THE EFFECTS OF ACUTE AEROBIC EXERCISE ON CARDIOVASCULAR REACTIVITY TO STRESS IN HEALTHY, TRAINED AND UNTRAINED MALES

by

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(ABSTRACT)

This study investigated the differences in the cardiovascular reactivity (CVR: HR, SBP, DBP) of trained and untrained individuals who performed the cold pressor test (CPT) after exercising for 30 minutes at 70% VO_2 max and participating in an attention control. Eighteen untrained and eleven trained males were randomly assigned to a treatment sequence. The subjects performed either 30 minutes of cycling at 70% VO_2 max or an attention control. Following 48 hours, the other activity was performed. The CPT followed 1 hour after each treatment session. Rest, peak, and recovery measurements were acquired. Examination of trained and untrained group means, regardless of condition, indicated that trained subjects had lower HR measurements at rest ($F_{1,25}$ = 6.86, $p \leq .05$) and peak ($F_{1,25}$ = 6.33, $p \leq .05$). Closer examination of the different effects due to the acute exercise and control conditions regardless of training state did not reveal any beneficial effects due to the exercise bout. In addition, this study did not support differences in CVR to the CPT due to an interaction of acute exercise with the trained and untrained states of individuals. Resting measures did reveal reduced DBP ($F_{1,25}$ = 4.06, $p \leq .05$) and HR ($F_{1,25}$ = 3.19, p = .09) in trained subjects compared with the untrained following the exercise session indicating a beneficial reduction in the anticipatory response to the stressor. This study did not statistically support the effectiveness of 30 minutes of exercise at 70% VO_2 max or advantages of a physically trained state in reducing CVR to the CPT. In addition, this study did not support the effectiveness of the

interaction of exercise at 70% VO_2 max with the trained or untrained state in reducing CVR to the CPT.

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CHAPTER I

INTRODUCTION

INTRODUCTION

Several possible psychological and behavioral, as well as physiological risk factors have been implicated in the occurrence of cardiovascular disease (CVD). Research supports that CVD may be potentiated behaviorally by characteristics such as Type A behavior pattern, physical inactivity and accentuated cardiovascular reactivity (CVR) (Jenkins, 1988). The responsible mechanisms are not yet clearly defined.

Excessive CVR to environmental stressors is the augmented activity of the autonomic nervous system which increases the responsiveness of the neuroendocrine and cardiovascular pathways. When Keys et al. (1971) examined possible risk factors for CVD, they determined that CVR to the cold pressor test (CPT) was a more significant predictor of CVD compared to other established risk factors that were examined. An excessive pressor response to environmental stressors may induce trauma to the vasculature because of the increase in heart rate (HR) and blood pressure (BP). In addition, the total peripheral resistance (TPR) is increased causing damage to the vessels (Blumenthal & McCubbin, 1987).

Because acute stress reactivity may play a role in CVD, attempts have been made to identify an intervention that would decrease the hyperresponsiveness of these pathways. Physical exercise appears to enhance cardiovascular health by attenuating the individual's stress response (Blumenthal & McCubbin, 1987). Exercise may reduce the stress response by conditioning behavioral patterns. Enhanced coping mechanisms and altered thought processes have been observed (Blumenthal & McCubbin, 1987; Keller & Seraganian, 1984).

Physiological changes due to exercise appear to also be beneficial for cardiovascular health. Regular aerobic exercise generally decreases resting and exercising HR, BP, and therefore TPR (Blumenthal & McCubbin, 1987). These alterations in physiological responses tend to reduce CVR. In addition, physical activity may provoke reductions in autonomic and neuroendocrine activity in response to a stressful stimuli (Krantz, Contrada, Hill, & Friedler, 1988). Psychophysiological studies have supported the reduction in HR and BP responses to a stressor and in recovery time from the stressor.

These changes due to exercise have initiated a new interest in the specificity of the activity required to elicit changes in CVR and prevent CVD. Research regarding the effects of acute aerobic exercise on CVR to a stressful stimuli is not very extensive and requires further attention. Additional examination of the effects of aerobic training and acute exercise would improve the understanding of the stress-reducing effects of exercise.

Statement of the Problem

Augmented reactivity of the autonomic nervous system has been presented as a primary contributing factor for CVD. Treatments are often administered to reduce the effects of the nervous system on the cardiovasculature. Pharmacological agents may interfere with efferent activity at the effector organ, the receptor, or the postganglionic nerve ending. Behavioral modulators have included biofeedback and relaxation procedures (Surwit, 1986).

Research has become interested in aerobic fitness as a possible treatment of extreme CVR. Many studies have examined the effects of the trained state and found beneficial results such as reduced resting and exercise HR, BP, and TPR which tends to reduce CVR (Blumenthal & McCubbin, 1987). In addition, the trained state may cause reductions in autonomic and neuroendocrine activity in response to stress (Krantz et al., 1988). Other studies examining this issue have shown inconclusive results; therefore, this study further examined the differences between the trained and untrained states.

Studies regarding the beneficial effects of aerobic fitness have become quite extensive; however, the literature in this area lacks information regarding the effectiveness of acute aerobic exercise to reduce stressor responses in trained and untrained individuals. Hemesath (1990) was able to demonstrate a tendency towards reduced DBP in response to the CPT ($p = .08$) 1 hour post-exercise. The subjects were untrained and performed 30 minutes of cycling at 55-60% VO_2 max. A second tendency seen was reduced SBP in response to the stressor 3 hours after the activity ($p = .08$). These results were not statistically significant. Another study which examined untrained subjects found that 1 and 2 hour bouts of cycling at 55% of VO_2 max may reduce the DBP response to the CPT (Ebbesen, Prkachin, Mills, & Green, 1989). This effect lasted up to 3 hours. Another significant study in this area involved 12 trained cyclists participating in an attention control, light exercise (50% aerobic capacity for 30 minutes), and heavy exercise (80% of aerobic capacity for 60 minutes) (Rejeski, Gregg, Thompson, & Berry, 1990). A Stroop color word test (SCWT) followed 30 minutes after each session. Heavy exercise produced lower responses in mean arterial pressure, SBP, and DBP.

Although significant reductions in CVR have been observed after 60 minutes of aerobic activity in trained and untrained subjects, the average person may find it difficult to perform for this duration. Closer examination of the ACSM recommended duration of 15-60 minutes would be beneficial; therefore, this study examined a duration of 30 minutes. Because of the lack of positive results at 55-60% of maximal aerobic capacity, a higher intensity may be required to elicit a reduction in CVR. Rejeski et al. (1990) supported this dose-response relationship in his recent research with trained subjects with the most beneficial effects at 80%. This intensity may also be too extreme for untrained individuals; therefore, this study examined the effects of 70% of VO_2 max on CVR.

To summarize, the purpose of this study was to assess the effects of acute aerobic exercise compared with no exercise on CVR among healthy, trained and untrained male subjects and the interaction of acute exercise with the two types of subjects. More specifically, this study will examine more closely the effects of acute activity (cycling at 70%

VO_2 max for 30 minutes) on HR, SBP and DBP measures in trained and untrained individuals during the CPT, a psychological stressor known to be predictive of CVD.

Research Hypotheses

Ho1: There is no difference in the CVR (HR, SBP, DBP) between trained and untrained individuals who perform the CPT 1 hour after aerobically exercising for 30 minutes at 70% VO_2 max and participating in an attention control.

Ho2: There is no difference in CVR (HR, SBP, DBP) to the CPT 1 hour after aerobically exercising for 30 minutes at 70% VO_2 max versus participation in an attention control condition in the combined trained and untrained subject sample.

Ho3: There is no difference in CVR (HR, SBP, DBP) to the CPT as a function of an interaction between subject fitness/training status and exercise versus control condition.

Definitions and Symbols

1. Cardiovascular Reactivity (CVR) - the degree of change in any function related to the cardiovascular system (HR, BP) that is created by the presence of a stressor. This reactivity is functionally established by measuring the cardiovascular parameters at baseline, arousal, and after the removal of the challenge.
2. Cold Pressor Test (CPT) - a task involving the immersion of the subject's hand in ice water for 1 minute to elicit a vasoconstrictive response. Water temperature is maintained at 0-3°C.

