.83	72.77	3.99	18.01

NAME FOR SET 10 MINUTE EXERCISE

.5	4.4	.25	.09	35.9	25.25	.42	177.4	120	96.53	11.58	48.89
.49	4.6	.24	.09	35.9	25.25	.42	177.4	122	96.88	11.82	51.11
.49	4.4	.26	.08	35.9	25.25	.42	177.4	122	100.4	12.25	55
.5	4.9	.26	.1	35.9	25.25	.42	177.4	120	111.8	13.42	49
.48	4.1	.24	.08	35.9	25.25	.42	177.4	124	86.35	10.71	51.25
.48	4.5	.24	.08	35.9	25.25	.42	177.4	124	94.78	11.75	56.25

MEANS FOR THIS SET OF OBSERVATIONS:

.49	4.48	.25	.09	35.9	25.25	.42	177.4	122	97.79	11.92	51.92

NAME FOR SET 15 MINUTE EXERCISE

.47	4.7	.23	.1	35.8	25.25	.42	177.4	127	95.4	12.12	47
.47	4.7	.22	.09	35.8	25.25	.42	177.4	127	91.25	11.59	52.22
.49	4.4	.22	.09	35.8	25.25	.42	177.4	122	85.42	10.42	48.89
.49	4.2	.24	.1	35.8	25.25	.42	177.4	122	88.95	10.85	42
.48	4.2	.23	.08	35.8	25.25	.42	177.4	124	85.25	10.57	52.5
.51	4	.27	.1	35.8	25.25	.42	177.4	117	95.31	11.15	40

MEANS FOR THIS SET OF OBSERVATIONS:

.49	4.37	.24	.09	35.8	25.25	.42	177.4	123.17	90.26	11.12	47.1

NAME FOR SET 20 MINUTE EXERCISE

.47	3.8	.24	.11	35.6	25.25	.42	177.4	127	81.39	10.34	34.55
.45	4.2	.23	.1	35.6	25.25	.42	177.4	133	86.21	11.47	42
.46	4.6	.2	.08	35.6	25.25	.42	177.4	130	82.1	10.67	57.5
.46	4.5	.21	.09	35.6	25.25	.42	177.4	130	84.33	10.96	50
.44	3.8	.21	.08	35.6	25.25	.42	177.4	136	71.22	9.69	47.5
.46	3.9	.21	.09	35.6	25.25	.42	177.4	130	73.09	9.5	43.33

MEANS FOR THIS SET OF OBSERVATIONS:

.46	4.13	.22	.09	35.6	25.25	.42	177.4	131	79.72	10.44	45.81

Subject #2 (cont'd)

NAME FOR SET 25 MINUTE EXERCISE

.46	3.8	.21	.1	35.9	25.25	.42	177.4	130	70.03	9.1	38
.46	4.9	.22	.09	35.9	25.25	.42	177.4	130	94.6	12.3	54.44
.44	4.4	.22	.08	35.9	25.25	.42	177.4	136	84.95	11.55	55
.45	4.4	.22	.09	35.9	25.25	.42	177.4	133	84.95	11.3	48.89
.44	4.1	.23	.09	35.9	25.25	.42	177.4	136	82.76	11.25	45.56
.46	3.8	.22	.11	35.9	25.25	.42	177.4	130	73.37	9.54	34.55

MEANS FOR THIS SET OF OBSERVATIONS:

.45	4.23	.22	.09	35.9	25.25	.42	177.4	132.5	81.78	10.84	46.07

NAME FOR SET 29 MINUTE EXERCISE

.44	4	.21	.09	35.9	25.25	.42	177.4	136	73.72	10.03	44.44
.44	4	.21	.1	35.9	25.25	.42	177.4	136	73.72	10.03	40
.44	3.6	.23	.1	35.9	25.25	.42	177.4	136	72.66	9.88	36
.44	3.4	.23	.09	35.9	25.25	.42	177.4	136	68.63	9.33	37.78
.45	3.6	.24	.11	35.9	25.25	.42	177.4	133	75.82	10.08	32.73
.45	3.7	.19	.1	35.9	25.25	.42	177.4	133	61.69	8.21	37

MEANS FOR THIS SET OF OBSERVATIONS:

.44	3.72	.22	.1	35.9	25.25	.42	177.4	135	71.04	9.59	37.99

NAME FOR SET IPE

.45	4.2	.21	.09	35.9	25.25	.42	177.4	133	77.4	10.29	46.67
.46	4.4	.21	.09	35.9	25.25	.42	177.4	130	81.09	10.54	48.89
.46	4.6	.19	.09	35.9	25.25	.42	177.4	130	76.7	9.97	51.11
.46	3.9	.21	.1	35.9	25.25	.42	177.4	130	71.87	9.34	39
.47	3.9	.21	.11	35.9	25.25	.42	177.4	127	71.87	9.13	35.45
.47	3.5	.2	.11	35.9	25.25	.42	177.4	127	61.43	7.8	31.82

MEANS FOR THIS SET OF OBSERVATIONS:

.46	4.08	.21	.1	35.9	25.25	.42	177.4	129.5	73.39	9.51	42.16

NAME FOR SET 10 MINUTE RECOVERY

.71	2	.29	.14	35.6	25.25	.42	177.4	84	51.76	4.35	14.29
.79	2.1	.23	.15	35.6	25.25	.42	177.4	75	43.1	3.23	14
.89	2	.29	.15	35.6	25.25	.42	177.4	67	51.76	3.47	13.33
.9	2	.29	.15	35.6	25.25	.42	177.4	66	51.76	3.42	13.33
.84	2	.28	.14	35.6	25.25	.42	177.4	71	49.98	3.55	14.29
.78	2.1	.25	.15	35.6	25.25	.42	177.4	76	46.85	3.56	14

MEANS FOR THIS SET OF OBSERVATIONS:

.82	2.03	.27	.15	35.6	25.25	.42	177.4	73.17	49.2	3.6	13.87

Subject #3

REST SUPINE

.91	4.1	.36	.1	35.5	28	.41	174.06	65	159.82	10.39	41
.96	3.7	.36	.1	35.5	28	.41	174.06	62	144.23	8.94	37
.94	3.4	.35	.11	35.5	28	.41	174.06	63	128.85	8.12	30.91
.9	3.7	.35	.11	35.5	28	.41	174.06	66	140.22	9.25	33.64
.79	4.2	.34	.09	35.5	28	.41	174.06	75	154.62	11.6	46.67
.7	4.2	.38	.09	35.5	28	.41	174.06	85	172.81	14.69	46.67

MEANS FOR THIS SET OF OBSERVATIONS:

.87 3.88 .36 .1 35.5 28 .41 174.06 69.33 150.09 10.5 39.31

NAME FOR SET REST SEATED

.85	2.6	.3	.11	39.9	28	.41	174.06	70	66.86	4.68	23.64
.87	2.7	.29	.12	39.9	28	.41	174.06	68	67.11	4.56	22.5
.88	2.7	.31	.13	39.9	28	.41	174.06	68	71.74	4.88	20.77
.88	2.6	.3	.12	39.9	28	.41	174.06	68	66.86	4.55	21.67
.88	2.7	.3	.12	39.9	28	.41	174.06	68	69.43	4.72	22.5
.88	2.7	.31	.11	39.9	28	.41	174.06	68	71.74	4.88	24.55

MEANS FOR THIS SET OF OBSERVATIONS:

.87 2.67 .3 .12 39.9 28 .41 174.06 68.33 68.96 4.71 22.6

NAME FOR SET 10 MINUTE EXERCISE

.68	3.3	.29	.05	39.1	28	.41	174.06	88	85.42	7.52	66
.7	3.3	.3	.08	39.1	28	.41	174.06	85	88.37	7.51	41.25
.7	3.8	.3	.09	39.1	28	.41	174.06	85	101.75	8.65	42.22
.69	3.8	.3	.08	39.1	28	.41	174.06	86	101.75	8.75	47.5
.71	3.8	.32	.09	39.1	28	.41	174.06	84	108.54	9.12	42.22
.71	3.4	.3	.09	39.1	28	.41	174.06	84	91.04	7.65	37.78

MEANS FOR THIS SET OF OBSERVATIONS:

.7 3.57 .3 .08 39.1 28 .41 174.06 85.33 96.15 8.2 46.16

15 MINUTE EXCERCISE

.73	3.6	.3	.09	39.3	28	.41	174.06	82	95.42	7.82	40
.69	4.1	.28	.08	39.3	28	.41	174.06	86	101.43	8.72	51.25
.7	3.9	.3	.08	39.3	28	.41	174.06	85	103.37	8.79	48.75
.7	3.9	.3	.07	39.3	28	.41	174.06	85	103.37	8.79	55.71
.72	3.6	.31	.08	39.3	28	.41	174.06	83	98.6	8.18	45
.7	3.8	.3	.07	39.3	28	.41	174.06	85	100.72	8.56	54.29

MEANS FOR THIS SET OF OBSERVATIONS:

.71 3.82 .3 .08 39.3 28 .41 174.06 84.33 100.49 8.48 49.17

NAME FOR SET 20 MINUTE EXERCISE

.66	4.1	.33	.07	38.5	28	.41	174.06	90	124.56	11.21	58.57
.65	4.1	.29	.08	38.5	28	.41	174.06	92	109.46	10.07	51.25
.68	4.1	.32	.08	38.5	28	.41	174.06	88	120.79	10.63	51.25
.67	4.3	.31	.08	38.5	28	.41	174.06	89	122.72	10.92	53.75
.66	4.4	.3	.08	38.5	28	.41	174.06	90	121.52	10.94	55
.65	3.9	.29	.07	38.5	28	.41	174.06	92	104.12	9.58	55.71

MEANS FOR THIS SET OF OBSERVATIONS:

.66 4.15 .31 .08 38.5 28 .41 174.06 90.17 117.2 10.56 54.26

Subject #3 (cont'd)

NAME FOR SET 25 MINUTE EXERCISE

.65	3.6	.3	.07	38	28	.41	174.06	92	102.06	9.39	51.43
.65	3.3	.31	.07	38	28	.41	174.06	92	96.67	8.89	47.14
.69	3.4	.31	.08	38	28	.41	174.06	86	99.6	8.57	42.5
.69	3.4	.31	.07	38	28	.41	174.06	86	99.6	8.57	48.57
.69	3.5	.32	.09	38	28	.41	174.06	86	105.84	9.1	38.89
.68	3.5	.32	.08	38	28	.41	174.06	88	105.84	9.31	43.75

MEANS FOR THIS SET OF OBSERVATIONS:

.68	3.45	.31	.08	38	28	.41	174.06	88.33	101.6	8.97	45.38

NAME FOR SET 29 MINUTE EXERCISE

.64	3.8	.3	.08	39	28	.41	174.06	93	102.28	9.51	47.5
.64	3.6	.3	.07	39	28	.41	174.06	93	96.89	9.01	51.43
.63	4	.3	.07	39	28	.41	174.06	95	107.66	10.23	57.14
.63	3.7	.31	.07	39	28	.41	174.06	95	102.91	9.78	52.86
.65	3.8	.31	.08	39	28	.41	174.06	92	105.69	9.72	47.5
.64	3.6	.3	.07	39	28	.41	174.06	93	96.89	9.01	51.43

MEANS FOR THIS SET OF OBSERVATIONS:

.64	3.75	.3	.07	39	28	.41	174.06	93.5	102.05	9.54	51.31

NAME FOR SET IPE

.69	3.7	.29	.07	39.1	28	.41	174.06	86	95.77	8.24	52.86
.69	4.4	.29	.08	39.1	28	.41	174.06	86	113.89	9.79	55
.71	4.4	.3	.07	39.1	28	.41	174.06	84	117.82	9.9	62.86
.74	3.8	.3	.07	39.1	28	.41	174.06	81	101.75	8.24	54.29
.76	3.6	.3	.08	39.1	28	.41	174.06	78	96.4	7.52	45
.72	3.8	.3	.07	39.1	28	.41	174.06	83	101.75	8.45	54.29

MEANS FOR THIS SET OF OBSERVATIONS:

.72	3.95	.3	.07	39.1	28	.41	174.06	83	104.57	8.69	54.05

NAME FOR SET 10 MINUTE RECOVERY

.8	2.5	.29	.11	40.8	28	.41	174.06	75	59.43	4.46	22.73
.83	2.7	.28	.12	40.8	28	.41	174.06	72	61.97	4.46	22.5
.82	2.6	.27	.11	40.8	28	.41	174.06	73	57.55	4.2	23.64
.85	2.8	.29	.12	40.8	28	.41	174.06	70	66.56	4.66	23.33
.85	2.7	.29	.11	40.8	28	.41	174.06	70	64.19	4.49	24.55
.84	2.6	.29	.11	40.8	28	.41	174.06	71	61.81	4.39	23.64

MEANS FOR THIS SET OF OBSERVATIONS:

.83	2.65	.29	.11	40.8	28	.41	174.06	71.83	61.92	4.44	23.4

Subject #4

R EST SUPINE

1.17	2.1	.35	.11	29.9	25.86	.47	212.41	51	116.78	5.96	19.09
1.11	2.2	.34	.1	29.9	25.86	.47	212.41	54	118.85	6.42	22
1.14	2.8	.36	.1	29.9	25.86	.47	212.41	52	160.16	8.33	28
1.17	2.6	.36	.11	29.9	25.86	.47	212.41	51	148.72	7.58	23.64
1.19	2	.4	.11	29.9	25.86	.47	212.41	50	127.11	6.36	18.18
1.09	2.7	.36	.1	29.9	25.86	.47	212.41	55	154.44	8.49	27

MEANS FOR THIS SET OF OBSERVATIONS:

1.15	2.4	.36	.11	29.9	25.86	.47	212.41	52.17	137.68	7.19	22.98

NAME FOR SET REST SEATED

.84	1.7	.27	.12	34.6	25.86	.47	212.41	71	54.46	3.87	14.17
.86	1.4	.26	.13	34.6	25.86	.47	212.41	69	43.19	2.98	10.77
.88	1.4	.27	.12	34.6	25.86	.47	212.41	68	44.85	3.05	11.67
.92	1.3	.27	.14	34.6	25.86	.47	212.41	65	41.65	2.71	9.29
.91	1.4	.26	.13	34.6	25.86	.47	212.41	65	43.19	2.81	10.77
.91	1.3	.25	.12	34.6	25.86	.47	212.41	65	38.56	2.51	10.83

MEANS FOR THIS SET OF OBSERVATIONS:

.89	1.42	.26	.13	34.6	25.86	.47	212.41	67.17	44.32	2.99	11.25

NAME FOR SET 10 MINUTE EXERCISE

.74	3.1	.27	.08	34.1	25.86	.47	212.41	81	102.25	8.28	38.75
.75	2.7	.2	.09	34.1	25.86	.47	212.41	80	65.97	5.28	30
.73	2.9	.29	.08	34.1	25.86	.47	212.41	82	102.74	8.42	36.25
.71	2.4	.21	.1	34.1	25.86	.47	212.41	84	61.57	5.17	24
.72	2.3	.21	.09	34.1	25.86	.47	212.41	83	59	4.9	25.56
.73	3.1	.23	.09	34.1	25.86	.47	212.41	82	87.1	7.14	34.44