Significance of the Study

The development of CVD may be initiated by the acute reactivity of the autonomic nervous system. It appears that a majority of the CVD psychosocial risk factors operate through the central nervous system to create changes in autonomic nervous functioning and endocrine activity to impact the cardiovascular system (Jenkins, 1976). Behavioral and pharmacological treatments of CVD both often work by reducing the effects of the autonomic system on the end organs of the cardiovascular system . Thus, a decrease in CVR is observed (Surwit, 1986).

Exercise appears to be a modulator of CVR. The mechanism by which exercise may be a method of reducing stress reactivity has been given little attention. A physiological model has suggested that exercise has anti-anxiety and anti-depressant effects which may result in improvements in physiological and biochemical stress responses. Stressors increase responses such as muscle tension, heart rate, neural conductance, blood pressure, and secretion of catecholamines and glucocorticoids. It has been hypothesized that exercise decreases the magnitude and recovery time of these responses; in turn, such negative emotions as depression anger and anxiety are reduced (Blumenthal & McCubbin, 1987; King, Taylor, Haskell, & DeBusk, 1989). These cardiovascular adaptations and reduced stress responses similarly suggest altered sensitivity of alpha or beta receptors or neuroendocrine release (Dimsdale, Alpert, & Schneiderman, 1986).

The studies in this area concentrate on the relationship between CVR and fitness level as opposed to an exercise bout. Many limitations are noticeable in the research designs of these studies. They tend to be nonrandom and correlational, with subjects being selected based on current fitness or other characteristics (e.g., Type A behavior pattern) (King et al., 1989). Response measurements and physical fitness have also been poorly defined. (Blumenthal et al., 1988; Roth, 1989). Such problems in methodology inhibit a clearer understanding about the effects of exercise on CVR. Further investigation of acute aerobic exercise with improved methodologic controls is needed to support and better define previous findings in training studies.

A few CVR studies have examined acute exercise, as opposed to chronic, and supported that a bout of exercise prior to a physical, cognitive, and social stressor reduces autonomic activity (Ebbesen et al., 1989; Rejeski, 1990). Additional research would improve the understanding of the duration and intensity required to produce beneficial stress reducing effects. Further study of the effects of acute physical activity in individuals may help to explain the necessity of exercise for stress management in the trained or sedentary individual. Positive results may be further applied to the prevention and rehabilitation of CVD.

Delimitations

The following delimitations were imposed in this study:

1. Untrained subjects were 18 healthy males, aged 18-23, volunteering through the current Introductory Psychology Experimental Pool at VPI & SU.
2. Trained subjects were 11 healthy males, aged 21-25, recruited from the Va Tech Bicycling Team and the Blacksburg Bicycling Club.
3. The selection of subjects was dependent upon screening criteria (medical background and weekly activity level).
4. The aerobic exercise session was predetermined at 70% VO_2 max based on the initial VO_2 max bicycle test that each subject performed.
5. During the CPT, CVR was assessed by the change scores from rest to peak in HR, SBP, and DBP.

Limitations

The following limitations were imposed in this study:

1. The application of these results is limited to trained males aged 21-25 and untrained males aged 18-23.
2. The application of these results is limited to the CPT used in this study.
3. The application of these results is limited to the exercise intensity of 70% VO_2 max on a bicycle.

Basic Assumptions

For the purpose of this study it was assumed that:

1. During the determination of VO_2 max, the subjects performed with maximal effort.
2. The subjects complied with the written and verbal instructions explained to them at the orientation of the experiment.
3. During the CPT, CVR was predicted based on relatively stable HR and BP measures.

Summary

CVD may be potentiated by a variety of behavioral, psychological, and physiological risk factors; however, treatment of CVD often involves the reduction of neuroendocrine and autonomic activity. Thus, CVR appears to play a significant role in CVD. An increased interest in the identification of methods to reduce accentuated CVR has been observed. (Jenkins, 1976; Surwit, 1986).

Research has become interested in aerobic fitness as a possible treatment of extreme CVR. Many studies have examined the effects of the trained state and found beneficial results such as reduced resting and exercise HR, BP, and TPR which tends to reduce CVR (Blumenthal & McCubbin, 1987). In addition, the trained state may cause reductions in autonomic and neuroendocrine activity in response to stress (Krantz et al., 1988). More specifically, the cardiovascular and stress response adaptations suggest changes in the sensitivity of alpha or beta receptors or neuroendocrine release (Dimsdale et al., 1986). Many Investigations do support that trained subjects were less reactive and recover more rapidly than untrained subjects in response to cognitive and psychosocial stressors (Hollander & Seraganian, 1984; Keller & Seraganian, 1984; Plante & Karpowitz, 1987). Although many of the studies in this area appear to support what they had intended to observe, a substantial amount of research design limitations have reduced the efficacy of their results (Blumenthal et al., 1988; King et al., 1989; Roth, 1989). Other studies examining this issue have shown inconclusive results; therefore, this study further examined the differences between the trained and untrained states.

The past studies lack the closer examination of the effects which follow an acute bout of exercise in individuals. A few investigations have examined the protective time frame which follows immediately after an exercise session. Exercise prior to a stressor may lead to reduced autonomic reactivity (Ebbesen et al., 1989). The effects of acute aerobic exercise on the individual requires further study to explain the importance of exercise for stress management in the normal population. The amount of exercise required to be adequate in stress reduction remains unclear; thus, the examination of different work intensities and CVR may be beneficial.

Although significant reductions in CVR have been observed after 60 minutes of aerobic activity in trained and untrained subjects, the average person may find it difficult to perform for this duration; therefore, this study examined a more reasonable (ACSM recommended) duration of 30 minutes. Because of the lack of positive results at 55-60% of maximal aerobic capacity, a higher intensity may be required to elicit a reduction in CVR. Rejeski et al. (1990) supported this dose-response relationship with trained subjects with the most beneficial results at 80%. This intensity may also be too extreme for untrained individuals therefore, this study examined the effects of 70% VO_2 max on CVR.

In summary, this study examined the effects of acute exercise on CVR during the administration of the CPT in trained and untrained males. The effects of an exercise intensity of 70% VO_2 max for 30 minutes were compared with the control reactivity session (no exercise) in both groups of subjects. In addition, the interactions of the acute exercise bout and the attention control with the trained and untrained individuals to reduce CVR were examined. This study is significant to the better understanding of the appropriate exercise intensity, duration, and training state required to reduce CVR and the risk of CVD.

CHAPTER II

REVIEW OF THE LITERATURE

REVIEW OF THE LITERATURE

Introduction

Research has examined the risk reduction of CVD by regular aerobic exercise either for work or recreation. Improved aerobic fitness has been associated with changes in serum components such as a reduction in low density lipoproteins (LDL) and an increase in high density lipoproteins (HDL). Regular aerobic activity has also been responsible for lower arterial BP and HR (Jennings et al., 1986). Psychological studies have supported that regular aerobic exercise may cause a significant reduction in anxiety and tension (Blumenthal, Williams, Wallace & Needels, 1982). Exercise appears to be beneficial beyond these changes; therefore, interest has been directed toward the potential role aerobic exercise might play in the attenuation of the negative effects of psychological stress on the cardiovascular system.

Psychological stress increases the effects of the sympathetic nervous system. Sympathetic activity will alter the rhythm of the heart, vascular constriction, and lipid mobilization. Regular aerobic exercise may prevent the influence of stress on the sympathetic system and promote cardiovascular health. Due to these positive changes, research has investigated the beneficial effects of reducing stress reactivity. A majority of the work previously done refers to the trained state.

Cardiovascular Reactivity and Cardiovascular Disease

When faced with a challenge, an individual may react through a variety of psychophysiologic defenses and reactions. Enhanced CVR in some individuals may be associated with an elevated risk of CVD. Examination of this risk factor primarily involves observing changes in the autonomic nervous system, for example, elevations in HR, BP, and cardiac output (Surwit, 1986).

Animal models have been used in the investigation of the relationship between CVR and CVD. One study which proved very beneficial examined monkeys fed atherosclerotic diets. The monkeys were exposed to a stimulus which threatened them and produced extreme HR increases. The animals were labelled as high or low reactors based on their HR increase. The presence of CVD was doubled in the high reactors compared to the low reactors (Manuck, Kaplan, & Clarkson, 1983). Manuck, Kaplan, Adams, and Clarkson (1989) further supported the relationship between CVR to stress and CVD in a study of female monkeys. The monkeys were fed an atherogenic diet for 30 months. At the end of the period, their HRs were recorded under stressed and baseline conditions. High HR reactive animals were found to have significantly greater coronary artery atherosclerosis.

Another significant study which investigated the influence of CVR on the promotion of CVD determined the effects of a stressor, the CPT, on individuals responsivity. In this study, hyperreactive subjects were defined as having a rise in diastolic blood pressure (DBP) greater than 20 mm during the CPT (Keys et al., 1971). The relative risk ratio for CVD or myocardial infarcts in the hyperreactive men was 2.4 times greater than their less reactive counterparts. Not only did Keys support CVR as a risk factor for CVD, but he also reinforced the CPT as an informative test in the determination of CVR.

Menkes et al. (1989) examined CVR as a predictor of hypertension, a risk factor of CVD. The researchers studied 910 white male medical students who had their BP and HR taken before and during a CPT in the years 1948-1964. In the 20-36 year follow-up period, an association was observed between maximum systolic blood pressure (SBP) change and the incidence of hypertension. This relationship was most apparent 20 years after testing. These results support that enhanced CVR may predict the development of hypertension.

Exercise and Cardiovascular Disease

Regular aerobic exercise induces healthy physiologic adaptations, such as enhanced cardiorespiratory endurance, muscle strength, and fat metabolism. The importance of adequate physical exercise to cardiovascular health is becoming better understood. Exercise appears to be associated with an attenuation in the incidence of CVD as well as in the mortality (Biddle & Fox, 1989; McArdle, Katch, & Katch, 1986).

Research has observed the effects of a variety of exercise intensities and durations on the cardiovascular system. One specific study followed up on 1916 to 1950 Harvard alumni. At 80 years of age, there were one-quarter to one-third fewer deaths due to CVD in the more active men. The physically active men expended 2000 or more kcal per week at work and leisure activities (Paffenbarger, Hyde, Wing, & Hsieh, 1986). Three years later, in a study performed by Blumenthal et al. (1989) 101 older men and women were randomly assigned to an aerobic exercise group, a yoga and flexibility control group, or a waiting list control group. After 4 months, the aerobic exercise group had lower DBP and better perceptions of themselves than the other groups.

Another study examined leisure-time activity in men with sedentary jobs. The men who reported vigorous leisure activities had two-thirds the risk of developing CVD than those who remained sedentary in the first 2 years of the study. The men who persisted with their vigorous activity through the following 8 year period had only half the incidences of CVD that the sedentary men experienced (Morris et al., 1973). The work that followed by Paffenbarger and Hale (1975) demonstrated an inverse relationship between the level of occupational physical activity and risk of CVD. The results of these studies support the importance of exercise in the prevention of CVD.

Exercise and Cardiovascular Reactivity

Research supports that exercise has many psychological and physiological effects. Changes in morale, cognitive processes, metabolism, receptor activity, weight, blood pressure, and hormones have been observed (Dimsdale et al., 1986; Hughes, 1984; Steptoe, Edwards, Moses, & Mathews, 1989; Tomporowski & Ellis, 1986). In addition, adaptations in CVR caused by exercise appear to be important for stress management in individuals (Blumenthal & McCubbin, 1987; Dimsdale et al., 1986). The beneficial effects of aerobic exercise have been studied quite extensively. Research involves a variety of exercise conditions; even exercise mode appears to effect the degree of stress reduction (Berger & Owen, 1988; Ford, Puckett, Blessing, & Tucker, 1989).

Cross-Sectional Studies. One collection of studies has investigated stress reactivity in aerobically fit subjects. The individuals who exercise regularly appear to respond less to stressful stimuli than those who are more sedentary. Two studies measured reactivity of aerobically fit and unfit men and women during cognitive and psychosocial tasks through electrodermal activity. The more physically active individuals had more rapid electrodermal recovery after the tasks (Hollander & Seraganian, 1984; Keller & Seraganian, 1984). These studies support lower CVR in individuals who are more fit.

Intense aerobic exercisers, moderate aerobic exercisers, and nonexercisers were faced with two stressors, electric shock avoidance and an intelligence test, in the work by Plante and Karpowitz (1987). The exercisers were less physiologically reactive during the stressors and in recovery. A similar study examined the stress responsivity of the three types of exercise groups to a bicycle task, shock avoidance task, and the CPT. The less fit individuals showed greater myocardial response (HR, SBP, and pre-ejection measures) to the first two tasks (Light, Obrist, James, & Strogatz, 1987).

Aerobic fitness level related to reactivity to a psychosocial stressor has been investigated. One study monitored 15 highly trained and 15 untrained subjects exposed to a psychosocial stressor. Trained subjects showed more rapid HR recovery and lower levels of anxiety following the conclusion of the session (Sinyor, Schwartz, Peronnet, Brisson, & Seraganian, 1983). Similar results were discovered by Holmes and Roth (1985) in their examination of 10 fit and 10 unfit subjects. A lower pulse rate was also witnessed during the task.

A study involving an extensive variation of stressors seemed beneficial in the examination of the effects of different stimuli on the aerobically fit. A film of industrial accidents, the SCWT, the CPT, and a running task were the stressors applied. SBP, DBP, HR, norepinephrine, epinephrine, and psychological responses were measured. SBP and DBP responses to the film, SCWT, and running were less in fit subjects. HR was also lower except at maximal running. Norepinephrine was lower in the more active subjects throughout the running task (Hull, Young, & Ziegler, 1984). A year later, another study administered a variety of stressors including: a structured interview, presentation of a snake, mental arithmetic, a CPT, and two competitive card games. Significant differences between Type A and B subjects during the structured interview and the card games. Type A individuals showed greater BP increases; this was even greater in those less fit (Lake, Suarez, Schneiderman, & Tocci, 1985).

Czajkowski et al. (1990) examined the relationships among aerobic fitness, psychological characteristics, and CVR by studying 62 men divided into fit and less fit groups. Subjects' CVR was assessed during a mental arithmetic and video game task. Aerobically fit subjects showed a smaller increase in DBP and HR. They also reported their feelings as less anxious and angry than the less fit subjects. In a similar study, twenty male subjects were classified as highly fit or not fit (Martinez, 1990). Each subject performed a 2 minute CPT. Initial examination of the two groups showed insignificant results. The subjects were divided up into two groups based on the degree of their reactivity and it was determined that CVR may be attenuated in the fit group by a change in plasma cortisol. Thus exercise may be beneficial in individuals who are considered to be high reactors.

Electrocardiographic T-wave amplitude responses in individuals have been measured to determine stress response. Subjects were monitored during the performance of hard and easy versions of a mental arithmetic task. Greater attenuation of amplitude was noticed in the low as compared to the high aerobic fitness group. This suggests that psychologically-elicited sympathetic cardiac activity is reduced by enhanced fitness (Shulhan, Scher, & Furedy, 1986).

A meta-analysis was conducted to study the relationship between aerobic fitness and psychosocial stress response. The results of 34 studies involving 1,449 subjects were statistically combined to better understand the inconsistent findings in this area (Crews & Landers, 1987). The average effect size indicated that aerobically fit subjects had reduced CVR in response to stress compared to other nonexercising groups.

Other studies examining fitness level and CVR have shown inconclusive results. Kagan and Berg (1987) examined 40 volunteers who performed two cognitive tasks, one under a condition of no stress and the other while being verbally pressured. Aerobic activity was related to an inferior cognitive performance and elevated BP under stress. Another study examined 12 male marathoners compared with an age matched control group. Each subject performed a video game, a reaction time task, and a 90-second CPT. The physiologic and cardiovascular responses of the marathoners to the challenges were no different than those of the control group (Dorheim et al., 1984). Both of these studies contradict the beneficial findings previously observed.