MEANS FOR THIS SET OF OBSERVATIONS:

.73	2.75	.24	.09	34.1	25.86	.47	212.41	82	79.77	6.53	31.5

NAME FOR SET 15 MINUTE EXERCISE

.72	4.4	.31	.09	33.9	25.86	.47	212.41	83	168.6	13.99	48.89
.76	3.6	.32	.09	33.9	25.86	.47	212.41	78	142.39	11.11	40
.73	3.8	.3	.09	33.9	25.86	.47	212.41	82	140.91	11.55	42.22
.75	3.6	.31	.1	33.9	25.86	.47	212.41	80	-137.94	11.04	36
.75	4.2	.32	.09	33.9	25.86	.47	212.41	80	166.13	13.29	46.67
.74	3.8	.3	.1	33.9	25.86	.47	212.41	81	140.91	11.41	38

MEANS FOR THIS SET OF OBSERVATIONS:

.74	3.9	.31	.09	33.9	25.86	.47	212.41	80.67	149.48	12.07	41.96

NAME FOR SET 20 MINUTE EXERCISE

.73	4	.26	.09	33.6	25.86	.47	212.41	82	130.86	10.73	44.44
.74	3.8	.31	.09	33.6	25.86	.47	212.41	81	148.22	12.01	42.22
.77	3.4	.35	.09	33.6	25.86	.47	212.41	77	149.73	11.53	37.78
.72	3.6	.29	.09	33.6	25.86	.47	212.41	83	131.36	10.9	40
.7	3.6	.31	.09	33.6	25.86	.47	212.41	85	140.42	11.94	40
.7	3.5	.3	.09	33.6	25.86	.47	212.41	85	132.11	11.23	38.89

MEANS FOR THIS SET OF OBSERVATIONS:

.73	3.65	.3	.09	33.6	25.86	.47	212.41	82.17	138.78	11.39	40.56

Subject #4 (cont'd)

2 5 MINUTE EXERCISE

.67	3.1	.32	.09	35.2	25.86	.47	212.41	89	113.73	10.12	34.44
.69	3	.29	.09	35.2	25.86	.47	212.41	86	99.74	8.58	33.33
.7	3.2	.31	.09	35.2	25.86	.47	212.41	85	113.73	9.67	35.56
.71	3.3	.33	.11	35.2	25.86	.47	212.41	84	124.85	10.49	30
.68	3.4	.33	.1	35.2	25.86	.47	212.41	88	128.63	11.32	34
.67	3.1	.33	.09	35.2	25.86	.47	212.41	89	117.28	10.44	34.44

MEANS FOR THIS SET OF OBSERVATIONS:

.69	3.18	.32	.1	35.2	25.86	.47	212.41	86.83	116.33	10.1	33.63

NAME FOR SET 29 MINUTE EXERCISE

.75	3.3	.29	.09	34.3	25.86	.47	212.41	80	115.55	9.24	36.67
.74	3.8	.3	.08	34.3	25.86	.47	212.41	81	137.64	11.15	47.5
.76	3.8	.29	.08	34.3	25.86	.47	212.41	78	133.06	10.38	47.5
.73	3.8	.24	.09	34.3	25.86	.47	212.41	82	110.12	9.03	42.22
.74	4	.28	.1	34.3	25.86	.47	212.41	81	135.23	10.95	40
.71	4	.32	.09	34.3	25.86	.47	212.41	84	154.55	12.98	44.44

MEANS FOR THIS SET OF OBSERVATIONS:

.74	3.78	.29	.09	34.3	25.86	.47	212.41	81	131.02	10.62	43.06

NAME FOR SET IPE

.74	3.2	.2	.07	34.3	25.86	.47	212.41	81	77.27	6.26	45.71
.74	3.1	.19	.09	34.3	25.86	.47	212.41	81	71.12	5.76	34.44
.86	2.9	.23	.08	34.3	25.86	.47	212.41	69	80.53	5.56	36.25
.89	3	.19	.07	34.3	25.86	.47	212.41	67	68.82	4.61	42.86
.9	2.7	.27	.08	34.3	25.86	.47	212.41	66	88.02	5.81	33.75
.84	2.8	.23	.08	34.3	25.86	.47	212.41	71	77.76	5.52	35

MEANS FOR THIS SET OF OBSERVATIONS:

.83	2.95	.22	.08	34.3	25.86	.47	212.41	72.5	77.25	5.59	38

NAME FOR SET 10 MINUTE RECOVERY

.88	1.3	.27	.12	34.6	25.86	.47	212.41	68	41.65	2.83	10.83
.87	1	.26	.13	34.6	25.86	.47	212.41	68	30.85	2.1	7.69
.87	1.1	.24	.12	34.6	25.86	.47	212.41	68	31.33	2.13	9.17
.86	1.4	.2	.12	34.6	25.86	.47	212.41	69	33.22	2.29	11.67
.86	1	.24	.12	34.6	25.86	.47	212.41	69	28.48	1.96	8.33
.89	1	.25	.13	34.6	25.86	.47	212.41	67	29.66	1.99	7.69

MEANS FOR THIS SET OF OBSERVATIONS:

.87	1.13	.24	.12	34.6	25.86	.47	212.41	68.17	32.53	2.22	9.23

Subject #5

REST SUPINE
.2 2 .37 .13 26.6 26.63 .37 155.12 49 115.05 5.64 15.38
.17 1.8 .38 .14 26.6 26.63 .37 155.12 51 106.34 5.42 12.86
.16 2.2 .34 .14 26.6 26.63 .37 155.12 51 116.29 5.93 15.71
.2 2 .39 .14 26.6 26.63 .37 155.12 49 121.26 5.94 14.29
.2 1.8 .38 .14 26.6 26.63 .37 155.12 49 106.34 5.21 12.86
.19 2.1 .35 .13 26.6 26.63 .37 155.12 50 114.27 5.71 16.15

EANS FOR THIS SET OF OBSERVATIONS:
.19 1.98 .37 .14 26.6 26.63 .37 155.12 49.83 113.26 5.64 14.54

REST SEATED
1.08 2.4 .29 .15 29.6 26.63 .37 155.12 55 87.38 4.81 16
1.1 1.8 .32 .17 29.6 26.63 .37 155.12 54 72.32 3.91 10.59
1.04 2 .28 .16 29.6 26.63 .37 155.12 57 70.31 4.01 12.5
1.07 2.2 .29 .17 29.6 26.63 .37 155.12 56 80.1 4.49 12.94
1.06 2.4 .31 .17 29.6 26.63 .37 155.12 56 93.41 5.23 14.12
1.05 2.5 .31 .17 29.6 26.63 .37 155.12 57 97.3 5.55 14.71

MEANS FOR THIS SET OF OBSERVATIONS:
1.07 2.22 .3 .17 29.6 26.63 .37 155.12 55.83 83.47 4.66 13.48

ME FOR SET 10 MINUTE EXERCISE
53 3.7 .22 .08 29 26.63 .37 155.12 113 106.47 12.03 46.25
53 3.8 .25 .07 29 26.63 .37 155.12 113 124.26 14.04 54.29
52 3.8 .23 .09 29 26.63 .37 155.12 115 114.32 13.15 42.22
52 3.9 .24 .07 29 26.63 .37 155.12 115 122.43 14.08 55.71
52 3.9 .26 .07 29 26.63 .37 155.12 115 132.63 15.25 55.71
52 4 .26 .08 29 26.63 .37 155.12 115 136.03 15.64 50

EANS FOR THIS SET OF OBSERVATIONS:
52 3.85 .24 .08 29 26.63 .37 155.12 114.33 122.69 14.03 50.7

ME FOR SET 15 MINUTE EXERCISE
5 3.4 .23 .06 29.2 26.63 .37 155.12 120 100.89 12.11 56.67
5 3.4 .24 .06 29.2 26.63 .37 155.12 120 105.28 12.63 56.67
5 3.2 .23 .08 29.2 26.63 .37 155.12 120 94.95 11.39 40
48 3.6 .22 .08 29.2 26.63 .37 155.12 124 102.18 12.67 45
49 3.9 .23 .07 29.2 26.63 .37 155.12 122 115.73 14.12 55.71
49 4 .22 .08 29.2 26.63 .37 155.12 122 113.53 13.85 50

EANS FOR THIS SET OF OBSERVATIONS:
49 3.58 .23 .07 29.2 26.63 .37 155.12 121.33 105.43 12.8 50.67

120 MINUTE EXERCISE
.46 3.5 .2 .07 29.2 26.63 .37 155.12 130 90.31 11.74 50
.47 3.7 .2 .08 29.2 26.63 .37 155.12 127 95.47 12.12 46.25
.46 3.1 .24 .06 29.2 26.63 .37 155.12 130 95.99 12.48 51.67
.47 3.5 .21 .08 29.2 26.63 .37 155.12 127 94.83 12.04 43.75
.47 3.8 .23 .06 29.2 26.63 .37 155.12 127 112.76 14.32 63.33
.48 3.4 .22 .09 29.2 26.63 .37 155.12 124 96.5 11.97 37.78

MEANS FOR THIS SET OF OBSERVATIONS:
.47 3.5 .22 .07 29.2 26.63 .37 155.12 127.5 97.64 12.45 48.8

Subject #5 (cont'd)

NAME FOR SET 25 MINUTE EXERCISE

.41	4	.18	.07	29.4	26.63	.37	155.12	146	91.63	13.38	57.14
.42	4.2	.2	.06	29.4	26.63	.37	155.12	142	106.9	15.18	70
.41	4.2	.18	.09	29.4	26.63	.37	155.12	146	96.21	14.05	46.67
.42	4.4	.19	.08	29.4	26.63	.37	155.12	142	106.39	15.11	55
.42	4.4	.17	.07	29.4	26.63	.37	155.12	142	95.19	13.52	62.86
.41	4.2	.21	.05	29.4	26.63	.37	155.12	146	112.25	16.39	84

MEANS FOR THIS SET OF OBSERVATIONS:

.42	4.23	.19	.07	29.4	26.63	.37	155.12	144	101.43	14.6	62.61

NAME FOR SET 29 MINUTE

.5	4.6	.18	.07	29.1	26.63	.37	155.12	120	107.56	12.91	65.71
.49	4.6	.19	.07	29.1	26.63	.37	155.12	122	113.53	13.85	65.71
.49	3.4	.21	.08	29.1	26.63	.37	155.12	122	92.75	11.32	42.5
.5	4.8	.21	.07	29.1	26.63	.37	155.12	120	130.94	15.71	68.57
.5	3.6	.23	.07	29.1	26.63	.37	155.12	120	107.56	12.91	51.43
.48	4.2	.19	.07	29.1	26.63	.37	155.12	124	103.66	12.85	60

MEANS FOR THIS SET OF OBSERVATIONS:

.49	4.2	.2	.07	29.1	26.63	.37	155.12	121.33	109.33	13.26	58.99

NAME FOR SET IPE

.49	4	.2	.09	29.1	26.63	.37	155.12	122	103.92	12.68	44.44
.49	4.6	.22	.09	29.1	26.63	.37	155.12	122	131.46	16.04	51.11
.48	3.7	.22	.05	29.1	26.63	.37	155.12	124	105.74	13.11	74
.51	3	.24	.06	29.1	26.63	.37	155.12	117	93.53	10.94	50
.49	4	.21	.07	29.1	26.63	.37	155.12	122	109.12	13.31	57.14
.53	3.7	.25	.06	29.1	26.63	.37	155.12	113	120.16	13.58	61.67

MEANS FOR THIS SET OF OBSERVATIONS:

.5	3.83	.22	.07	29.1	26.63	.37	155.12	120	110.66	13.28	56.39

NAME FOR SET 10 MINUTE RECOVERY

.7	2.6	.18	.14	30.3	26.63	.37	155.12	85	56.07	4.77	18.57
.74	2.3	.18	.14	30.3	26.63	.37	155.12	81	49.6	4.02	16.43
.73	2.4	.24	.15	30.3	26.63	.37	155.12	82	69.01	5.66	16
.73	2	.25	.15	30.3	26.63	.37	155.12	82	59.91	4.91	13.33
.74	2	.22	.15	30.3	26.63	.37	155.12	81	52.72	4.27	13.33
.72	2.2	.25	.15	30.3	26.63	.37	155.12	83	65.9	5.47	14.67

MEANS FOR THIS SET OF OBSERVATIONS:

.73	2.25	.22	.15	30.3	26.63	.37	155.12	82.33	58.87	4.85	15.39

Subject #6

R EST SUPINE

.87	1	.31	.09	38	27.88	.41	173.51	68	28.95	1.97	11.11
.85	1	.29	.08	38	27.88	.41	173.51	70	27.09	1.9	12.5
.89	1.2	.33	.1	38	27.88	.41	173.51	67	36.99	2.48	12
.87	1	.32	.09	38	27.88	.41	173.51	68	29.89	2.03	11.11
.86	.9	.28	.09	38	27.88	.41	173.51	69	23.54	1.62	10
.84	.9	.32	.09	38	27.88	.41	173.51	71	26.9	1.91	10

MEANS FOR THIS SET OF OBSERVATIONS:

.86	1	.31	.09	38	27.88	.41	173.51	68.83	28.89	1.98	11.12

NAME FOR SET REST SEAATED

.77	2.1	.3	.11	39.3	27.88	.41	173.51	77	55.01	4.24	19.09
.79	1.8	.31	.12	39.3	27.88	.41	173.51	75	48.73	3.65	15
.82	1.7	.31	.11	39.3	27.88	.41	173.51	73	46.02	3.36	15.45
.81	1.9	.3	.11	39.3	27.88	.41	173.51	74	49.77	3.68	17.27
.79	1.8	.3	.11	39.3	27.88	.41	173.51	75	47.15	3.54	16.36
.77	2	.3	.11	39.3	27.88	.41	173.51	77	52.39	4.03	18.18

MEANS FOR THIS SET OF OBSERVATIONS:

.79	1.88	.3	.11	39.3	27.88	.41	173.51	75.17	49.85	3.75	16.89

NAME FOR SET 15 MINUTE EXERCISE

.54	3.6	.26	.07	39.7	27.88	.41	173.51	111	80.09	8.89	51.43
.54	3.5	.26	.06	39.7	27.88	.41	173.51	111	77.87	8.64	58.33
.55	3.3	.27	.06	39.7	27.88	.41	173.51	109	76.24	8.31	55
.54	3.6	.26	.06	39.7	27.88	.41	173.51	111	80.09	8.89	60
.54	3.4	.27	.06	39.7	27.88	.41	173.51	111	78.55	8.72	56.67
.57	3.7	.27	.07	39.7	27.88	.41	173.51	105	85.48	8.98	52.86

MEANS FOR THIS SET OF OBSERVATIONS:

.55	3.52	.27	.06	39.7	27.88	.41	173.51	109.67	79.72	8.74	55.71

NAME FOR SET 20 MINUTE EXERCISE

.51	4.2	.25	.06	39.6	27.88	.41	173.51	117	90.3	10.57	70
.5	4.3	.25	.06	39.6	27.88	.41	173.51	120	92.45	11.09	71.67
.51	4.2	.24	.06	39.6	27.88	.41	173.51	117	86.69	10.14	70
.52	4.6	.25	.06	39.6	27.88	.41	173.51	115	98.9	11.37	76.67
.52	4	.25	.05	39.6	27.88	.41	173.51	115	86	9.89	80
.51	4.2	.25	.05	39.6	27.88	.41	173.51	117	90.3	10.57	84

MEANS FOR THIS SET OF OBSERVATIONS:

.51	4.25	.25	.06	39.6	27.88	.41	173.51	116.83	90.78	10.61	75.39

NAME FOR SET 25 MINUTE EXERCISE

.54	3.6	.27	.08	39.4	27.88	.41	173.51	111	84.45	9.37	45
.54	3.8	.25	.08	39.4	27.88	.41	173.51	111	82.53	9.16	47.5
.55	3.4	.26	.06	39.4	27.88	.41	173.51	109	76.8	8.37	56.67
.56	3.3	.27	.06	39.4	27.88	.41	173.51	107	77.41	8.28	55
.56	3.3	.26	.08	39.4	27.88	.41	173.51	107	74.54	7.98	41.25
.55	3.6	.26	.08	39.4	27.88	.41	173.51	109	81.32	8.86	45

MEANS FOR THIS SET OF OBSERVATIONS:

.55	3.5	.26	.07	39.4	27.88	.41	173.51	109	79.51	8.67	48.4

Subject #6 (cont'd)

NAME FOR SET 29 MINUTE EXERCISE

.58	3.8	.25	.07	39.5	27.88	.41	173.51	103	82.12	8.46	54.29
.58	3.8	.27	.08	39.5	27.88	.41	173.51	103	88.69	9.13	47.5
.59	3.2	.27	.07	39.5	27.88	.41	173.51	103	74.68	7.69	45.71
.58	3.3	.26	.06	39.5	27.88	.41	173.51	103	74.16	7.64	55
.57	3.6	.27	.07	39.5	27.88	.41	173.51	105	84.02	8.82	51.43
.58	3.2	.27	.08	39.5	27.88	.41	173.51	103	74.68	7.69	40

MEANS FOR THIS SET OF OBSERVATIONS:
.58 3.48 .27 .07 39.5 27.88 .41 173.51 103.33 79.73 8.24 48.99

NAME FOR SET IPE

.59	4.3	.27	.07	39.5	27.88	.41	173.51	101	100.36	10.14	61.43
.58	4.3	.28	.08	39.5	27.88	.41	173.51	103	104.07	10.72	53.75
.65	3.8	.29	.07	39.5	27.88	.41	173.51	92	95.26	8.76	54.29
.67	3.9	.29	.06	39.5	27.88	.41	173.51	89	97.76	8.7	65
.64	4	.28	.07	39.5	27.88	.41	173.51	93	96.81	9	57.14
.65	3.9	.28	.06	39.5	27.88	.41	173.51	92	94.39	8.68	65

MEANS FOR THIS SET OF OBSERVATIONS:
.63 4.03 .28 .07 39.5 27.88 .41 173.51 95 98.11 9.33 59.43

NAME FOR SET 10 MINUTE RECOVERY

.72	1.4	.28	.11	39.3	27.88	.41	173.51	83	34.23	2.84	12.73
.72	1.3	.29	.1	39.3	27.88	.41	173.51	83	32.92	2.73	13
.71	1.2	.28	.1	39.3	27.88	.41	173.51	84	29.34	2.46	12
.71	1.2	.28	.11	39.3	27.88	.41	173.51	84	29.34	2.46	10.91
.72	1.2	.28	.11	39.3	27.88	.41	173.51	83	29.34	2.44	10.91
.76	1.2	.28	.11	39.3	27.88	.41	173.51	78	29.34	2.29	10.91

MEANS FOR THIS SET OF OBSERVATIONS:
.72 1.25 .28 .11 39.3 27.88 .41 173.51 82.5 30.75 2.54 11.74

Subject #7

JREST SUPINE

1.22	1.5	.35	.09	30.6	27	.41	175.16	49	71.59	3.51	16.67
1.11	1.6	.34	.09	30.6	27	.41	175.16	54	74.18	4.01	17.78
1.07	1.5	.34	.09	30.6	27	.41	175.16	56	69.55	3.89	16.67
1.21	1.3	.35	.09	30.6	27	.41	175.16	49	62.05	3.04	14.44
1.25	1.5	.34	.09	30.6	27	.41	175.16	48	69.55	3.34	16.67
1.08	1.5	.34	.09	30.6	27	.41	175.16	55	69.55	3.83	16.67

MEANS FOR THIS SET OF OBSERVATIONS:
1.16 1.48 .34 .09 30.6 27 .41 175.16 51.83 69.41 3.6 16.48

NAME FOR SET REST SEATED

1	2.1	.31	.09	34	27	.41	175.16	60	71.91	4.31	23.33
.87	2	.28	.11	34	27	.41	175.16	68	61.86	4.21	18.18
.88	1.9	.29	.11	34	27	.41	175.16	68	60.86	4.14	17.27
.88	2	.29	.11	34	27	.41	175.16	68	64.07	4.36	18.18
.8	2.1	.26	.11	34	27	.41	175.16	75	60.31	4.52	19.09
.82	2.1	.26	.11	34	27	.41	175.16	73	60.31	4.4	19.09

MEANS FOR THIS SET OF OBSERVATIONS:
.88 2.03 .28 .11 34 27 .41 175.16 68.67 63.22 4.32 19.19

NAME FOR SET 10 MINUTE EXERCISE

.59	3.6	.27	.06	33.8	27	.41	175.16	101	108.64	10.97	60
.59	3.5	.27	.06	33.8	27	.41	175.16	101	105.62	10.67	58.33
.59	3.4	.28	.06	33.8	27	.41	175.16	101	106.4	10.75	56.67
.58	3	.26	.06	33.8	27	.41	175.16	103	87.18	8.98	50
.6	3.2	.29	.06	33.8	27	.41	175.16	99	103.72	10.27	53.33
.6	3.5	.25	.06	33.8	27	.41	175.16	99	97.8	9.68	58.33

MEANS FOR THIS SET OF OBSERVATIONS:
.59 3.37 .27 .06 33.8 27 .41 175.16 100.67 101.56 10.22 56.11

NAME FOR SET 15 MINUTE EXERCISE

.58	2.8	.22	.06	33.3	27	.41	175.16	103	70.93	7.31	46.67
.57	3.4	.23	.06	33.3	27	.41	175.16	105	90.05	9.46	56.67
.59	2.8	.25	.06	33.3	27	.41	175.16	101	80.61	8.14	46.67
.58	3.4	.22	.06	33.3	27	.41	175.16	103	86.13	8.87	56.67
.58	3.2	.25	.08	33.3	27	.41	175.16	103	92.12	9.49	40
.58	2.9	.25	.06	33.3	27	.41	175.16	103	83.48	8.6	48.33

MEANS FOR THIS SET OF OBSERVATIONS:
.58 3.08 .24 .06 33.3 27 .41 175.16 103 83.89 8.64 49.17

NAME FOR SET 20 MINUTE EXERCISE

.52	3.9	.21	.06	33.3	27	.41	175.16	115	94.31	10.85	65
.53	4.4	.22	.06	33.3	27	.41	175.16	113	111.47	12.6	73.33
.52	4	.22	.05	33.3	27	.41	175.16	115	101.33	11.65	80
.52	3.7	.23	.05	33.3	27	.41	175.16	115	97.99	11.27	74
.51	4.2	.21	.06	33.3	27	.41	175.16	117	101.56	11.88	70
.53	3.8	.25	.05	33.3	27	.41	175.16	113	109.39	12.36	76

MEANS FOR THIS SET OF OBSERVATIONS:
.52 4 .22 .06 33.3 27 .41 175.16 114.67 102.68 11.77 73.06

NAME FOR SET 25 MINUTE EXERCISE

.54	4.3	.24	.06	34	27	.41	173.18	111	112.71	12.51	71.67

Subject #7 (cont'd)

1 5 MINUTE EXERCISE

.54	4.3	.24	.06	34	27	.41	175.16	111	113.99	12.65	71.67
.54	3.9	.26	.06	34	27	.41	175.16	111	112.01	12.43	65
.54	3.8	.23	.06	34	27	.41	175.16	111	96.54	10.72	63.33
.53	3.6	.25	.06	34	27	.41	175.16	113	99.41	11.23	60
.54	4.1	.25	.06	34	27	.41	175.16	111	113.22	12.57	68.33
.53	4.1	.25	.06	34	27	.41	175.16	113	113.22	12.79	68.33

MEANS FOR THIS SET OF OBSERVATIONS:

.54	3.97	.25	.06	34	27	.41	175.16	111.67	108.07	12.07	66.11

NAME FOR SET 29 MINUTE EXERCISE

.52	4.4	.22	.06	33.6	27	.41	175.16	115	109.48	12.59	73.33
.52	4.3	.24	.05	33.6	27	.41	175.16	115	116.72	13.42	86
.52	4.6	.22	.05	33.6	27	.41	175.16	115	114.46	13.16	92
.51	4.6	.22	.05	33.6	27	.41	175.16	117	114.46	13.39	92
.52	4.2	.24	.05	33.6	27	.41	175.16	115	114.01	13.11	84
.51	4.3	.24	.05	33.6	27	.41	175.16	117	116.72	13.66	86

MEANS FOR THIS SET OF OBSERVATIONS:

.52	4.4	.23	.05	33.6	27	.41	175.16	115.67	114.31	13.22	85.56

NAME FOR SET IPE

.55	4.3	.26	.06	33.6	27	.41	175.16	109	126.45	13.78	71.67
.59	4.2	.23	.06	33.6	27	.41	175.16	101	109.26	11.04	70
.56	4.6	.24	.05	33.6	27	.41	175.16	107	124.87	13.36	92
.57	5	.2	.05	33.6	27	.41	175.16	105	113.1	11.88	100
.57	5.1	.22	.05	33.6	27	.41	175.16	105	126.9	13.32	102
.57	4.3	.22	.05	33.6	27	.41	175.16	105	106.1	11.23	86

MEANS FOR THIS SET OF OBSERVATIONS:

.57	4.58	.23	.05	33.6	27	.41	175.16	105.33	117.93	12.44	86.94

NAME FOR SET 10 MINUTE RECOVERY

.7	2	.24	.11	34.1	27	.41	175.16	85	52.71	4.48	18.18
.7	2.4	.24	.11	34.1	27	.41	175.16	85	63.25	5.38	21.82
.68	2.5	.23	.11	34.1	27	.41	175.16	88	63.14	5.56	22.73
.67	2.8	.26	.1	34.1	27	.41	175.16	89	79.94	7.11	28
.69	2.4	.26	.1	34.1	27	.41	175.16	86	68.52	5.89	24
.7	2	.26	.1	34.1	27	.41	175.16	85	57.1	4.85	20

MEANS FOR THIS SET OF OBSERVATIONS:

.69	2.35	.25	.11	34.1	27	.41	175.16	86.33	64.11	5.55	22.45

Subject #8

R EST SUPINE

1.05	3.6	.28	.1	30.1	27.88	.43	186.87	57	161.6	9.21	36
1.1	3.5	.31	.1	30.1	27.88	.43	186.87	54	173.95	9.39	35
1.12	3.6	.31	.1	30.1	27.88	.43	186.87	53	178.92	9.48	36
1.14	3.7	.26	.11	30.1	27.88	.43	186.87	52	154.23	8.02	33.64
1.1	3.5	.28	.11	30.1	27.88	.43	186.87	54	157.11	8.48	31.82
1.1	3.5	.29	.11	30.1	27.88	.43	186.87	54	162.73	8.79	31.82

MEANS FOR THIS SET OF OBSERVATIONS:

1.1	3.57	.29	.11	30.1	27.88	.43	186.87	54	164.76	8.9	34.05

NAME FOR SET REST SEATED

.82	2.8	.24	.12	34.5	27.88	.43	186.87	73	82.01	5.99	23.33
.82	2.7	.24	.11	34.5	27.88	.43	186.87	73	79.08	5.77	24.55
.82	2.6	.24	.11	34.5	27.88	.43	186.87	73	76.15	5.56	23.64
.83	2.8	.25	.11	34.5	27.88	.43	186.87	72	85.42	6.15	25.45
.84	2.9	.24	.12	34.5	27.88	.43	186.87	71	84.94	6.03	24.17
.82	3	.24	.1	34.5	27.88	.43	186.87	73	87.87	6.41	29.41

MEANS FOR THIS SET OF OBSERVATIONS:

.83	2.8	.24	.11	34.5	27.88	.43	186.87	72.5	82.58	5.99	25.09

NAME FOR SET 10 MINUTE EXERCISE

.62	4.3	.26	.06	34.5	27.88	.43	186.87	96	136.44	13.1	71.67
.62	4.1	.26	.07	34.5	27.88	.43	186.87	96	130.09	12.49	58.57
.62	4.1	.26	.09	34.5	27.88	.43	186.87	96	130.09	12.49	45.56
.62	4.1	.3	.07	34.5	27.88	.43	186.87	96	150.1	14.41	58.57
.63	4.4	.28	.08	34.5	27.88	.43	186.87	95	150.35	14.28	55
.62	4.3	.27	.07	34.5	27.88	.43	186.87	96	141.68	13.6	61.43

MEANS FOR THIS SET OF OBSERVATIONS:

.62	4.22	.27	.07	34.5	27.88	.43	186.87	95.83	139.79	13.39	58.47

115 MINUTE EXERCISE

.6	4.6	.26	.07	34.6	27.88	.43	186.87	99	145.11	14.37	65.71
.61	4.5	.27	.07	34.6	27.88	.43	186.87	98	147.42	14.45	64.2900001
.62	4.5	.26	.07	34.6	27.88	.43	186.87	96	141.96	13.63	64.2900001
.62	4.5	.26	.07	34.6	27.88	.43	186.87	96	141.96	13.63	64.2900001
.63	4.5	.26	.07	34.6	27.88	.43	186.87	95	141.96	13.49	64.2900001
.62	4.7	.26	.07	34.6	27.88	.43	186.87	96	148.27	14.23	67.14

MEANS FOR THIS SET OF OBSERVATIONS:

.62	4.55	.26	.07	34.6	27.88	.43	186.87	96.67	144.44	13.96	65

NAME FOR SET 20 MINUTE EXERCISE

.61	4.5	.26	.08	34.3	27.88	.43	186.87	98	144.45	14.16	56.25
.61	4.2	.26	.07	34.3	27.88	.43	186.87	98	134.82	13.21	60
.6	5.1	.24	.08	34.3	27.88	.43	186.87	99	151.12	14.96	63.75
.62	4.3	.27	.07	34.3	27.88	.43	186.87	96	143.34	13.76	61.43
.62	4.3	.26	.08	34.3	27.88	.43	186.87	96	138.03	13.25	53,75
.62	4.8	.26	.08	34.3	27.88	.43	186.87	96	154.08	14.79	60

MEANS FOR THIS SET OF OBSERVATIONS:

.61	4.53	.26	.08	34.3	27.88	.43	186.87	97.17	144.31	14.02	59.2

Subject #8 (cont'd)