Training Studies. Another group of studies in this area has approached the relationship between CVR and exercise in a different manner. These studies emphasize the effects of training programs on the reactivity in sedentary individuals. Training effects have been observed in healthy Type A middle-aged men. The men were randomly assigned to an aerobic exercise training group or a strength and flexibility group and were later stressed by a mental arithmetic task. HR, SBP, DBP, and oxygen consumption were attenuated in the aerobic exercise group during the task. These men also had lower BP, HR, and oxygen consumption in recovery (Blumenthal et al., 1988). Blumenthal et al. (1990) continued his work with Type A subjects in a very similar study with 27 healthy males. The subjects were randomly assigned to an aerobic exercise training group or to a strength training group. During the mental arithmetic task, the aerobic group produced a greater reduction in levels of HR, DBP, and rate pressure product (RPP) than the strength group. Thus, the aerobic group tended to demonstrate less CVR to mental stress. A related study randomized 27 Type A males to two training groups, aerobic exercise and strength development. After 12 consecutive weeks, the aerobically trained individuals reacted to a 5 minute reaction time task with lower DBP. Subjects who were borderline hypertensive were even less reactive than previously at baseline (Sherwood, Light, Blumenthal, 1989).

Forty-two college students participated in 30 minutes of aerobic exercise 4 days per week in an 8 week training study (Berglund, 1989). Each subject performed the CPT before and after training. A significant decrease in DBP response to the stressor was noted in the known compliers compared to the control subjects.

Other studies have not been successful in supporting a relationship between aerobic training and a reduction in CVR. Steptoe, Moses, Mathews, and Edwards (1990) studied 75 healthy, sedentary adults. Each subject carried out a sub-maximal exercise session and easy and difficult problem solving tasks. Differences between moderately fit and unfit individuals were noticed during pretraining measurements. The moderately fit subjects had lower respiration rates during the tasks, lower skin conductance after the tasks, and lower HRs throughout each activity. After baseline measurements, each subject was allocated to one of four 10 week training programs. The conditions included high and moderate aerobic exercise, undemanding strength training, and a flexibility program. There were no important modifications in psychophysiological stress reactions associated with the different training programs. A similar study by Geus, Doornen, Visser, and Orlebeke (1990) found differences between moderately fit and unfit sedentary subjects. Prior to training, DBP and HR were lower during the coping tasks in the more fit. Seven weeks of aerobic training were ineffective in changing either reactivity to or recovery from psychological stressors. Both of these studies were successful in supporting the beneficial effects of aerobic fitness in reducing CVR; even though they failed to support any beneficial effects of aerobic training.

Acute Exercise. Research investigating the attenuation of CVR has mostly been concerned with aerobic fitness. Very little attention has been given to the effects of acute exercise on CVR. Ebbesen et al. (1989) randomly assigned 24 males to 1 or 2 hours of exercise at 55% VO_2 max on a cycle ergometer. After the bout of activity the individuals were stressed by performing a CPT, the SCWT, and a public speaking task. Their responses (HR, BP, skin temperature, and blood catecholamines) were measured at 1, 3, and 24 hours following the tasks. The results show that one or more hours of acute aerobic exercise at 55% VO_2 max reduces the DBP response across all of the sessions. This effect was seen at 1 and 3 hours post-exercise. Because the effects of exercise were primarily observed due to the CPT, Ebbesen et al. (1989) inferred that acute exercise may suppress stress reactions mediated by α-adrenergic receptors.

Hemesath (1990) examined the effects of acute exercise on 19 untrained males. The subjects were randomly assigned to a minimal exercise condition (5 minutes of freewheel cycling) or a 30 minute cycling session at 55-60% VO_2 max. The CPT followed these sessions at 1, 3, and 24 hours. HR and BP were measured during rest, arousal, and recovery of the task. Statistical analyses showed nonsignificant exercise effects; however, some support was provided in two important data trends. The 30 minute exercise subjects tended to have reduced DBP in response to the stressor 1 hour post-exercise ($p = .08$) and reduced SBP in response to the stressor 3 hours post-exercise ($p = .08$).

Rejeski, Gregg, Thompson and Berry (1990) examined the effects of acute exercise on CVR in 12 trained cyclists. Each subject participated in an attention control condition, light exercise (50% of aerobic capacity for 30 minutes), and heavy exercise (80%

of aerobic capacity for 60 minutes). After 30 minutes of recovery they each performed the SCWT. Results showed that mean arterial pressure reactivity was reduced by the heavy and light exercise conditions. Heavy exercise produced significantly lower values than the light condition. During the task, SBP was significantly higher after the control condition and light exercise than following heavy exercise. DBP was significantly higher in the control condition than in either exercise condition. The authors suggested that there is a dose-response relationship between acute aerobic exercise and the attenuation of CVR to acute stress.

Steptoe, Kearsley, and Roy (1991) examined the effects of acute aerobic exercise in a two part study. In the first part of the study thirty males were randomly assigned to 20 minutes of exercise at 100 W, 25 W, or a non-exercise control. Twenty minutes after the activity, subjects performed a non-verbal mental arithmetic task for four-5 minute trials. Exercise produced significantly lower SBP and DBP values during the task. A dose relationship was observed. The second part of the study involved 72 active and inactive men. They exercise at 50 or 70% of HR max or rested for 20 minutes. After recovering for 30 minutes, each subject performed a mental arithmetic and video speech task. The active subjects had significantly lower SBP and DBP during the task after participating in the 70% activity session.

Other studies have failed to demonstrate a relationship between acute aerobic exercise and reduced CVR. A study by Roth (1989) examined 40 active and 40 inactive college students. The subjects were randomly assigned to an exercise or a control condition. Self-report measures of mood and cardiovascular response measures to cognitive tasks were collected before and after the 20 minute exercise/control sessions. Exercise did not have any significant effects on CVR; however, both active and inactive subjects experienced reductions in anxiety with the single bout of exercise. In the work done by Duda, Sedlock, Melby, and Thaman (1988), ten active and 10 inactive females participated in a single bout of exercise at 70% of age predicted maximal HR and a control condition. Acute exercise was ineffective at reducing CVR to stress when compared to the control group. Several years prior, a group of sedentary subjects exercised for 20 minutes at 60% of age-predicted maximum HR (Russel, Epstein, & Erickson, 1983). Five minutes after exercising, the subjects performed a stressor. Responses in HR, skin conductance, and electromyography of the frontalis muscle were compared with a control. The results yielded insignificant effects. Ward, Carmelli, and McElroy (1984) also failed to find beneficial effects produced by acute exercise. Sixteen trained males performed a reaction time task twice, once after exercise and once without prior activity. Fourteen untrained males were also tested once. No significant differences in reactivity were observed.

Several methodological problems have been observed in the studies in this area. Selection of subjects has often not been representative of the general population (e.g., Type A individuals). Small sample sizes have also limited the significance of results. In addition to sampling, measurement techniques have lacked clear definition as well as validity (Blumenthal et al., 1988). The stress tasks used to observe CVR need to be identified as adequate stimuli. The techniques used to measure CVR have not always been sufficient to clearly identify physiological reactivity (e.g., attitude questionnaires). Thus, the existing studies examining exercise and CVR have not conclusively presented a relationship. To develop a more clear understanding of how exercise relates to CVR, studies need to control the level of fitness, degree of exercise, and measurement techniques more effectively.

Summary

The recognition of CVR as a potential risk factor for CVD has sparked the investigation of treatment for hyperreactivity to a stressor. A majority of the research suggests that exercise reduces an individual's autonomic response to stress, reducing the risk for CVD (Surwit, 1986). Many Investigations do support that trained subjects were less reactive and recover more rapidly than untrained subjects in response to cognitive and psychosocial stressors (Hollander & Seraganian, 1984; Keller & Seraganian, 1984; Plante & Karpowitz, 1987). Although many of the studies in this area appear to support what they had intended to observe, a substantial amount of research design limitations have reduced the efficacy of their results (Blumenthal et al., 1988; King et al., 1989; Roth, 1989). Other studies examining this issue have shown inconclusive results; therefore, further examination of the differences between the trained and untrained states is necessary.