25 MINUTE EXERCISE

.59	5.2	.24	.07	34	27.88	.43	186.87	101	156.81	15.84	74.29
.59	5.5	.26	.08	34	27.88	.43	186.87	101	179.68	18.15	68.75
.58	5.2	.25	.09	34	27.88	.43	186.87	103	163.35	16.82	57.78
.56	5.3	.25	.09	34	27.88	.43	186.87	103	166.49	17.15	58.89
.57	4.7	.23	.09	34	27.88	.43	186.87	105	135.83	14.26	52.22
.59	4.8	.25	.06	34	27.88	.43	186.87	101	150.78	15.23	80

MEANS FOR THIS SET OF OBSERVATIONS:

.58	5.12	.25	.08	34	27.88	.43	186.87	102.33	158.82	16.24	65.32

NAME FOR SET 29 MINUTE EXERCISE

.58	4.9	.26	.06	35.2	27.88	.43	186.87	103	149.35	15.38	81.67
.57	5	.24	.07	35.2	27.88	.43	186.87	105	140.68	14.77	71.43
.57	5	.25	.07	35.2	27.88	.43	186.87	105	146.54	15.39	71.43
.58	4.8	.25	.09	35.2	27.88	.43	186.87	103	140.68	14.49	53.33
.57	4.5	.25	.07	35.2	27.88	.43	186.87	105	131.88	13.85	64.2900001
.58	5	.25	.08	35.2	27.88	.43	186.87	103	146.54	15.09	62.5

MEANS FOR THIS SET OF OBSERVATIONS:

.58	4.87	.25	.07	35.2	27.88	.43	186.87	104	142.61	14.83	67.44

NAME FOR SET IPE

.59	4.9	.26	.07	35.2	27.88	.43	186.87	101	149.35	15.08	70
.6	5	.25	.07	35.2	27.88	.43	186.87	99	146.54	14.51	71.43
.6	5.4	.21	.07	35.2	27.88	.43	186.87	99	132.94	13.16	77.14
.6	5.3	.24	.06	35.2	27.88	.43	186.87	99	149.12	14.76	88.33
.61	4.6	.24	.07	35.2	27.88	.43	186.87	98	129.42	12.68	65.71
.6	5.4	.24	.07	35.2	27.88	.43	186.87	99	151.93	15.04	77.14

MEANS FOR THIS SET OF OBSERVATIONS:

.6	5.1	.24	.07	35.2	27.88	.43	186.87	99.17	143.22	14.21	74.96

NAME FOR SET 10 MINUTE RECOVERY

.84	3.2	.25	.12	34.9	27.88	.43	186.87	71	95.4	6.77	26.67
.83	3.2	.25	.13	34.9	27.88	.43	186.87	72	95.4	6.87	24.62
.84	3	.27	.12	34.9	27.88	.43	186.87	71	96.6	6.86	25
.81	2.7	.24	.13	34.9	27.88	.43	186.87	74	77.28	5.72	20.77
.8	3	.24	.11	34.9	27.88	.43	186.87	75	85.86	6.44	27.27
.81	3.2	.25	.12	34.9	27.88	.43	186.87	74	95.4	7.06	26.67

MEANS FOR THIS SET OF OBSERVATIONS:

.82	3.05	.25	.12	34.9	27.88	.43	186.87	72.83	90.99	6.62	25.17

Subject #9

R EST SUPINE

.9	2.9	.33	.12	33.4	27.95	.37	152	66	101.87	6.72	24.17
.94	2.7	.33	.12	33.4	27.95	.37	152	63	94.84	5.97	22.5
.92	2.7	.34	.13	33.4	27.95	.37	152	65	97.71	6.35	20.77
.86	2.8	.34	.11	33.4	27.95	.37	152	69	101.33	6.99	25.45
.85	3	.33	.12	33.4	27.95	.37	152	70	105.38	7.38	25
.8	2.4	.37	.11	33.4	27.95	.37	152	75	94.52	7.09	21.82

MEANS FOR THIS SET OF OBSERVATIONS:

.88	2.75	.34	.12	33.4	27.95	.37	152	68	99.28	6.75	23.28

NAME FOR SET REST SEATED

.8	1.5	.27	.15	38	27.95	.37	152	75	33.3	2.5	10
.84	1.6	.27	.14	38	27.95	.37	152	71	35.52	2.52	11.43
.8	1.4	.25	.16	38	27.95	.37	152	75	28.78	2.16	8.75
.81	1.5	.26	.14	38	27.95	.37	152	74	32.07	2.37	10.71
.85	1.7	.26	.14	38	27.95	.37	152	70	36.35	2.54	12.14
.83	1.5	.28	.14	38	27.95	.37	152	72	34.54	2.49	10.71

MEANS FOR THIS SET OF OBSERVATIONS:

.82	1.53	.27	.15	38	27.95	.37	152	72.83	33.43	2.43	10.63

NAME FOR SET 10 MINUTE EXERCISE

.6	3.1	.28	.09	37.7	27.95	.37	152	99	72.52	7.18	34.44
.6	3.2	.28	.1	37.7	27.95	.37	152	99	74.86	7.41	32
.6	3.7	.28	.1	37.7	27.95	.37	152	99	86.55	8.57	37
.63	3.3	.31	.09	37.7	27.95	.37	152	95	85.47	8.12	36.67
.59	3.8	.2	.1	37.7	27.95	.37	152	101	63.5	6.41	38
.6	3.8	.19	.1	37.7	27.95	.37	152	99	60.32	5.97	38

MEANS FOR THIS SET OF OBSERVATIONS:

.6	3.48	.26	.1	37.7	27.95	.37	152	98.67	73.87	7.28	36.02

]15 MINUTE EXERCISE

.58	4.1	.22	.1	38	27.95	.37	152	103	74.17	7.64	41
.57	4.2	.21	.1	38	27.95	.37	152	105	72.53	7.62	42
.57	4.8	.21	.1	38	27.95	.37	152	105	82.89	8.7	48
.58	4.2	.19	.1	38	27.95	.37	152	103	65.62	6.76	42
.58	4.6	.19	.1	38	27.95	.37	152	103	71.87	7.4	46
.58	4	.22	.11	38	27.95	.37	152	103	72.36	7.45	36.36

MEANS FOR THIS SET OF OBSERVATIONS:

.58	4.32	.21	.1	38	27.95	.37	152	103.67	73.24	7.6	42.56

NAME FOR SET 20 MINUTE EXERCISE

.61	3.6	.29	.09	37.8	27.95	.37	152	98	86.76	8.5	40
.62	3.4	.29	.08	37.8	27.95	.37	152	96	81.94	7.87	42.5
.62	3.2	.29	.1	37.8	27.95	.37	152	96	77.12	7.4	32
.6	3.2	.29	.1	37.8	27.95	.37	152	99	77.12	7.63	32
.6	3.9	.26	.1	37.8	27.95	.37	152	99	84.27	8.34	39
.6	3.8	.28	.09	37.8	27.95	.37	152	99	88.42	8.75	42.22

MEANS FOR THIS SET OF OBSERVATIONS:

.61	3.52	.28	.09	37.8	27.95	.37	152	97.83	82.61	8.08	37.95

Subject #9 (cont'd)

NAME FOR SET 25 MINUTE EXERCISE

.63	3.6	.26	.09	37.9	27.95	.37	152	95	77.38	7.35	40
.64	3	.28	.08	37.9	27.95	.37	152	93	69.44	6.46	37.5
.64	3.3	.28	.09	37.9	27.95	.37	152	93	76.38	7.1	36.67
.65	3	.28	.09	37.9	27.95	.37	152	92	69.44	6.39	33.33
.64	3	.28	.09	37.9	27.95	.37	152	93	69.44	6.46	33.33
.61	3.5	.21	.11	37.9	27.95	.37	152	98	60.76	5.95	31.82

MEANS FOR THIS SET OF OBSERVATIONS:

.64	3.23	.27	.09	37.9	27.95	.37	152	94	70.47	6.62	35.44

129 MINUTE EXERCISE

.65	3.9	.3	.1	37.5	27.97	.37	152	92	98.9	9.1	39
.63	3.6	.33	.09	37.5	27.95	.37	152	95	100.31	9.53	40
.62	3	.32	.09	37.5	27.95	.37	152	96	81.06	7.78	33.33
.63	3.4	.3	.09	37.5	27.95	.37	152	95	86.13	8.18	37.78
.63	4	.3	.09	37.5	27.95	.37	152	95	101.33	9.63	44.44
.61	3.7	.28	.1	37.5	27.95	.37	152	98	87.48	8.57	37

MEANS FOR THIS SET OF OBSERVATIONS:

.63	3.6	.31	.09	37.5	27.95	.37	152	95.17	92.54	8.8	38.59

NAME FOR SET IPE

.65	2.5	.27	.08	37.5	27.95	.37	152	92	56.1	5.24	31.25
.68	2.6	.26	.09	37.5	27.95	.37	152	88	57.08	5.02	28.89
.65	2.4	.26	.09	37.5	27.95	.37	152	92	52.69	4.85	26.67
.65	2.5	.25	.1	37.5	27.95	.37	152	92	52.77	4.86	25
.67	2.6	.27	.1	37.5	27.95	.37	152	89	59.28	5.28	26
.69	2.5	.28	.09	37.5	27.95	.37	152	86	59.11	5.08	27.78

MEANS FOR THIS SET OF OBSERVATIONS:

.67	2.52	.27	.09	37.5	27.95	.37	152	89.83	56.32	5.05	27.6

NAME FOR SET 10 MINUTE RECOVERY

.83	1.3	.25	.15	37.6	27.95	.37	152	72	27.3	1.97	8.67
.83	1.2	.24	.13	37.6	27.95	.37	152	72	24.19	1.74	9.23
.81	1.4	.26	.13	37.6	27.95	.37	152	74	30.57	2.26	10.77
.79	1.2	.26	.14	37.6	27.95	.37	152	75	26.21	1.97	8.57
.79	1.4	.24	.14	37.6	27.95	.37	152	75	28.22	2.12	10
.8	1.6	.22	.13	37.6	27.95	.37	152	75	29.56	2.22	12.31

MEANS FOR THIS SET OF OBSERVATIONS:

.81	1.35	.25	.14	37.6	27.95	.37	152	73.83	27.68	2.04	9.92

Subject #10

R EST SUPINE

.71	3.9	.35	.07	38.6	25.37	.37	151.13	84	89.11	7.49	55.71
.74	4.1	.35	.08	38.6	25.37	.37	151.13	81	93.68	7.59	51.25
.76	4.2	.36	.08	38.6	25.37	.37	151.13	78	98.71	7.7	52.5
.75	4	.35	.08	38.6	25.37	.37	151.13	80	91.4	7.31	50
.74	4	.36	.08	38.6	25.37	.37	151.13	81	94.01	7.61	50
.72	4.2	.34	.08	38.6	25.37	.37	151.13	83	93.23	7.74	52.5

MEANS FOR THIS SET OF OBSERVATIONS:
.74 4.07 .35 .08 38.6 25.37 .37 151.13 81.17 93.36 7.57 51.99

NAME FOR SET REST SEATED

.72	3.7	.31	.1	42.5	25.37	.37	151.13	83	61.77	5.13	37
.72	3.7	.3	.09	42.5	25.37	.37	151.13	83	59.78	4.96	41.11
.73	3.4	.32	.1	42.5	25.37	.37	151.13	82	58.59	4.8	34
.74	3.2	.31	.11	42.5	25.37	.37	151.13	81	53.42	4.33	29.09
.73	3.6	.31	.11	42.5	25.37	.37	151.13	82	60.1	4.93	32.73
.72	3.9	.29	.11	42.5	25.37	.37	151.13	83	60.91	5.06	35.45

MEANS FOR THIS SET OF OBSERVATIONS:
.73 3.58 .31 .1 42.5 25.37 .37 151.13 82.33 59.09 4.87 34.9

NAME FOR SET 15 MINUTE EXERCISE

.64	4.4	.3	.08	43.9	25.37	.37	151.13	93	66.62	6.2	55
.64	4.7	.3	.08	43.9	25.37	.37	151.13	93	71.17	6.62	58.75
.63	4.6	.31	.07	43.9	25.37	.37	151.13	95	71.97	6.84	65.71
.63	4	.3	.08	43.9	25.37	.37	151.13	95	60.57	5.75	50
.64	4.1	.3	.07	43.9	25.37	.37	151.13	93	62.08	5.77	58.57
.64	4.6	.3	.08	43.9	25.37	.37	151.13	93	69.65	6.48	57.5

MEANS FOR THIS SET OF OBSERVATIONS:
.64 4.4 .3 .08 43.9 25.37 .37 151.13 93.67 67.01 6.28 57.59

NAME FOR SET 20 MINUTE EXERCISE

.64	4.4	.31	.08	43.9	25.37	.37	151.13	93	68.85	6.4	55
.63	4.4	.32	.08	43.9	25.37	.37	151.13	95	71.07	6.75	55
.64	4.4	.31	.07	43.9	25.37	.37	151.13	93	68.85	6.4	62.86
.66	4.6	.32	.08	43.9	25.37	.37	151.13	90	74.3	6.69	57.5
.63	4.6	.31	.08	43.9	25.37	.37	151.13	95	71.97	6.84	57.5
.65	4.6	.31	.08	43.9	25.37	.37	151.13	92	71.97	6.62	57.5

MEANS FOR THIS SET OF OBSERVATIONS:
.64 4.5 .31 .08 43.9 25.37 .37 151.13 93 71.17 6.62 57.56

NAME FOR SET 25 MINUTE EXERCISE

.62	5.4	.29	.08	43.9	25.37	.37	151.13	96	79.04	7.59	67.5
.63	5.3	.29	.08	43.9	25.37	.37	151.13	95	77.58	7.37	66.25
.63	5.3	.31	.08	43.9	25.37	.37	151.13	95	82.93	7.88	66.25
.63	4.9	.29	.08	43.9	25.37	.37	151.13	95	71.72	6.81	61.25
.63	4.9	.3	.08	43.9	25.37	.37	151.13	95	74.2	7.05	61.25
.64	5.1	.3	.08	43.9	25.37	.37	151.13	93	77.22	7.18	63.75

MEANS FOR THIS SET OF OBSERVATIONS:
.63 5.15 .3 .08 43.9 25.37 .37 151.13 94.83 77.11 7.31 64.38

Subject #10 (cont'd)

NAME FOR SET 29 MINUTE EXERCISE

.62	4.5	.28	.08	43.2	25.37	.37	151.13	96	65.67	6.3	56.25
.61	4.3	.3	.08	43.2	25.37	.37	151.13	98	67.24	6.59	53.75
.62	4.8	.29	.09	43.2	25.37	.37	151.13	96	72.55	6.97	53.33
.61	4.8	.29	.09	43.2	25.37	.37	151.13	98	72.55	7.11	53.33
.62	4.6	.32	.09	43.2	25.37	.37	151.13	96	76.72	7.37	51.11
.64	4.2	.31	.08	43.2	25.37	.37	151.13	93	67.86	6.31	52.5

MEANS FOR THIS SET OF OBSERVATIONS:

.62	4.53	.3	.09	43.2	25.37	.37	151.13	96.17	70.43	6.77	53.38

NAME FOR SET IPE

.65	4.4	.32	.08	43.1	25.37	.37	151.13	92	73.73	6.78	55
.66	4.6	.31	.08	43.1	25.37	.37	151.13	90	74.67	6.72	57.5
.66	4.4	.3	.07	43.1	25.37	.37	151.13	90	69.12	6.22	62.86
.68	4.6	.29	.08	43.1	25.37	.37	151.13	88	69.85	6.15	57.5
.68	4.8	.28	.09	43.1	25.37	.37	151.13	88	70.38	6.19	53.33
.68	4.8	.28	.08	43.1	25.37	.37	151.13	88	70.38	6.19	60

MEANS FOR THIS SET OF OBSERVATIONS:

.67	4.6	.3	.08	43.1	25.37	.37	151.13	89.33	71.35	6.38	57.7

NAME FOR SET 10 MINUTE RECOVERY

.72	3.2	.31	.08	43.6	25.37	.37	151.13	83	50.76	4.21	40
.72	3.2	.31	.1	43.6	25.37	.37	151.13	83	50.76	4.21	32
.7	3.3	.3	.1	43.6	25.37	.37	151.13	85	50.66	4.31	33
.7	3.2	.31	.1	43.6	25.37	.37	151.13	85	50.76	4.31	32
.67	3.2	.29	.1	43.6	25.37	.37	151.13	89	47.49	4.23	32
.69	3.3	.29	.09	43.6	25.37	.37	151.13	86	48.97	4.21	36.67

MEANS FOR THIS SET OF OBSERVATIONS:

.7	3.23	.3	.1	43.6	25.37	.37	151.13	85.17	49.9	4.25	34.28

Subject #11

R EST SUPINE

.84	1.3	.32	.08	23.8	27	.41	171.88	71	92.02	6.53	16.25
.84	1.7	.32	.09	23.8	27	.41	171.88	71	120.34	8.54	18.89
.89	1.9	.33	.09	23.8	27	.41	171.88	67	138.7	9.29	21.11
.95	1.4	.33	.09	23.8	27	.41	171.88	63	102.2	6.44	15.56
.84	1.5	.34	.1	23.8	27	.41	171.88	71	112.82	8.01	15
.97	1.5	.33	.1	23.8	27	.41	171.88	61	109.5	6.68	15

MEANS FOR THIS SET OF OBSERVATIONS:

.89	1.55	.33	.09	23.8	27	.41	171.88	67.33	112.6	7.58	16.97

NAME FOR SET REST SEATED

.85	1.9	.3	.11	26.9	27	.41	171.88	70	98.7	6.91	17.27
.9	1.6	.3	.1	26.9	27	.41	171.88	66	83.12	5.49	16
.86	1.8	.28	.11	26.9	27	.41	171.88	69	87.27	6.02	16.36
.84	2	.28	.1	26.9	27	.41	171.88	71	96.97	6.89	20
.84	2.1	.28	.1	26.9	27	.41	171.88	71	101.82	7.23	21
.88	2.1	.29	.1	26.9	27	.41	171.88	68	105.46	7.17	21

MEANS FOR THIS SET OF OBSERVATIONS:

.86	1.92	.29	.1	26.9	27	.41	171.88	69.17	95.56	6.62	18.61

NAME FOR SET 15 MINUTE EXERCISE

.51	3.1	.27	.05	26.4	27	.41	171.88	117	150.48	17.61	62
.51	3.4	.25	.05	26.4	27	.41	171.88	117	152.82	17.88	68
.51	3.3	.26	.04	26.4	27	.41	171.88	117	154.26	18.05	82.5
.51	2.6	.26	.04	26.4	27	.41	171.88	117	121.54	14.22	65
.52	2.9	.27	.05	26.4	27	.41	171.88	115	140.77	16.19	58
.51	3.2	.25	.05	26.4	27	.41	171.88	117	143.83	16.83	64

MEANS FOR THIS SET OF OBSERVATIONS:

.51	3.08	.26	.05	26.4	27	.41	171.88	116.67	143.95	16.8	66.58

NAME FOR SET 20 MINUTE EXERCISE

.49	3	.25	.04	26.7	27	.41	171.88	122	131.83	16.08	75
.48	3.4	.23	.04	26.7	27	.41	171.88	124	137.45	17.04	85
.48	3.1	.25	.05	26.7	27	.41	171.88	124	136.22	16.89	62
.49	3.2	.26	.04	26.7	27	.41	171.88	122	146.24	17.84	80
.5	3.1	.24	.05	26.7	27	.41	171.88	120	130.77	15.69	62
.49	3	.24	.05	26.7	27	.41	171.88	122	126.55	15.44	60

MEANS FOR THIS SET OF OBSERVATIONS:

.49	3.13	.25	.05	26.7	27	.41	171.88	122.33	134.84	16.5	70.67

NAME FOR SET 25 MINUTE EXERCISE

.55	3.4	.27	.06	26	27	.41	171.88	109	170.16	18.55	56.67
.55	3.2	.27	.05	26	27	.41	171.88	109	160.15	17.46	64
.55	3.4	.26	.06	26	27	.41	171.88	109	163.86	17.86	56.67
.54	3.6	.25	.06	26	27	.41	171.88	111	166.82	18.52	60
.54	3.4	.25	.06	26	27	.41	171.88	111	157.56	17.49	56.67
.56	3.4	.25	.06	26	27	.41	171.88	107	157.56	16.86	56.67

MEANS FOR THIS SET OF OBSERVATIONS:

.55	3.4	.26	.06	26	27	.41	171.88	109.33	162.63	17.79	58.44

Subject #11 (cont'd)

NAME FOR SET 29 MINUTE EXERCISE

.54	3.4	.23	.05	27	27	.41	171.88	111	134.41	14.92	68
.54	3.9	.26	.06	27	27	.41	171.88	111	174.29	19.35	65
.54	3.8	.23	.06	27	27	.41	171.88	111	150.23	16.68	63.33
.56	3.4	.28	.05	27	27	.41	171.88	107	163.63	17.51	68
.54	3.6	.25	.05	27	27	.41	171.88	111	154.7	17.17	72
.55	3.4	.28	.05	27	27	.41	171.88	109	163.63	17.84	68

MEANS FOR THIS SET OF OBSERVATIONS:

.55	3.58	.26	.05	27	27	.41	171.88	110	156.82	17.24	67.39

]IPE

.54	3.5	.23	.06	27	27	.41	171.88	111	138.37	15.36	58.33
.55	3.8	.22	.06	27	27	.41	171.88	109	143.7	15.66	63.33
.56	3.2	.26	.05	27	27	.41	171.88	107	143.01	15.3	64
.59	3.4	.23	.05	27	27	.41	171.88	101	134.41	13.58	68
.58	3.5	.24	.06	27	27	.41	171.88	103	144.38	14.87	58.33
.6	3.5	.28	.05	27	27	.41	171.88	99	168.45	16.68	70

MEANS FOR THIS SET OF OBSERVATIONS:

.57	3.48	.24	.06	27	27	.41	171.88	105	145.39	15.24	63.67

]10 MINUTE RECOVERY

.74	2.1	.25	.1	27.5	27	.41	171.88	81	86.99	7.05	21
.8	1.4	.26	.1	27.5	27	.41	171.88	75	60.31	4.52	14
.77	1.9	.27	.1	27.5	27	.41	171.88	77	84.1	6.54	19
.78	1.8	.28	.11	27.5	27	.41	171.88	76	83.51	6.35	16.36
.8	1.8	.25	.1	27.5	27	.41	171.88	75	74.56	5.59	18

MEANS FOR THIS SET OF OBSERVATIONS:

.78	1.8	.26	.1	27.5	27	.41	171.88	76.8	78.07	6.01	17.67

Subject #12

REST SUPINE

.98	3.8	.33	.09	36.1	27	.43	182.03	61	127.69	7.79	42.22
.88	3.4	.34	.1	36.1	27	.43	182.03	68	117.71	8	34
.92	3	.33	.09	36.1	27	.43	182.03	65	100.81	6.55	33.33
1	3.2	.33	.1	36.1	27	.43	182.03	60	107.53	6.45	32
.97	3.8	.33	.09	36.1	27	.43	182.03	61	127.69	7.79	42.22
1.01	3	.34	.1	36.1	27	.43	182.03	59	103.86	6.13	30

MEANS FOR THIS SET OF OBSERVATIONS:

.96	3.37	.33	.1	36.1	27	.43	182.03	62.33	114.21	7.12	35.63

NAME FOR SET

.9	2.4	.29	.11	39.4	27	.43	182.03	66	59.5	3.93	21.82
.92	2	.29	.11	39.4	27	.43	182.03	65	49.58	3.22	18.18
.94	1.8	.29	.12	39.4	27	.43	182.03	63	44.62	2.81	15
.93	1.8	.3	.13	39.4	27	.43	182.03	64	46.16	2.95	13.85
.89	2.4	.28	.11	39.4	27	.43	182.03	67	57.44	3.85	21.82
.9	1.9	.28	.12	39.4	27	.43	182.03	66	45.48	3	15.83

MEANS FOR THIS SET OF OBSERVATIONS:

.91	2.05	.29	.12	39.4	27	.43	182.03	65.1700001	50.46	3.29	17.75

NAME FOR SET 10 MINUTE EXERCISE

.68	2.7	.26	.11	39.6	27	.43	182.03	88	59.4	5.23	24.55
.69	2.8	.23	.12	39.6	27	.43	182.03	86	54.5	4.69	23.33
.67	3.4	.25	.09	39.6	27	.43	182.03	89	71.93	6.4	37.78
.68	3.2	.29	.11	39.6	27	.43	182.03	88	78.53	6.91	29.09
.66	2.9	.27	.1	39.6	27	.43	182.03	90	66.26	5.96	29
.66	3.2	.27	.11	39.6	27	.43	182.03	90	73.11	6.58	29.09

MEANS FOR THIS SET OF OBSERVATIONS:

.67	3.03	.26	.11	39.6	27	.43	182.03	88.5	67.29	5.96	28.81

NAME FOR SET 15 MINUTE EXERCISE

.68	2.4	.26	.11	39.4	27	.43	182.03	88	53.34	4.69	21.82
.68	2.3	.26	.1	39.4	27	.43	182.03	88	51.12	4.5	23
.68	2.4	.25	.1	39.4	27	.43	182.03	88	51.29	4.51	24
.68	2.4	.26	.09	39.4	27	.43	182.03	88	53.34	4.69	26.67
.66	2.6	.24	.1	39.4	27	.43	182.03	90	53.34	4.8	26
.67	2.7	.25	.09	39.4	27	.43	182.03	89	57.7	5.14	30

MEANS FOR THIS SET OF OBSERVATIONS:

.68	2.47	.25	.1	39.4	27	.43	182.03	88.5	53.36	4.72	25.25

NAME FOR SET 20 MINUTE EXERCISE

.66	3.7	.26	.08	38.5	27	.43	182.03	90	86.12	7.75	46.25
.68	3.4	.26	.07	38.5	27	.43	182.03	88	79.14	6.96	48.57
.65	3.5	.26	.08	38.5	27	.43	182.03	92	81.47	7.5	43.75
.64	4.1	.27	.08	38.5	27	.43	182.03	93	99.11	9.22	51.25
.65	4.4	.24	.09	38.5	27	.43	182.03	92	94.54	8.7	48.89
.66	3.9	.26	.09	38.5	27	.43	182.03	90	90.78	8.17	43.33

MEANS FOR THIS SET OF OBSERVATIONS:

.66	3.83	.26	.08	38.5	27	.43	182.03	90.83	88.53	8.05	47.01

Subject #12 (cont'd)

25 MINUTE EXERCISE

.69	2.8	.26	.12	40.2	27	.43	182.03	86	59.78	5.14	23.33
.66	3.1	.24	.1	40.2	27	.43	182.03	90	61.09	5.5	31
.67	2.8	.27	.1	40.2	27	.43	182.03	89	62.08	5.52	28
.68	3.1	.26	.1	40.2	27	.43	182.03	88	66.18	5.82	31
.69	3.2	.26	.1	40.2	27	.43	182.03	86	68.32	5.88	32
.68	3	.25	.11	40.2	27	.43	182.03	88	61.59	5.42	27.27

MEANS FOR THIS SET OF OBSERVATIONS:

.68	3	.26	.11	40.2	27	.43	182.03	87.83	63.17	5.55	28.77

NAME FOR SET 29 MINUTE EXERCISE

.66	3.6	.25	.09	38.7	27	.43	182.03	90	79.74	7.18	40
.66	3.5	.25	.1	38.7	27	.43	182.03	90	77.53	6.98	35
.67	3.1	.26	.12	38.7	27	.43	182.03	89	71.41	6.36	25.83
.66	3.6	.26	.1	38.7	27	.43	182.03	90	82.93	7.46	36
.65	3.8	.26	.08	38.7	27	.43	182.03	92	87.54	8.05	47.5
.65	2.8	.25	.1	38.7	27	.43	182.03	92	62.02	5.71	28

(Con't [illegible])

MEANS FOR THIS SET OF OBSERVATIONS:

.66	3.4	.26	.1	38.7	27	.43	182.03	90.5	76.86	6.96	35.39

NAME FOR SET IPE

.66	2.6	.28	.1	38.9	27	.43	182.03	90	63.84	5.75	26
.69	2.7	.24	.09	38.9	27	.43	182.03	86	56.83	4.89	30
.7	2.2	.26	.1	38.9	27	.43	182.03	85	50.16	4.26	22
.71	2.2	.31	.1	38.9	27	.43	182.03	84	59.81	5.02	22
.71	2.4	.25	.12	38.9	27	.43	182.03	84	52.62	4.42	20
.71	2.5	.25	.1	38.9	27	.43	182.03	84	54.81	4.6	25

MEANS FOR THIS SET OF OBSERVATIONS:

.7	2.43	.27	.1	38.9	27	.43	182.03	85.5	56.34	4.82	24.17

NAME FOR SET 10 MINUTE RECOVERY

.79	2.4	.27	.11	40.1	27	.43	182.03	75	53.48	4.01	21.82
.88	2	.25	.13	40.1	27	.43	182.03	68	41.26	2.81	15.38
.84	2	.26	.12	40.1	27	.43	182.03	71	42.91	3.05	16.67
.82	2.6	.28	.12	40.1	27	.43	182.03	73	60.08	4.39	21.67
.82	2.1	.26	.13	40.1	27	.43	182.03	73	45.06	3.29	16.15
.83	2.2	.26	.14	40.1	27	.43	182.03	72	47.2	3.4	15.71

MEANS FOR THIS SET OF OBSERVATIONS:

.83	2.22	.26	.13	40.1	27	.43	182.03	72	48.33	3.49	17.9

Subject #13

R EST SUP[INE

.86	1.4	.36	.12	36.1	26.25	.4	167.16	69	44.55	3.07	11.67
.85	1.5	.29	.11	36.1	26.25	.4	167.16	70	38.45	2.69	13.64
.82	1.3	.32	.11	36.1	26.25	.4	167.16	73	36.77	2.68	11.82
.83	1.3	.31	.12	36.1	26.25	.4	167.16	72	35.62	2.56	10.83
.82	1.3	.32	.12	36.1	26.25	.4	167.16	73	36.77	2.68	10.83
.84	1.4	.37	.11	36.1	26.25	.4	167.16	71	45.78	3.25	12.73

MEANS FOR THIS SET OF OBSERVATIONS:

.84	1.37	.33	.12	36.1	26.25	.4	167.16	71.33	39.66	2.82	11.92

NAME FOR SET REST SEATED

.79	2.4	.28	.12	42.1	26.25	.4	167.16	75	43.67	3.28	20
.77	2.9	.28	.14	42.1	26.25	.4	167.16	77	52.77	4.06	20.71
.76	2.9	.26	.13	42.1	26.25	.4	167.16	78	49	3.82	22.31
.78	2.8	.27	.14	42.1	26.25	.4	167.16	76	49.13	3.73	20
.79	2.4	.29	.13	42.1	26.25	.4	167.16	75	45.23	3.39	18.46
.77	2.7	.26	.12	42.1	26.25	.4	167.16	77	45.62	3.51	22.5

MEANS FOR THIS SET OF OBSERVATIONS:

.78	2.68	.27	.13	42.1	26.25	.4	167.16	76.33	47.57	3.63	20.66

115 MINUTE EXERCISE

.54	4.6	.26	.08	41.9	26.25	.4	167.16	111	78.47	8.71	57.5
.53	4.4	.26	.08	41.9	26.25	.4	167.16	113	75.06	8.48	55
.54	4.3	.25	.09	41.9	26.25	.4	167.16	111	70.53	7.83	47.78
.54	4.2	.25	.08	41.9	26.25	.4	167.16	111	68.89	7.65	52.5
.54	4	.27	.08	41.9	26.25	.4	167.16	111	70.86	7.87	50
.54	4.4	.26	.09	41.9	26.25	.4	167.16	111	75.06	8.33	48.89

MEANS FOR THIS SET OF OBSERVATIONS:

.54	4.32	.26	.08	41.9	26.25	.4	167.16	111.33	73.14	8.14	51.94

NAME FOR SET 20 MINUTE EXERCISE

.52	4.6	.25	.08	41.3	26.25	.4	167.16	115	77.66	8.93	57.5
.51	4.3	.26	.08	41.3	26.25	.4	167.16	117	75.5	8.83	53.75
.49	4.8	.28	.07	41.3	26.25	.4	167.16	122	90.76	11.07	68.57
.48	4.4	.24	.06	41.3	26.25	.4	167.16	124	71.31	8.84	73.33
.49	4.6	.26	.07	41.3	26.25	.4	167.16	122	80.77	9.85	65.71
.48	4.4	.24	.08	41.3	26.25	.4	167.16	124	71.31	8.84	55

MEANS FOR THIS SET OF OBSERVATIONS:

.5	4.52	.26	.07	41.3	26.25	.4	167.16	120.67	77.88	9.4	62.31

NAME FOR SET 25 MINUTE EXERCISE

.5	4.1	.25	.07	40.9	26.25	.4	167.16	120	70.58	8.47	58.57
.5	4.2	.24	.08	40.9	26.25	.4	167.16	120	69.41	8.33	52.5
.5	4.7	.25	.08	40.9	26.25	.4	167.16	120	80.91	9.71	58.75
.5	4.3	.25	.07	40.9	26.25	.4	167.16	120	74.02	8.88	61.43
.5	4.4	.26	.08	40.9	26.25	.4	167.16	120	78.77	9.45	55
.49	4.3	.24	.08	40.9	26.25	.4	167.16	122	71.06	8.67	53.75

MEANS FOR THIS SET OF OBSERVATIONS:

.5	4.33	.25	.08	40.9	26.25	.4	167.16	120.33	74.12	8.92	56.67

Subject #13 (cont'd)

NAME FOR SET 29 MINUTE EXERCISE

.51	4.5	.24	.08	40.9	26.25	.4	167.16	117	74.37	8.7	56.25
.49	4.1	.25	.09	40.9	26.25	.4	167.16	122	70.58	8.61	45.56
.5	4.7	.26	.07	40.9	26.25	.4	167.16	120	84.14	10.1	67.14
.49	4.1	.24	.07	40.9	26.25	.4	167.16	122	67.76	8.27	58.57
.5	4.6	.23	.08	40.9	26.25	.4	167.16	120	72.85	8.74	57.5
.49	4.2	.26	.08	40.9	26.25	.4	167.16	122	75.19	9.17	52.5

MEANS FOR THIS SET OF OBSERVATIONS:

.5	4.37	.25	.08	40.9	26.25	.4	167.16	120.5	74.15	8.93	56.25

NAME FOR SET IPE

.49	4.6	.25	.07	41.6	26.25	.4	167.16	122	76.54	9.34	65.71
.52	4.5	.22	.07	41.6	26.25	.4	167.16	115	65.89	7.58	64.2900001
.52	4.5	.23	.08	41.6	26.25	.4	167.16	115	68.89	7.92	56.25
.52	4.6	.22	.08	41.6	26.25	.4	167.16	115	67.36	7.75	57.5
.53	4.6	.22	.09	41.6	26.25	.4	167.16	113	67.36	7.61	51.11
.54	4.6	.24	.07	41.6	26.25	.4	167.16	111	73.48	8.16	65.71

MEANS FOR THIS SET OF OBSERVATIONS:

.52	4.57	.23	.08	41.6	26.25	.4	167.16	115.17	69.92	8.06	60.1

NAME FOR SET 10 MINUTE RECOVERY

.64	2.8	.25	.11	42.8	26.25	.4	167.16	93	44.02	4.09	25.45
.64	2.7	.25	.12	42.8	26.25	.4	167.16	93	42.44	3.95	22.5
.64	2.9	.25	.12	42.8	26.25	.4	167.16	93	45.59	4.24	24.17
.68	2.6	.27	.12	42.8	26.25	.4	167.16	88	44.14	3.88	21.67
.68	2.7	.26	.11	42.8	26.25	.4	167.16	88	44.14	3.88	24.55
.68	2.8	.25	.11	42.8	26.25	.4	167.16	88	44.02	3.87	25.45

MEANS FOR THIS SET OF OBSERVATIONS:

.66	2.75	.26	.12	42.8	26.25	.4	167.16	90.5	44.06	3.99	23.96

Subject #14

REST SUPINE

1.22	2.9	.37	.12	33.1	26.62	.42	180.27	49	125.11	6.13	24.17
1.14	2.6	.36	.12	33.1	26.62	.42	180.27	52	109.13	5.67	21.67
1.19	2.8	.32	.12	33.1	26.62	.42	180.27	50	104.47	5.22	23.33
1.17	2.8	.34	.11	33.1	26.62	.42	180.27	51	110.1	5.66	25.45
1.19	3	.3	.12	33.1	26.62	.42	180.27	50	104.94	5.25	25
1.19	2.7	.36	.12	33.1	26.62	.42	180.27	50	113.33	5.67	22.5

MEANS FOR THIS SET OF OBSERVATIONS:

1.18	2.8	.34	.12	33.1	26.62	.42	180.27	50.33	111.33	5.6	23.69

NAME FOR SET REST SEATED

.98	1.8	.3	.13	36.4	26.62	.42	180.27	61	52.06	3.18	13.85
.97	2	.31	.13	36.4	26.62	.42	180.27	61	59.78	3.65	15.38
.99	2.2	.32	.13	36.4	26.62	.42	180.27	60	67.87	4.07	16.92
1.06	2	.31	.12	36.4	26.62	.42	180.27	56	59.78	3.35	16.67
1.06	1.8	.31	.13	36.4	26.62	.42	180.27	56	53.8	3.01	13.85
1.04	1.8	.29	.13	36.4	26.62	.42	180.27	57	50.33	2.87	13.85

MEANS FOR THIS SET OF OBSERVATIONS:

1.02	1.93	.31	.13	36.4	26.62	.42	180.27	58.5	57.27	3.35	15.09

NAME FOR SET 10 MINUTE EXERCISE

.68	5.4	.28	.07	38	26.62	.42	180.27	88	133.76	11.77	77.14
.68	5.5	.3	.07	38	26.62	.42	180.27	88	145.97	12.85	78.57
.7	4.9	.31	.07	38	26.62	.42	180.27	85	134.38	11.42	70
.69	5.6	.3	.08	38	26.62	.42	180.27	86	148.62	12.78	70
.66	4.8	.3	.08	38	26.62	.42	180.27	90	127.39	11.47	60
.69	5	.31	.08	38	26.62	.42	180.27	86	137.12	11.79	62.5

MEANS FOR THIS SET OF OBSERVATIONS:

.68	5.2	.3	.08	38	26.62	.42	180.27	87.17	137.87	12.01	69.7

NAME FOR SET 15 MINUTE EXERCISE

.8	4.5	.35	.08	37	26.62	.42	180.27	75	146.97	11.02	56.25
.77	4.8	.31	.1	37	26.62	.42	180.27	77	138.85	10.69	48
.79	4.3	.32	.09	37	26.62	.42	180.27	75	128.4	9.63	47.78
.76	4.5	.3	.08	37	26.62	.42	180.27	78	125.97	9.83	56.25
.76	4.9	.31	.09	37	26.62	.42	180.27	78	141.74	11.06	54.44
.76	4.8	.31	.09	37	26.62	.42	180.27	78	138.85	10.83	53.33

MEANS FOR THIS SET OF OBSERVATIONS:

.77	4.63	.32	.09	37	26.62	.42	180.27	76.83	136.8	10.51	52.68

NAME FOR SET 20 MINUTE EXERCISE

.69	4.4	.28	.08	37.6	26.62	.42	180.27	86	111.32	9.57	55
.71	4.1	.32	.08	37.6	26.62	.42	180.27	84	118.55	9.96	51.25
.7	4.3	.29	.09	37.6	26.62	.42	180.27	85	112.68	9.58	47.78
.73	4.2	.32	.07	37.6	26.62	.42	180.27	82	121.44	9.96	60
.73	4.4	.3	.08	37.6	26.62	.42	180.27	82	119.27	9.78	55
.71	4.8	.29	.08	37.6	26.62	.42	180.27	84	125.78	10.57	60

MEANS FOR THIS SET OF OBSERVATIONS:

.71	4.37	.3	.08	37.6	26.62	.42	180.27	83.83	118.17	9.9	54.84

Subject #14 (cont'd)

25 MINUTE EXERCISE

.76	4.2	.32	.08	37.4	26.62	.42	180.27	78	122.74	9.57	52.5
.76	4.2	.32	.1	37.4	26.62	.42	180.27	78	122.74	9.57	42
.68	4	.31	.08	37.4	26.62	.42	180.27	88	113.24	9.97	50
.71	4	.29	.09	37.4	26.62	.42	180.27	84	105.94	8.9	44.44
.71	4.7	.3	.1	37.4	26.62	.42	180.27	84	128.77	10.82	47
.7	4.8	.3	.08	37.4	26.62	.42	180.27	85	131.51	11.18	60

MEANS FOR THIS SET OF OBSERVATIONS:

.72	4.32	.31	.09	37.4	26.62	.42	180.27	82.83	120.82	10	49.32

NAME FOR SET 29 MINUTE EXERCISE

.7	4.1	.26	.06	37.3	26.62	.42	180.27	85	97.88	8.32	68.33
.74	4	.29	.07	37.3	26.62	.42	180.27	81	106.51	8.63	57.14
.76	3.5	.31	.1	37.3	26.62	.42	180.27	78	99.62	7.77	35
.77	4.1	.33	.09	37.3	26.62	.42	180.27	77	124.23	9.57	45.56
.75	3.9	.24	.09	37.3	26.62	.42	180.27	80	85.94	6.88	43.33
.72	3.8	.24	.12	37.3	26.62	.42	180.27	83	83.74	6.95	31.67

MEANS FOR THIS SET OF OBSERVATIONS:

.74	3.9	.28	.09	37.3	26.62	.42	180.27	80.67	99.65	8.02	46.84

NAME FOR SET IPE

.69	4	.29	.09	37.2	26.62	.42	180.27	86	107.08	9.21	44.44
.72	3.6	.31	.09	37.2	26.62	.42	180.27	83	103.02	8.55	40
.74	3.3	.32	.08	37.2	26.62	.42	180.27	81	97.48	7.9	41.25
.76	3.4	.3	.11	37.2	26.62	.42	180.27	78	94.16	7.34	30.91
.75	3.4	.29	.08	37.2	26.62	.42	180.27	80	91.02	7.28	42.5
.78	3.4	.31	.08	37.2	26.62	.42	180.27	76	97.3	7.39	42.5

MEANS FOR THIS SET OF OBSERVATIONS:

.74	3.52	.3	.09	37.2	26.62	.42	180.27	80.67	98.34	7.95	40.27

Subject #15

REST SUPINE

1.22	2.4	.44	.11	32.9	28	.4	169.76	49	129.84	6.36	21.82
1.21	2.2	.43	.11	32.9	28	.4	169.76	49	116.32	5.7	20
1.18	2.3	.4	.12	32.9	28	.4	169.76	50	113.12	5.66	19.17
1.19	2.3	.46	.12	32.9	28	.4	169.76	50	130.09	6.5	19.17
1.17	2.2	.42	.11	32.9	28	.4	169.76	51	113.61	5.79	20
1.21	2.2	.43	.11	32.9	28	.4	169.76	49	116.32	5.7	20

MEANS FOR THIS SET OF OBSERVATIONS:

1.2	2.27	.43	.11	32.9	28	.4	169.76	49.67	119.88	5.95	20.03

NAME FOR SET REST SEATED

1.04	2.4	.34	.12	36	28	.4	169.76	57	83.8	4.78	20
1.06	2.1	.34	.15	36	28	.4	169.76	56	73.32	4.11	14
1.1	2	.34	.15	36	28	.4	169.76	54	69.83	3.77	13.33
1.1	2.1	.34	.15	36	28	.4	169.76	54	73.32	3.96	14

MEANS FOR THIS SET OF OBSERVATIONS:

1.08	2.15	.34	.14	36	28	.4	169.76	55.25	75.07	4.15	15.33

NAME FOR SET 10 MINUTE EXERCISE

.85	2.9	.3	.11	36.8	28	.4	169.76	70	85.5	5.99	26.36
.84	2.9	.3	.11	36.8	28	.4	169.76	71	85.5	6.07	26.36
.86	2.8	.31	.1	36.8	28	.4	169.76	69	85.3	5.89	28
.85	2.5	.32	.11	36.8	28	.4	169.76	70	78.62	5.5	22.73
.87	2.6	.3	.11	36.8	28	.4	169.76	68	76.66	5.21	23.64
.85	2.5	.31	.11	36.8	28	.4	169.76	70	76.16	5.33	22.73

MEANS FOR THIS SET OF OBSERVATIONS:

.85	2.7	.31	.11	36.8	28	.4	169.76	69.67	81.29	5.66	24.97

NAME FOR SET 15 MINUTE EXERCISE

.87	3.4	.29	.1	36.9	28	.4	169.76	68	96.38	6.55	34
.92	3.2	.29	.11	36.9	28	.4	169.76	65	90.71	5.9	29.09
.87	3.4	.3	.11	36.9	28	.4	169.76	68	99.7	6.78	30.91
.89	3.2	.3	.11	36.9	28	.4	169.76	67	93.84	6.29	29.09
.87	3.4	.31	.11	36.9	28	.4	169.76	68	103.02	7.01	30.91
.89	3.6	.3	.1	36.9	28	.4	169.76	67	105.56	7.07	36