Several methodological problems have prevented the determination of concrete conclusions regarding the relationship between exercise and CVR. Subject selection has been restrictive (e.g., Type A behavior) instead of using a more general population. The significance of results has also been limited by small sample sizes. The techniques used to measure CVR have not always been controlled or the most appropriate.

The reviewed studies support that most of the work in this area investigates the effects of aerobic fitness and training on reactivity. Current research involving the immediate stress reducing ability of acute aerobic exercise is very limited. In order to develop a more clear understanding of how exercise is related to CVR, more attention should be devoted to the beneficial effects of acute aerobic exercise on CVR in trained and untrained individuals. The exercise intensity and duration required to reduce the effects of stress should be further investigated. Better control over subject selection as well as CVR measurement techniques would also help to improve the understanding of the best means to reduce excessive CVR and the risk of CVD.

CHAPTER III

JOURNAL MANUSCRIPT

THE EFFECTS OF ACUTE AEROBIC EXERCISE ON CARDIOVASCULAR REACTIVITY TO STRESS IN HEALTHY, TRAINED AND UNTRAINED MALES

(ABSTRACT)

This study investigated the differences in the cardiovascular reactivity (CVR: HR, SBP, DBP) of trained and untrained individuals who performed the cold pressor test (CPT) after exercising for 30 minutes at 70% VO_2 max and participating in an attention control. Eighteen untrained and eleven trained males were randomly assigned to a treatment sequence. The subjects performed either 30 minutes of cycling at 70% VO_2 max or an attention control. Following 48 hours, the other activity was performed. The CPT followed 1 hour after each treatment session. Rest, peak, and recovery measurements were acquired. Examination of trained and untrained group means, regardless of condition, indicated that trained subjects had lower HR measurements at rest ($F_{1,25}$ = 6.86, $p \leq .05$) and peak ($F_{1,25}$ = 6.33, $p \leq .05$). Closer examination of the different effects due to the acute exercise and control conditions regardless of training state did not reveal any beneficial effects due to the exercise bout. In addition, this study did not support differences in CVR to the CPT due to an interaction of acute exercise with the trained and untrained states of individuals. Resting measures did reveal reduced DBP ($F_{1,25}$ = 4.06, $p \leq .05$) and HR ($F_{1,25}$ = 3.19, p = .09) in trained subjects compared with the untrained following the exercise session indicating a beneficial reduction in the anticipatory response to the stressor. This study did not statistically support the effectiveness of 30 minutes of exercise at 70% VO_2 max or advantages of a physically trained state in reducing CVR to the CPT. In addition, this study did not support the effectiveness of the interaction of exercise at 70% VO_2 max with the trained or untrained state in reducing CVR to the CPT.

INTRODUCTION

Excessive cardiovascular reactivity (CVR) is the augmented activity of the autonomic nervous system which increases the responsiveness of the neuroendocrine and cardiovascular pathways. Acute CVR appears to be a risk factor for cardiovascular disease (CVD). This relationship has been observed in several studies (Keys et al., 1971; Manuck, Kaplan, Adams, & Clarkson, 1989; Menkes et al., 1989). Keys et al. (1971) quantified this risk factor as a rise in diastolic blood pressure (DBP) greater than 20 mm Hg during the cold pressor test (CPT). Men with this elevation had 2.4 times greater risk for CVD. Because acute CVR may play a role in the development of CVD, attempts have been made to identify an intervention that would decrease the hyperresponsiveness of the cardiovascular pathways.

Current literature supports that regular exercise is associated with an attenuation in the incidence of CVD as well as in the mortality (Biddle & Fox, 1989; McArdle, Katch, & Katch, 1986). More specifically, regular physical activity may enhance cardiovascular health by attenuating the individual's stress response (Blumenthal & McCubbin, 1987). A meta-analysis was conducted to study the relationship between aerobic fitness and psychosocial stress response (Crews & Landers, 1987). The results of 34 studies involving 1,449 subjects were statistically combined to better understand the inconsistent findings in this area. The average effect size indicated that aerobically fit subjects had reduced CVR to stress compared to other nonexercising groups; however, this analysis only supported the effects of chronic aerobic exercise. This is true of most of the available research.

Although many studies have examined the effects of the trained state and found beneficial results such as reduced resting and exercise HR, BP, and TPR which tends to reduce CVR (Blumenthal & McCubbin, 1987), several methodological problems have been observed in the studies in this area. Limited subject selection, small sample sizes, unclear measuring techniques, as well as questionable stressors have all contributed to the lack of significant results pertaining to the relationship between exercise and CVR (Blumenthal et al., 1988). To develop a clearer understanding of how exercise relates to CVR, studies need to control the level of fitness, degree of exercise, and measurement techniques more effectively. The existing studies examining exercise and CVR have not demonstrated conclusive results; therefore, this study further examined the differences between the trained and untrained states.

Few studies have been conducted to examine the effects of acute exercise on CVR. Investigations dealing with this issue help to identify whether the positive training effects are due to repeated acute effects. Despite the fact that some studies have failed to demonstrate a relationship between acute aerobic exercise and reduced CVR (Duda, Sedlock, Melby, & Thaman, 1988; Roth, 1989), others have shown an effect of attenuated CVR after an exercise bout. Ebbesen, Prkachin, Mills, and Green (1989) randomly assigned 24 untrained males to 1 or 2 hours of exercise at 55% VO_2 max on a cycle ergometer, or to a minimal exercise condition. After the bout of activity the individuals were stressed by performing a CPT, the Stroop color word task (SCWT), and a public speaking task. Their responses [heart rate (HR), blood pressure (BP), skin temperature, and blood catecholamines] were measured at 1, 3, and 24 hours following the tasks. The results showed that one or two hours of acute aerobic exercise at 55% VO_2 max reduced the DBP response across all of the sessions. This effect was seen at 1 and 3 hours post-exercise.

Hemesath (1990) examined the effects of acute exercise on 19 untrained males. The subjects were randomly assigned to a minimal exercise condition or a 30 minute cycling session at 55-60% VO_2 max. The CPT followed these sessions at 1, 3, and 24 hours. Statistical analyses showed nonsignificant exercise effects; however, some support was provided in two important data trends. The 30 minute exercise subjects tended to have reduced DBP in response to the stressor 1 hour post-exercise (p = .08) and reduced SBP in response to the stressor 3 hours post-exercise (p = .08).

Rejeski, Gregg, Thompson and Berry (1990) examined the effects of acute exercise on CVR in 12 trained cyclists. Each subject participated in an attention control condition, light exercise (50% of aerobic capacity for 30 minutes), and heavy exercise (80% of aerobic capacity for 60 minutes). After 30 minutes of recovery they each performed the SCWT. Results showed that mean arterial pressure reactivity was reduced by the heavy and light exercise conditions. Heavy exercise produced significantly lower values than the light condition. During the task, SBP was significantly higher after the control condition and light exercise than following heavy exercise. DBP was significantly higher in the control condition than in either exercise condition. The authors suggested that there is a dose-response relationship between acute aerobic exercise and the attenuation of CVR to acute stress.

Steptoe, Kearsley, and Roy (1991) examined the effects of acute aerobic exercise in a two part study. In the first part of the study thirty males were randomly assigned to 20 minutes of exercise at 100 W, 25 W, or a non-exercise control. Twenty minutes after the activity, subjects performed a non-verbal mental arithmetic task for four-5 minute trials. Exercise produced significantly lower SBP and DBP values during the task. A dose relationship was observed. The second part of the study involved 72 active and inactive men. They exercise at 50 or 70% of HR max or rested for 20 minutes. After recovering for 30 minutes, each subject performed a mental arithmetic and video speech task. The active subjects had significantly lower SBP and DBP during the task after participating in the 70% activity session.

The investigations mentioned here have examined the protective time frame which follows immediately after an exercise session and express varied results. The effects of acute aerobic exercise on the individual requires further study to explain the importance of exercise for stress management in the normal population. The amount of exercise required to be adequate in stress reduction remains unclear; thus, the examination of different work intensities and CVR may be beneficial. Significant reductions in CVR have been observed after 60 minutes of aerobic activity in trained and untrained subjects. The average person may find it difficult to perform for this duration; therefore, this study examined a more reasonable (ACSM recommended) duration of 30 minutes. Because of the lack of positive results with exercising 30 minutes at 55-60% of maximal aerobic capacity, a higher intensity may be required to elicit a reduction in CVR. Rejeski et al. (1990) supported this dose-response relationship in trained subjects with the most beneficial results at 80% VO_2 max. This intensity may also be too extreme for untrained individuals therefore, this study examined the effects of 70% VO_2 max on CVR.