MEANS FOR THIS SET OF OBSERVATIONS:

.89	3.37	.3	.11	36.9	28	.4	169.76	67.17	98.2	6.6	31.67

20 MINUTE EXERCISE

.91	3.3	.32	.11	36.2	28	.4	169.76	65	107.25	6.97	30
.88	3.2	.36	.11	36.2	28	.4	169.76	68	116.1	7.96	29.09
.9	3.4	.31	.1	36.2	28	.4	169.76	66	107.05	7.07	34
.87	3.1	.3	.12	36.2	28	.4	169.76	68	94.45	6.42	25.83
.87	3.1	.33	.1	36.2	28	.4	169.76	68	103.9	7.07	31
.91	3.1	.33	.1	36.2	28	.4	169.76	65	103.9	6.75	31

MEANS FOR THIS SET OF OBSERVATIONS:

.89	3.2	.33	.11	36.2	28	.4	169.76	66.67	105.59	7.04	30.15

Subject #15 (cont'd)

NAME FOR SET 25 MINUTE EXERCISE

.88	3.1	.34	.1	36	28	.4	169.76	68	108.24	7.36	31
.91	3.6	.32	.1	36	28	.4	169.76	65	118.3	7.69	36
.92	3.1	.32	.1	36	28	.4	169.76	65	101.87	6.62	31
.9	3	.34	.11	36	28	.4	169.76	66	104.75	6.91	27.27
.91	3.3	.32	.11	36	28	.4	169.76	65	108.44	7.05	30
~~.89~~	~~3.1~~	~~.37~~	~~.1~~	~~36~~	~~28~~	~~.4~~	~~169.76~~	~~67~~	~~117.79~~	~~7.89~~	~~31~~

MEANS FOR THIS SET OF OBSERVATIONS:

.9	3.2	.34	.1	36	28	.4	169.76	66	109.9	7.25	31.05

NAME FOR SET 29 MINUTE EXERCISE

.89	2.7	.32	.08	37.2	28	.4	169.76	67	83.09	5.57	33.75
.9	2.8	.33	.11	37.2	28	.4	169.76	66	88.87	5.87	25.45
.91	3.2	.32	.11	37.2	28	.4	169.76	65	98.48	6.4	29.09
.9	2.8	.33	.12	37.2	28	.4	169.76	66	88.87	5.87	23.33
.89	3.4	.32	.11	37.2	28	.4	169.76	67	104.64	7.01	30.91
.9	3.1	.31	.11	37.2	28	.4	169.76	66	92.42	6.1	28.18

MEANS FOR THIS SET OF OBSERVATIONS:

.9	3	.32	.11	37.2	28	.4	169.76	66.17	92.73	6.13	28.45

NAME FOR SET IPE

.88	3.1	.33	.12	37	28	.4	169.76	68	99.45	6.76	25.83
.93	3.1	.31	.11	37	28	.4	169.76	64	93.43	5.98	28.18
.9	3.2	.37	.11	37	28	.4	169.76	66	115.11	7.6	29.09
.87	3	.32	.1	37	28	.4	169.76	68	93.33	6.35	30
.9	3.3	.34	.12	37	28	.4	169.76	66	109.08	7.2	27.5
.9	3.5	.32	.13	37	28	.4	169.76	66	108.88	7.19	26.92

MEANS FOR THIS SET OF OBSERVATIONS:

.9	3.2	.33	.12	37	28	.4	169.76	66.33	103.21	6.85	27.92

NAME FOR SET 10 MINUTE RECOVERY

.99	2.4	.32	.15	37	28	.4	169.76	60	74.66	4.48	16
.97	2.2	.31	.14	37	28	.4	169.76	61	66.3	4.04	15.71
1	2.6	.31	.15	37	28	.4	169.76	60	78.36	4.7	17.33
1.01	2.5	.3	.15	37	28	.4	169.76	59	72.91	4.3	16.67
1.01	2.4	.31	.15	37	28	.4	169.76	59	72.33	4.27	16
.99	2.2	.31	.15	37	28	.4	169.76	60	66.3	3.98	14.67

MEANS FOR THIS SET OF OBSERVATIONS:

.1	2.38	.31	.15	37	28	.4	169.76	59.83	71.81	4.3	16.06

Subject #16

REST SUPINE

1.1	2.4	.31	.12	31.6	27	.41	174.06	54	94.54	5.11	20
1.08	2.3	.33	.11	31.6	27	.41	174.06	55	96.45	5.3	20.91
1.05	2.6	.31	.12	31.6	27	.41	174.06	57	102.42	5.84	21.67
1.11	2.6	.33	.13	31.6	27	.41	174.06	54	109.03	5.89	20
1.1	2.4	.32	.11	31.6	27	.41	174.06	54	97.59	5.27	21.82
1.1	2.5	.32	.11	31.6	27	.41	174.06	54	101.66	5.49	22.73

MEANS FOR THIS SET OF OBSERVATIONS:
1.09 2.47 .32 .12 31.6 27 .41 174.06 54.67 100.28 5.48 21.19

REST SEATED

.93	1.4	.27	.13	35.9	27	.41	174.06	64	37.21	2.38	10.77
.92	1.5	.26	.14	35.9	27	.41	174.06	65	38.4	2.5	10.71
.98	1.4	.29	.14	35.9	27	.41	174.06	61	39.97	2.44	10
.96	1.4	.27	.13	35.9	27	.41	174.06	62	37.21	2.31	10.77
.87	1.7	.26	.15	35.9	27	.41	174.06	68	43.52	2.96	11.33
.93	1.4	.28	.14	35.9	27	.41	174.06	64	38.59	2.47	10

MEANS FOR THIS SET OF OBSERVATIONS:
.93 1.47 .27 .14 35.9 27 .41 174.06 64 39.15 2.51 10.6

NAME FOR SET 15 MINUTE EXERCISE

.52	2.7	.21	.07	35.4	27	.41	174.06	115	57.41	6.6	38.57
.5	3	.23	.08	35.4	27	.41	174.06	120	69.86	8.38	37.5
.51	2.4	.23	.07	35.4	27	.41	174.06	117	55.89	6.54	34.29
.51	2.7	.25	.08	35.4	27	.41	174.06	117	68.35	7.1	33.75
.51	2.6	.27	.06	35.4	27	.41	174.06	117	71.08	8.32	43.33
.5	2.7	.27	.07	35.4	27	.41	174.06	120	73.81	8.86	38.57

MEANS FOR THIS SET OF OBSERVATIONS:
.51 2.68 .24 .07 35.4 27 .41 174.06 117.67 66.07 7.78 37.67

NAME FOR SET 20 MINUTE EXERCISE

.47	4	.24	.09	36.2	27	.41	174.06	127	92.95	11.81	44.44
.46	3.9	.23	.06	36.2	27	.41	174.06	130	86.85	11.29	65
.48	3.5	.24	.07	36.2	27	.41	174.06	124	81.33	10.09	50
.47	3.9	.23	.07	36.2	27	.41	174.06	127	86.85	11.03	55.71
.47	3.6	.22	.07	36.2	27	.41	174.06	127	76.69	9.74	51.43
.46	4.1	.24	.08	36.2	27	.41	174.06	130	95.28	12.39	51.25

MEANS FOR THIS SET OF OBSERVATIONS:
.47 3.83 .23 .07 36.2 27 .41 174.06 127.5 86.66 11.06 52.97

NAME FOR SET 25 MINUTE EXERCISE

.47	4	.21	.07	36	27	.41	174.06	127	82.24	10.44	57.14
.48	3.6	.24	.07	36	27	.41	174.06	124	84.59	10.49	51.43
.47	3.8	.24	.07	36	27	.41	174.06	127	89.29	11.34	54.29
.46	4.2	.22	.08	36	27	.41	174.06	130	90.47	11.76	52.5
.47	3.8	.23	.07	36	27	.41	174.06	127	85.57	10.87	54.29
.46	4	.23	.07	36	27	.41	174.06	130	90.07	11.71	57.14

MEANS FOR THIS SET OF OBSERVATIONS:
.47 3.9 .23 .07 36 27 .41 174.06 127.5 87.04 11.1 54.46

Subject #16 (cont'd)

NAME FOR SET 29 MINUTE EXERCISE

.45	3.4	.21	.07	35.2	27	.41	174.06	133	73.12	9.72	48.57
.45	4	.21	.09	35.2	27	.41	174.06	133	86.02	11.44	44.44
.44	3.4	.22	.06	35.2	27	.41	174.06	136	76.6	10.42	56.67
.45	3.6	.23	.07	35.2	27	.41	174.06	133	84.79	11.28	51.43
.47	3.9	.23	.08	35.2	27	.41	174.06	127	91.86	11.67	48.75
.46	3.6	.22	.07	35.2	27	.41	174.06	130	81.11	10.54	51.43

MEANS FOR THIS SET OF OBSERVATIONS:

.45	3.65	.22	.07	35.2	27	.41	174.06	132	82.25	10.85	50.21

NAME FOR SET IPE

.46	3.8	.2	.08	36.2	27	.41	174.06	130	73.59	9.57	47.5
.45	4	.21	.07	36.2	27	.41	174.06	133	81.33	10.82	57.14
.44	3.8	.18	.06	36.2	27	.41	174.06	136	66.23	9.01	63.33
.45	3.9	.18	.07	36.2	27	.41	174.06	133	67.97	9.04	55.71
.44	4	.18	.07	36.2	27	.41	174.06	136	69.72	9.48	57.14
.46	4	.18	.07	36.2	27	.41	174.06	130	69.72	9.06	57.14

MEANS FOR THIS SET OF OBSERVATIONS:

.45	3.92	.19	.07	36.2	27	.41	174.06	133	71.43	9.5	56.33

NAME FOR SET 10 MINUTE RECOVERY

.61	2.2	.32	.06	36.4	27	.41	174.06	98	67.42	6.61	36.67
.62	2.3	.32	.07	36.4	27	.41	174.06	96	70.48	6.77	32.86
.64	2.3	.33	.06	36.4	27	.41	174.06	93	72.69	6.76	38.33
.64	2.2	.32	.07	36.4	27	.41	174.06	93	67.42	6.27	31.43
.64	2.1	.32	.06	36.4	27	.41	174.06	93	64.35	5.98	35
.64	2.1	.32	.06	36.4	27	.41	174.06	93	64.35	5.98	35

MEANS FOR THIS SET OF OBSERVATIONS:

.63	2.2	.32	.06	36.4	27	.41	174.06	94.33	67.79	6.4	34.88

Subject #17

R EST SUPINE

1.04	3	.32	.1	32.5	27.5	.43	186.25	57	128.02	7.3	30
1.01	2.8	.34	.11	32.5	27.5	.43	186.25	59	126.95	7.49	25.45
1.02	2.8	.34	.12	32.5	27.5	.43	186.25	58	126.95	7.36	23.33
1.04	2.7	.34	.11	32.5	27.5	.43	186.25	57	122.42	6.98	24.55
.97	2.8	.34	.11	32.5	27.5	.43	186.25	61	126.95	7.74	25.45
.9	2.8	.31	.1	32.5	27.5	.43	186.25	66	115.75	7.64	28

MEANS FOR THIS SET OF OBSERVATIONS:

.1	2.82	.33	.11	32.5	27.5	.43	186.25	59.67	124.51	7.42	26.13

NAME FOR SET REST SEATED

.84	2.8	.31	.11	35.1	27.5	.43	186.25	71	99.24	7.05	25.45
.89	2.8	.3	.11	35.1	27.5	.43	186.25	67	96.04	6.43	25.45
.84	2.8	.29	.12	35.1	27.5	.43	186.25	71	92.83	6.59	23.33
.84	2.8	.3	.1	35.1	27.5	.43	186.25	71	96.04	6.82	28
.85	2.8	.29	.1	35.1	27.5	.43	186.25	70	92.83	6.5	28
.83	2.8	.29	.11	35.1	27.5	.43	186.25	72	92.83	6.68	25.45

MEANS FOR THIS SET OF OBSERVATIONS:

.85	2.8	.3	.11	35.1	27.5	.43	186.25	70.33	94.97	6.68	25.95

NAME FOR SET 15 MINUTE EXERCISE

.51	5.7	.17	.06	36.1	27.5	.43	186.25	117	104.73	12.25	95
.53	5.8	.17	.06	36.1	27.5	.43	186.25	113	106.57	12.04	96.67
.54	5.6	.18	.06	36.1	27.5	.43	186.25	111	108.95	12.09	93.33
.54	5.1	.17	.06	36.1	27.5	.43	186.25	111	93.71	10.4	85
.53	5.4	.17	.06	36.1	27.5	.43	186.25	113	99.22	11.21	90
.54	5.7	.16	.06	36.1	27.5	.43	186.25	111	98.57	10.94	95

MEANS FOR THIS SET OF OBSERVATIONS:

.53	5.55	.17	.06	36.1	27.5	.43	186.25	112.67	101.96	11.49	92.5

NAME FOR SET 20 MINUTE EXERCISE

.61	4.7	.17	.07	35.9	27.5	.43	186.25	98	87.32	8.56	67.14
.6	4.4	.17	.07	35.9	27.5	.43	186.25	99	81.75	8.09	62.86
.59	4.5	.17	.07	35.9	27.5	.43	186.25	101	83.61	8.44	64.2900001
.59	4.2	.18	.07	35.9	27.5	.43	186.25	101	82.62	8.34	60
.58	4.2	.19	.07	35.9	27.5	.43	186.25	103	87.21	8.98	60
.57	4.3	.18	.06	35.9	27.5	.43	186.25	105	84.59	8.88	71.67

MEANS FOR THIS SET OF OBSERVATIONS:

.59	4.38	.18	.07	35.9	27.5	.43	186.25	101.17	84.52	8.55	64.33

NAME FOR SET 25 MINUTE EXERCISE

.62	5.4	.19	.07	35.9	27.5	.43	186.25	96	112.13	10.76	77.14
.62	5.2	.2	.08	35.9	27.5	.43	186.25	96	113.66	10.91	65
.62	5.3	.19	.07	35.9	27.5	.43	186.25	96	110.05	10.57	75.71
.6	5	.19	.07	35.9	27.5	.43	186.25	99	103.83	10.28	71.43
.58	5.6	.18	.07	35.9	27.5	.43	186.25	103	110.16	11.35	80
.58	4.5	.18	.07	35.9	27.5	.43	186.25	103	88.52	9.12	64.2900001

MEANS FOR THIS SET OF OBSERVATIONS:

.6	5.17	.19	.07	35.9	27.5	.43	186.25	98.83	106.39	10.5	72.26

Subject #17 (cont'd)

NAME FOR SET 29 MINUTE EXERCISE

.6	4.5	.27	.08	35.5	27.5	.43	186.25	99	135.8	13.44	56.25
.58	5.1	.25	.06	35.5	27.5	.43	186.25	103	142.5	14.68	85
.62	4.9	.22	.07	35.5	27.5	.43	186.25	96	120.48	11.57	70
.57	4.4	.27	.07	35.5	27.5	.43	186.25	105	132.78	13.94	62.86
.56	4.9	.25	.07	35.5	27.5	.43	186.25	107	136.91	14.65	70
.57	4.9	.27	.08	35.5	27.5	.43	186.25	105	147.87	15.53	61.25