The purpose of this study was to assess the effects of acute aerobic exercise compared with no exercise on CVR among healthy, trained and untrained male subjects and the interaction of acute exercise with the two types of subjects. More specifically, this study examined more closely the effects of acute activity (cycling at 70% VO_2 max for 30 minutes) on HR, SBP and DBP measures in trained and untrained individuals during the CPT, a psychological stressor shown to be predictive of CVD.

METHODS

Subjects

Eighteen untrained male volunteers were recruited from the Introductory Psychology Experimental Pool at VPI & SU for the Spring 1991 semester. Each subject acquired a total of six extra credit points. The untrained state was defined as presently participating in an aerobic or anaerobic activity less than twice a week for 30 minutes or less each session. Untrained subjects were also at a maximal aerobic capacity of 13 METs or less.

Eleven trained male cyclists were recruited from the Virginia Tech Cycling Team and the Blacksburg Cycling Club. The trained state was defined as currently cycling four days a week or more for at least 30 minutes each session. Trained subjects were also at a maximal aerobic capacity of greater than 13 METs.

The subject's health and training status was determined through a health questionnaire. The males were free of any relative or absolute contraindications to graded exercise or reactivity testing. In addition, the subjects were required to be:

1. nonsmokers
2. 18-25 years old;
3. normotensive (i.e., < 140/90 mm Hg resting BP);
4. free of health contraindications to participate in a 30 minute cycling session or a version of the CPT;
5. free of a history of CVD and Raynaud's Syndrome.

Instructional Procedures

Each subject attended a meeting in which the nature of the study was described briefly. Possible risks and benefits of the study were explained through written and oral exchange. Each subject completed a detailed medical history questionnaire to ensure that they were at minimal risk for exercise or stress induced problems. An informed consent form was signed by all subjects, that were deemed appropriate for the study, in agreement to the research procedures.

During the initial questionnaire session of the study, the subjects were provided with oral instructions necessary for the experiment. Subjects willing to participate agreed not to ingest analgesics for 2 days prior to testing, and not to eat or drink (except water) during the 3 hours before their session. The subjects were also instructed to avoid exercise at least 48 hours prior to each experimental session. The individuals who are were willing to comply with the protocol were randomly assigned to a treatment sequence by groups of four in the order in which they signed up.

Baseline CVR

During the first session, subjects reported to the Behavioral Physiology Laboratory for assessment of baseline HR, SBP and DBP. In order to establish a baseline CVR, the subjects performed the CPT. Upon arrival to the lab, subjects were seated comfortably in an easy chair with the BP cuff wrapped around the non-dominant arm just superior to the antecubital fossa. The subject placed both arms on the armrests. Subjects were asked several questions to determine their adherence to the pre-session protocol. Before the lab technician left the room, the subject was told to follow the directions given on the audiotape. The technician observed the subject in a nearby office via camera and monitored physiological responses via a computer link to the automated BP system (Industrial and Biomedical Sensors Corporation Model SD-700A). After each individual rested for 5 minutes, the technician returned to start the cycling of the cuff inflation and left again without interacting with the individual. HR, SBP, and DBP were measured each minute. Following another 5 minutes, 5 minutes of resting measurements were recorded. Each subject had a total rest time of 15 minutes.

After the rest period, the CPT was administered. The individual was directed by the audiotaped instructions to gently immerse his dominant hand up to the wrist in the container of ice water (0-3°C) and to keep it there for 1 minute. The HR, SBP, and DBP measurements were collected at approximately 50 seconds into the task. At the end of the task, the subject was told to gently withdraw his hand from the water and to sit quietly through the recovery measurements. Five minutes of recovery measurements were then recorded. At the completion of the testing period, the subject answered a post-session questionnaire to determine their perception of the task. Subjects expressed how stressful the task was on a scale of 0-6 with 6 being the most stressful. Subjects also expressed how well they coped during the task on a similar scale with 6 being not well.

Determination of VO_2 Max

A maximal exercise test followed the baseline reactivity test in the first session. Using a Bodyguard Model 990 cycle ergometer, each subject performed a progressive cycling test until their maximum aerobic capacity was reached. With pedalling rate at 50 rpm's, external work was initiated at 25 watts and increased by 25 watts for the first stage, then 50 watts each stage there after. The duration of each stage was 2 minutes. HR and EKG changes were monitored by a 3 lead Physio-Control Lifepak 6 EKG system. Ratings of perceived exertion (RPE) were recorded using the Borg 6-20 point scale.

Determination of VO_2 max involved the determination of inspired gas volumes by a Parkinson-Cowan Dry Gas Meter. The gas meter was electrically integrated with a visual display which reported measurements to the nearest 0.1 liter, reporting minute ventilation and total ventilation. Oxygen and carbon dioxide were determined through electronic gas analyzers (Ametek CD3A and S3A) equipped with a paramagnetic oxygen sensor and an infrared carbon dioxide sensor. These measures were acquired every minute throughout each stage. Calibration of this system and the other equipment used was performed according to manufacturer's specifications before each testing session.

Maximal aerobic capacity was reached when a combination or one of the following was reached: RPE was 19 or 20, age-predicted maximal HR was achieved (based on the Karvonen method), the subject was unable to continue cycling at 50 rpm, and/or oxygen consumption did not change or decreased at a higher workload.

Acute Exercise and CVR

The following sessions involved a bout of acute exercise or an attention control followed by the stressor. After being randomly assigned to a treatment sequence, half of the individuals initially experienced moderate work in which cycling was performed at 70% of VO_2 max for 30 minutes. The subjects free wheeled for 5 minutes working up to the targeted intensity which was determined during the first period. The exercise was followed by a 5 minute free wheeling cool-down period. Pedalling rate was maintained at 50 rpm's. The same Bodyguard cycle from the maximal testing session was used throughout these exercise trials. BP, RPE, and HR were measured each minute for the first 5 minutes and then every 5 minutes thereafter. HR and EKG changes were observed by a three lead Physio-Control Lifepak 6 EKG monitor.

The other half of the subjects initially participated in a 40 minute attention control session. BP, HR, %fat, frame size, height, weight and flexibility were determined at this time. Flexibility was determined by the sit-and-reach test and %fat was determined using skin folds (chest, abdomen, and thigh). Frame size was estimated by height and elbow width. Forty-eight hours later the subjects performed the second activity to which they were not originally assigned.

Following the treatment sessions (exercise or control), the subjects relaxed for 1 hour. The subjects were allowed to leave the laboratory, but they were instructed to not eat or drink (except for water), take medication, or exercise. At the end of the hour, the subjects reported to the Behavioral Physiology Laboratory to perform the CPT which was used to measure baseline CVR. The same equipment was used throughout each of these sessions.

Statistical Procedures

All statistical analyses were conducted on the Statistical Analysis System (SAS). Test-retest reliability estimates for SBP, DBP, and HR responses (change score and peak) to the CPT were calculated using the initial baseline sessions and the control sessions that were performed in the first treatment session. To determine any existing differences between the trained and untrained groups, a series of one-way ANOVAs were conducted on the following: age, max HR, max BP, max METs, RER (respiratory exchange ratio) exercise session measurements (HR, BP, RPE), baseline CPT measurements (rest, peak, perception based on questionnaire), weight, height, flexibility (sit-and-reach data), and % fat.

Due to the variable sequence and unbalanced cells, each main effect (type and treatment) required separate error terms. Thus, a split-plot GLM ANOVA was used to compare rest, peak, and change scores from rest to peak during the CPT. Change scores calculated for RPP (Rate Pressure Product) were also analyzed in this manner. This change score was used to determine change in myocardial oxygen demand. A split-plot design was used to examine the first minute of recovery BP and HR measurements (recovery measurements minus resting). In addition, this model was used to determine the differences in perception of the experimental CPT sessions obtained from the post-session questionnaire. Least squares means were used to compensate for the unbalanced cells within this research design. Contrast statements were implemented to individually examine each group with each treatment. Simple effects were calculated to determine specific mean differences within significant interactions.

Correlational analyses were used to determine any relationships between maximum METs and baseline CVR measures, as well as between resting baseline and resting experimental CPT values.

Determination of significance of all analyses was set at an alpha level of .05. Each analysis was one tailed.

In reviewing the experimental data for all subjects and comparing it to those who met the a priori inclusion criteria of baseline DBP reactivity < 5 mm Hg, it was found that the results were quite similar. Hence, to increase sample size and statistical power, all subjects were included in the following results.

RESULTS

Subject Characteristics

Subjects did not differ significantly in peak SBP, DBP, or HR during the maximal exercise and acute exercise sessions (Table 1). They also did not differ in rest SBP, DBP, and HR during the control session. Significant differences were observed in maximum METs ($F_{1,27}$ = 50.79, $p \leq .001$), flexibility based on the sit-and-reach test ($F_{1,27}$ = 5.29, $p \leq .05$), exercise workload ($F_{1,27}$ = 47.53, $p \leq .001$), and % fat ($F_{1,27}$ = 4.05, $p \leq .05$). These results are indicative of the better fitness level of the trained subjects.

Insert Table 1 here

Exercise Data

The VO_2 max values for the trained subjects ranged from 45.9 to 69.7 ml/kg/min. The trained subjects were average to excellent in their performance based on their age predicted VO_2 max standards. The VO_2 max values for the untrained subjects ranged from 26.8 to 46.7 ml/kg/min. These values indicate very poor to average performances based on their age predicted VO_2 max standards (Pollock & Wilmore, 1990). Mean maximum HR measures for the trained and untrained subjects were 186.09 and 181.55. The mean HR value that was calculated based on 70% of the VO_2 max measures was 151.35 for the trained and 147.93 for the untrained. The two groups actually exercised at mean HRs equal to 149.94 and 146.04.

Reliability Estimates

Test-retest reliability estimates for SBP, DBP, and HR reactivity during the CPT following the control session of the first testing period and the baseline session were determined by Pearson Product Moment Correlations. Estimates for these parameters were SBP: $r = .58, p = .14$; DBP: $r = .69, p = .12$; and HR: $r = .32, p = .21$. The test-retest reliability of HR was relatively low compared with the other two parameters and previous studies. The reliability estimates for SBP and DBP were comparable with previous studies (Berglund, 1989; Hemesath, 1990). Thus, the protocol used in this study was moderately effective in eliminating some of the individual variance which occurs during the CPT. The test-retest reliability estimates of baseline reactivity and first period control session reactivity were also calculated for each individual group. The reliability estimates for the trained subjects' reactivity were determined to be SBP: $r = .12$, $p = .36$; DBP: $r = .10$, $p = .41$; and HR: $r = .07$, $p = .47$. The reliability estimates for the untrained subjects, who participated in the study after the trained, were substantially higher at SBP: $r = .72$, $p = .08$; DBP: $r = .83$, $p \leq .05$; and HR: $r = .51$, $p = .15$. These differences in estimates for trained and untrained subjects suggests that the testing technique may have improved over time.

Due to the instability observed between baseline rest and treatment rest measures, the reliability estimates reported based on change scores may not have provided the most accurate estimate of the reliability of the CPT. Thus, reliability estimates for peak SBP, DBP, and HR measurements recorded during the CPT following the control session of the first testing period and the baseline session were also determined. Estimates for these parameters were SBP: $r = .77$, $p = .11$; DBP: $r = .86$, $p = .06$; and HR: $r = .78$, $p = .09$. These values were more acceptable than the change score estimates. The reliability estimates for the trained subjects' peak SBP, DBP, and HR measures were determined to be SBP: $r = .45$, $p = .28$; DBP: $r = .58$, $p = .13$; and HR: $r = .60$, $p = .11$. The estimates for the untrained subjects were SBP: $r = .87$, $p = .07$; DBP: $r = .94$, $p \leq .05$; and HR: $r = .91$, $p \leq .05$. Three subjects that had experience in performing the CPT were removed from both reliability estimates (change score and peak).

Baseline CPT Differences

Analysis of the baseline (session I) CPT resting, peak, change score, and recovery measures did not indicate significant differences between trained and untrained subjects for BP measures. The groups did significantly differ in recovery HR values ($F_{1,27}$ = 5.66, p ≤ .05) with the untrained subjects recovering more rapidly (M ± SEM = -5.62 ± 1.35, -1.57 ± 1.84).

Treatment CPT Differences

A split-plot GLM ANOVA was used to analyze resting, peak, change score, and recovery measures of session II and III. Mean values of the trained and untrained subjects are provided in Table 2.

Trained versus Untrained. Examination of the differences between CPT measures in each type of subject, trained versus untrained, demonstrated lower resting HR means in the trained subjects (M ± SEM = 59.09 ± 2.80, 68.39 ± 2.18; $F_{1,25}$ = 6.86, p ≤ .05) compared to the untrained. Resting SBP also had a tendency to be lower in the trained subjects (M ± SEM = 110.78 ± 2.60, 117.14 ± 2.03; $F_{1,25}$=3.71, p = .07). Values calculated for peak HR measures were significantly lower in the trained subjects (M ± SEM = 62.53 ± 3.68, 74.25 ± 2.86; $F_{1,25}$ = 6.33, p ≤ .05).

Insert Table 2 here

Exercise versus Control. Results regarding the differences in CPT measures following the acute exercise session and the attention control in all subjects revealed significantly lower resting HR measures after the attention control (M ± SEM = 61.22 ± 1.20, 66.26 ± 1.20; $F_{1,25}$ = 8.77, p ≤ .01). Lower peak HR measures were also seen following the attention control (M ± SEM = 66.02 ± 1.52, 70.76 ± 1.52; $F_{1,25}$ = 4.89, p ≤ .05).

Interaction of Training State and Treatment. Examination of the interaction between the treatment received and the training state of the subjects demonstrated a significant interaction for resting DBP ($F_{1,25}$ = 4.06, p ≤ .05). Calculation of simple effects indicated significantly lower resting DBP in trained subjects dependent upon acute exercise (M ± SEM = 66.55 ± 1.57, 70.72 ± 1.23). A tendency for an interaction between the treatment received and the type of subject for resting HR was also seen ($F_{1,25}$ = 3.19, p = .09). Simple effects revealed three significant differences in means within the interaction. First, trained subjects had significantly lower resting HR dependent upon the acute exercise bout (M ± SEM = 63.13 ± 1.90, 69.39 ± 1.48). Second, trained subjects had significantly lower resting HR dependent upon the attention control session (M ± SEM = 55.05 ± 1.90, 67.39 ± 1.48). Third, the resting HR measures following the control session were significantly lower than those following the exercise session dependent upon the subjects being trained (M ± SEM = 55.05 ± 1.90, 63.13 ± 1.90). A tendency for an interaction between the treatment received and the type of subject was also seen for recovery DBP ($F_{1,25}$ = 3.61, p = .07). Significant simple effects were not observed; however, close examination of the mean values demonstrated a moderately lower recovery DBP (first minute of recovery minus rest) in untrained subjects (M ± SEM = 1.61 ± 2.31, 9.20 ± 2.96) following the exercise bout. An additional interaction was observed between the type of subject and the sequence of treatment for DBP recovery values ($F_{1,25}$ = 4.06, p ≤ .01). Noticable differences in mean values were not observed or calculated by simple effects for this interaction.

Contrasts. The specific contrast regarding the differences in CPT measures following the exercise and control condition within only the untrained subjects revealed no significant results or trends. The specific contrast of the measures following the two treatment sessions within the trained subjects demonstrated significantly lower recovery DBP following the control condition (M ± SEM = 1.50 ± 2.96, 9.20 ± 2.96; $F_{1,25}$ = 4.90, p ≤ .05).