MEANS FOR THIS SET OF OBSERVATIONS:

.58 4.78 .26 .07 35.5 27.5 .43 186.25 102.5 136.06 13.97 67.56

NAME FOR SET IPE

.65	4.2	.3	.08	35.9	27.5	.43	186.25	92	137.71	12.67	52.5
.64	4.8	.26	.08	35.9	27.5	.43	186.25	93	136.39	12.68	60
.67	4.2	.27	.07	35.9	27.5	.43	186.25	89	123.93	11.03	60
.66	4.7	.24	.07	35.9	27.5	.43	186.25	90	123.28	11.1	67.14
.65	4.5	.27	.07	35.9	27.5	.43	186.25	92	132.79	12.22	64.2900001
.67	4.3	.27	.07	35.9	27.5	.43	186.25	89	126.89	11.29	61.43

MEANS FOR THIS SET OF OBSERVATIONS:

.66 4.45 .27 .07 35.9 27.5 .43 186.25 90.83 130.16 11.83 60.89

NAME FOR SET 10 MINUTE RECOVERY

.77	3.5	.27	.1	36.5	27.5	.43	186.25	77	99.91	7.69	35
.79	3.4	.26	.1	36.5	27.5	.43	186.25	75	93.46	7.01	34
.83	3.5	.27	.11	36.5	27.5	.43	186.25	72	99.91	7.19	31.82
.82	3.4	.27	.1	36.5	27.5	.43	186.25	73	97.06	7.09	34
.84	3.5	.27	.1	36.5	27.5	.43	186.25	71	99.91	7.09	35
.85	3.5	.28	.1	36.5	27.5	.43	186.25	70	103.61	7.25	35

MEANS FOR THIS SET OF OBSERVATIONS:

.82 3.47 .27 .1 36.5 27.5 .43 186.25 73 98.98 7.22 34.14

Subject #18

```
NAME FOR SET REST SUPINE
.8  1.2  .32  .1  34.1  28.5  .4  168.19  75  45.11  3.38  12
.81  1.7  .33  .1  34.1  28.5  .4  168.19  74  65.91  4.88  17
.83  1.6  .34  .09  34.1  28.5  .4  168.19  72  63.91  4.6  17.78
.83  1.4  .33  .09  34.1  28.5  .4  168.19  72  54.28  3.91  15.56
.81  1.3  .34  .09  34.1  28.5  .4  168.19  74  51.93  3.84  14.44
.8  1.2  .32  .1  34.1  28.5  .4  168.19  75  45.11  3.38  12

MEANS FOR THIS SET OF OBSERVATIONS:
.81  1.4  .33  .1  34.1  28.5  .4  168.19  73.67  54.38  3.1  14.8

NAME FOR SET REST SEATED
.7  1.6  .34  .06  36.7  28.5  .4  168.19  85  55.18  4.69  26.67
.69  1.8  .33  .05  36.7  28.5  .4  168.19  86  60.25  5.18  36
.7  1.9  .34  .05  36.7  28.5  .4  168.19  85  65.52  5.57  38
.72  2  .34  .06  36.7  28.5  .4  168.19  83  68.97  5.72  33.33
.71  1.8  .33  .06  36.7  28.5  .4  168.19  84  60.25  5.06  30
.71  2.1  .33  .06  36.7  28.5  .4  168.19  84  70.29  5.9  35

MEANS FOR THIS SET OF OBSERVATIONS:
.71  1.87  .34  .06  36.7  28.5  .4  168.19  84.5  63.41  5.36  33.17

NAME FOR SET 15 MINUTE EXERCISE
.51  3.5  .24  .06  37  28.5  .4  168.19  117  83.82  9.81  58.33
.5  3.4  .23  .07  37  28.5  .4  168.19  120  78.04  9.36  48.57
.51  3.2  .25  .07  37  28.5  .4  168.19  117  79.83  9.34  45.71
.51  3  .24  .07  37  28.5  .4  168.19  117  71.85  8.41  42.86
.5  3.2  .24  .06  37  28.5  .4  168.19  120  76.64  9.2  53.33
.52  3.2  .23  .07  37  28.5  .4  168.19  115  73.45  8.45  45.71

MEANS FOR THIS SET OF OBSERVATIONS:
.51  3.25  .24  .07  37  28.5  .4  168.19  117.67  77.27  9.09  49.09

NAME FOR SET 20 MINUTE EXERCISE
.5  4  .23  .07  36.6  28.5  .4  168.19  120  93.83  11.26  57.14
.5  4  .24  .06  36.6  28.5  .4  168.19  120  97.9  11.75  66.67
.49  3.8  .24  .07  36.6  28.5  .4  168.19  122  93.01  11.35  54.29
.48  4.2  .23  .07  36.6  28.5  .4  168.19  124  98.52  12.22  60
.49  4.1  .23  .07  36.6  28.5  .4  168.19  122  96.17  11.73  58.57
.49  4  .23  .07  36.6  28.5  .4  168.19  122  93.83  11.45  57.14

MEANS FOR THIS SET OF OBSERVATIONS:
.49  4.02  .23  .07  36.6  28.5  .4  168.19  121.67  95.54  11.63  58.97

NAME FOR SET 25 MINUTE EXERCISE
.5  3.8  .22  .07  36.7  28.5  .4  168.19  120  84.79  10.18  54.29
.5  3.6  .24  .07  36.7  28.5  .4  168.19  120  87.63  10.52  51.43
.5  3.8  .24  .07  36.7  28.5  .4  168.19  120  92.5  11.1  54.29
.5  3.6  .24  .06  36.7  28.5  .4  168.19  120  87.63  10.52  60
.51  3.6  .22  .07  36.7  28.5  .4  168.19  117  80.33  9.4  51.43
.51  3.6  .24  .07  36.7  28.5  .4  168.19  117  87.63  10.25  51.43

MEANS FOR THIS SET OF OBSERVATIONS:
.5  3.67  .23  .07  36.7  28.5  .4  168.19  119  86.76  10.33  53.81
```

Subject #18 (cont'd)

NAME FOR SET 29 MINUTE EXERCISE

.5	3.4	.24	.08	36.1	28.5	.4	168.19	120	85.54	10.26	42.5
.5	3.2	.24	.07	36.1	28.5	.4	168.19	120	80.51	9.66	45.71
.5	3	.26	.06	36.1	28.5	.4	168.19	120	81.77	9.81	50
.5	3.4	.24	.07	36.1	28.5	.4	168.19	120	85.54	10.26	48.57
.5	3.2	.23	.06	36.1	28.5	.4	168.19	120	77.15	9.26	53.33
.5	3.6	.26	.07	36.1	28.5	.4	168.19	120	98.12	11.77	51.43

MEANS FOR THIS SET OF OBSERVATIONS:

.5	3.3	.25	.07	36.1	28.5	.4	168.19	120	84.77	10.17	48.59

NAME FOR SET IPE

.49	3.8	.24	.07	36.3	28.5	.4	168.19	122	94.55	11.54	54.29
.5	3.6	.24	.07	36.3	28.5	.4	168.19	120	89.58	10.75	51.43
.52	4	.23	.08	36.3	28.5	.4	168.19	115	95.38	10.97	50
.53	3.8	.23	.07	36.3	28.5	.4	168.19	113	90.61	10.24	54.29
.52	3.7	.21	.06	36.3	28.5	.4	168.19	115	80.56	9.26	61.67
.53	3.2	.23	.06	36.3	28.5	.4	168.19	113	76.31	8.62	53.33

MEANS FOR THIS SET OF OBSERVATIONS:

.52	3.68	.23	.07	36.3	28.5	.4	168.19	116.33	87.83	10.23	54.17

NAME FOR SET 10 MINUTE RECOVERY

.59	1.6	.33	.05	36.5	28.5	.4	168.19	101	54.14	5.47	32
.57	1.7	.33	.08	36.5	28.5	.4	168.19	105	57.53	6.04	21.25
.62	1.6	.34	.06	36.5	28.5	.4	168.19	96	55.78	5.36	26.67
.62	1.8	.32	.05	36.5	28.5	.4	168.19	96	59.07	5.67	36
.66	1.7	.32	.05	36.5	28.5	.4	168.19	90	55.78	5.02	34
.67	1.9	.32	.05	36.5	28.5	.4	168.19	89	62.35	5.55	38

MEANS FOR THIS SET OF OBSERVATIONS:

.62	1.72	.33	.06	36.5	28.5	.4	168.19	96.17	57.44	5.52	31.32

Subject #19

R EST SUPINE
.92 2.3 .36 .1 36.8 27.12 .41 174.06 65 78.27 5.09 23
.97 2.2 .3 .01 36.8 27.12 .41 174.06 61 62.39 3.81 220
1.02 2 .36 .1 36.8 27.12 .41 174.06 58 68.06 3.95 20
1 2.1 .34 .11 36.8 27.12 .41 174.06 60 67.49 4.05 19.09
.94 2.1 .34 .1 36.8 27.12 .41 174.06 63 67.49 4.25 21
.96 2.2 .34 .1 36.8 27.12 .41 174.06 62 70.71 4.38 22

MEANS FOR THIS SET OF OBSERVATIONS:
.97 2.15 .34 .09 36.8 27.12 .41 174.06 61.5 69.07 4.25 54.18

R EST SEATED
.81 3.8 .26 .12 41.4 27.12 .41 174.06 74 73.79 5.46 31.67
.76 3.6 .26 .13 41.4 27.12 .41 174.06 78 69.91 5.45 27.69
.78 4 .27 .12 41.4 27.12 .41 174.06 76 80.67 6.13 33.33
.8 3.8 .26 .13 41.4 27.12 .41 174.06 75 73.79 5.53 29.23
.76 4.1 .24 .13 41.4 27.12 .41 174.06 78 73.5 5.73 31.54
.78 3.9 .28 .12 41.4 27.12 .41 174.06 76 81.56 6.2 32.5

MEANS FOR THIS SET OF OBSERVATIONS:
.78 3.87 .26 .13 41.4 27.12 .41 174.06 76.17 75.54 5.75 30.99

NAME FOR SET 15 MINUTE EXERCISE
.5 4.4 .3 .06 40.7 27.12 .41 174.06 120 102.01 12.24 73.33
.52 4.3 .26 .06 40.7 27.12 .41 174.06 115 86.4 9.94 71.67
.49 4.6 .26 .06 40.7 27.12 .41 174.06 122 92.43 11.28 76.67
.49 4.2 .24 .07 40.7 27.12 .41 174.06 122 77.9 9.5 60
.48 4.6 .27 .06 40.7 27.12 .41 174.06 124 95.98 11.9 76.67
.51 4.2 .26 .05 40.7 27.12 .41 174.06 117 84.39 9.87 84

MEANS FOR THIS SET OF OBSERVATIONS:
.5 4.38 .27 .06 40.7 27.12 .41 174.06 120 89.85 10.79 73.72

NAME FOR SET 20 MINUTE EXERCISE
.49 4 .21 .06 40.4 27.12 .41 174.06 122 65.88 8.04 66.67
.48 4.3 .2 .06 40.4 27.12 .41 174.06 124 67.45 8.36 71.67
.48 4.3 .24 .06 40.4 27.12 .41 174.06 124 80.94 10.04 71.67
.48 4.6 .21 .06 40.4 27.12 .41 174.06 124 75.77 9.4 76.67
.48 4 .25 .06 40.4 27.12 .41 174.06 124 78.43 9.73 66.67
.48 4.3 .21 .06 40.4 27.12 .41 174.06 124 70.83 8.78 71.67

MEANS FOR THIS SET OF OBSERVATIONS:
.48 4.25 .22 .06 40.4 27.12 .41 174.06 123.67 73.22 9.06 70.83

NAME FOR SET 25 MINUTE EXERCISSE
.44 4.2 .21 .06 40.8 27.12 .41 174.06 136 67.83 9.22 70
.44 4.4 .2 .05 40.8 27.12 .41 174.06 136 67.68 9.2 88
.45 4.2 .25 .06 40.8 27.12 .41 174.06 133 80.75 10.74 70
.44 4.6 .2 .05 40.8 27.12 .41 174.06 136 70.75 9.62 92
.44 4.8 .2 .05 40.8 27.12 .41 174.06 136 73.83 10.04 96
.44 4.4 .2 .05 40.8 27.12 .41 174.06 136 67.68 9.2 88

MEANS FOR THIS SET OF OBSERVATIONS:
.44 4.43 .21 .05 40.8 27.12 .41 174.06 135.5 71.42 9.67 84

Subject #19 (cont'd)

NAME FOR SET 29 MINUTE EXERCISE

.43	5	.14	.06	40.7	27.12	.41	174.06	139	54.1	7.52	83.33
.44	5.2	.14	.06	40.7	27.12	.41	174.06	136	56.26	7.65	86.67
.44	4.7	.18	.06	40.7	27.12	.41	174.06	136	65.38	8.89	78.33
.44	5	.19	.06	40.7	27.12	.41	174.06	136	73.42	9.98	83.33
.46	5.1	.19	.06	40.7	27.12	.41	174.06	130	74.89	9.74	85
.44	4.8	.17	.06	40.7	27.12	.41	174.06	136	63.06	8.58	80

MEANS FOR THIS SET OF OBSERVATIONS:

.44	4.97	.17	.06	40.7	27.12	.41	174.06	135.5	64.52	8.73	82.78

NAME FOR SET IPE

.44	4	.19	.06	40.8	27.12	.41	174.06	136	58.45	7.95	66.67
.45	4.1	.18	.06	40.8	27.12	.41	174.06	133	56.75	7.55	68.33
.45	4.2	.16	.06	40.8	27.12	.41	174.06	133	51.68	6.87	70
.45	4.5	.15	.05	40.8	27.12	.41	174.06	133	51.91	6.9	90
.46	4.1	.17	.05	40.8	27.12	.41	174.06	130	53.6	6.97	82
.47	4.1	.16	.06	40.8	27.12	.41	174.06	127	50.45	6.41	68.33

MEANS FOR THIS SET OF OBSERVATIONS:

.45	4.17	.17	.06	40.8	27.12	.41	174.06	132	53.81	7.11	74.22

NAME FOR SET 10 MINUTE RECOVERY

.72	2.7	.27	.12	39.6	27.12	.41	174.06	83	59.51	4.94	22.5
.7	2.6	.25	.11	39.6	27.12	.41	174.06	85	53.06	4.51	23.64
.72	2.6	.25	.12	39.6	27.12	.41	174.06	83	53.06	4.4	21.67
.72	2.6	.26	.11	39.6	27.12	.41	174.06	83	55.19	4.58	23.64
.69	2.8	.3	.11	39.6	27.12	.41	174.06	86	68.57	5.9	25.45
.71	3	.29	.1	39.6	27.12	.41	174.06	84	71.02	5.97	30

MEANS FOR THIS SET OF OBSERVATIONS:

.71	2.72	.27	.11	39.6	27.12	.41	174.06	84	60.07	5.05	24.48