CPT Means

Comparisons of CPT means are presented in Figures 1, 2, and 3 and demonstrate important though not statistically significant tendencies. The first figure of SBP reactivity suggests reduced levels at rest and peak in trained subjects after acute exercise compared with the attention control session. The same appears to be true for the untrained. The trained subjects' SBP measures are shown to be lower in general compared with the untrained at rest, peak, and recovery. This tendency was demonstrated statistically for the resting values (M $\pm$ SEM = 110.78 $\pm$ 2.60, 117.14 $\pm$ 2.03; $F_{1,25} = 3.71$, p = .07).

Insert Figure 1 here

The second figure of DBP means displays the lowest means at rest and peak in the trained subjects after the acute aerobic exercise. The positive effect of the exercise session is not seen in the untrained subjects in this figure. The interaction of type of subject and treatment for resting DBP, more specifically the lower resting DBP in trained subjects dependent on the exercise bout, is also shown in this figure. The third figure of HR means emphasizes reduced values in all trained subjects compared with the untrained. The tendency for the interactions between type of subjects and treatments received are shown.

Within all of the figures presented, the response means for each treatment condition follow very similar patterns. Two exceptions are found in Figures 1 and 2. The trained subjects' recovery measurements appear to remain elevated following the exercise bout. Closer examination revealed an insignificant difference between this pattern and that of the other conditions.

Insert Figures 2 and 3 here

Figures 1 and 2 illustrate a moderate reduction in DBP and SBP resting values from baseline to experimental sessions. These observed differences prompted a secondary analysis of CVR by calculating the change score by subtracting the baseline resting measure from the peak values. Upon calculation of these second change scores, moderate differences between the exercise and control treatment change scores are apparent. The split plot GLM ANOVA was used for this analysis. The differences in SBP and DBP observed between treatments were not statistically significant; however, there was a trend toward lower SBP change scores after the exercise bout (M $\pm$ SEM = 4.46 $\pm$ 0.97, 2.44 $\pm$ 0.97; $F_{1,25} = 2.14$, p = .16) in both groups. HR was significantly lower in the trained subjects (M $\pm$ SEM = 0.36 $\pm$ 2.61, 7.41 $\pm$ 2.04; $F_{1,25}$ = 4.64, p $\leq$ .05) regardless of condition.

RPP Reactivity

Analysis of change score RPP (SBP x HR/100) revealed no significant differences in both main effects and interactions. Untrained subjects did appear to have a larger increase in RPP during the stressor compared with the trained subjects (M $\pm$ SEM = 11.77 $\pm$ 2.65, 9.79 $\pm$ 3.41), indicating a greater myocardial oxygen demand.

Correlational Analyses

Correlations of maximum METs and baseline SBP, DBP, and HR reactivity resulted in nonsignificant relationships. Correlations of baseline and experimental resting data demonstrated a closer relationship between baseline and control values than exercise values for SBP and DBP which is demonstrated in Figures 1 and 2.

Perception of CPT Differences

Examination of the differences in perception of the CPT between the two treatment sessions and the two subject types provided information regarding changes in the difficulty of the CPT. This analysis revealed a tendency for differences in perception of how stressful the CPT was between the two treatment sequences ($F_{1,25} = 3.59$, p = .07).

Subjects performing the exercise session first perceived the task to be more stressful than those starting with the control session (M ± SEM = 2.36 ± 0.10, 1.29 ± 0.10). In addition a tendency toward an interaction between treatment received and the sequence of the treatment ($F_{1,25} = 3.66$, p = .07) was observed. Simple effects showed that the subjects performing the exercise session first found the CPT to be more stressful following the exercise session compared with the other sequence (M ± SEM = 2.28 ± 0.14, 1.48 ± 0.15). In addition, the subjects performing the sequence beginning with the exercise bout found the CPT to be more stressful following the control condition compared with the other sequence (M ± SEM = 2.44 ± 0.14, 1.10 ± 0.15).

DISCUSSION

The results of this study did not statistically support that trained subjects have reduced CVR to stress compared with untrained subjects following acute exercise or an attention control. Examination of trained and untrained group means, regardless of condition, indicated that trained subjects had lower SBP and HR measurements at rest, peak, and recovery. The lower HR values at rest and peak were statistically significant. Examination of the mean change score RPP values revealed a higher change score in the untrained subjects indicating a larger myocardial oxygen demand. Trained subjects also appeared to have lower resting and peak DBP means.

The results of this study did not statistically support that 30 minutes of exercise at 70% of VO_2 max reduces CVR in all individuals regardless of training state. To the contrary, rest and peak HR values were lower following the attention control. Examination of SBP means in Figure 1 did reveal lower values at rest and peak following the acute exercise session.

This study did not support differences in CVR to the CPT due to the interaction of exercising for 30 minutes at 70% VO_2 max with the trained and untrained states of individuals. Interesting results regarding resting measures was observed. Significantly lower resting DBP measures were found in the trained subjects dependent upon the acute exercise session. There was also a tendency for this interaction for resting HR values. These findings might indicate that acute exercise in combination with a trained state beneficially reduces the anticipatory response to stress.

The results of this study did not statistically support that 30 minutes of exercise at 70% of VO_2 max reduces CVR in trained subjects. Closer examination of the different effects due to the acute exercise and control conditions within the trained subjects revealed a tendency for reduced DBP and SBP means at rest and peak following the acute exercise. The results of this study did not statistically support that 30 minutes of exercise at 70% of VO_2 max reduces CVR in untrained subjects. Examination of the two treatment sessions within the untrained subjects indicated a tendency for reduced SBP means at rest, peak, and recovery following acute exercise.

In general, this study attempted to improve and expand upon protocols of previous research in this area. Trained and untrained subjects were used to further understand the fitness level required to receive benefits from acute aerobic exercise. A more reasonable duration of exercise for trained untrained individuals was incorporated for more practical application (30 minutes). Although slightly higher than average, a reasonable intensity (70% VO_2 max) of exercise for trained and untrained subjects was used to further understand the degree of exercise required. Another beneficial change was the use of a non-exercise control session equal in length with the exercise session. This study limited the non-exercise stressors to the CPT, which is documented to be predictive of CVD in humans. In addition, the CPT protocol used was designed for minimal interactions. Despite these changes in protocol, CVR to the CPT was not significantly attenuated due to acute aerobic exercise. The trained state also showed no significant beneficial reductions in CVR.

The lack of positive results may be explained by several methodological concerns. First, variability in the data of this study may be attributed to the small sample sizes. Larger sample sizes were required, especially for trained subjects, to ensure more statistical power. Second, the variability in CVR to the CPT may have occurred due to effects such as past experience and individual pain tolerance. This study used a very strict protocol with minimal subject interaction and control of the subjects' food, fluid, and drug consumption. The test-retest reliability estimates for peak SBP, DBP, and HR measures during the CPT were very acceptable and supported that the protocol used was moderately effective in reducing variability from session to session. Reliability estimates calculated based on change scores compared with peak values support that stable resting measures are very important to accurately quantify CVR. The reliability of the CVR measures acquired during the CPT should be examined in future examinations. Variability in reactivity due to past experience, class examinations following the session, and comfortability with the technician were noted throughout data collection. Other investigations should attempt to better control subject scheduling by further enquiring about class projects that might interfere with reactivity to the CPT. Subjects who have had past experience should be eliminated from the study. Lastly, allowing subjects to become more comfortable with the technician through time should be prevented if possible.

The sequence of treatment sessions may have also been a contributing factor. The analysis of the post-session questionnaire showed a tendency for the sequence to effect the subject's perception of how stressful the CPT was. The subjects performing the exercise session first perceived the CPT to be more stressful than those performed the control session first. In addition, the interaction between treatment received and the sequence of sessions showed that the subjects performing the exercise session first found the CPT to be more stressful following exercise compared with the other sequence. The possible effect that sequence of treatment might have on the effectiveness of the stressor should be considered in the future.

The ordering of subjects groups appears to also be a methodology concern. Due to the different recruiting methods used for both groups, the trained subjects participated in the study before the untrained, instead of being tested simultaneously. A closer examination of the test-retest reliability estimates of baseline reactivity and first period control session reactivity in each individual group was prompted by this consideration. The reliability estimates for the trained subjects were substantially lower than the untrained for both change score and peak SBP, DBP, and HR measurements. This may demonstrate that measurements became more stable with practice of the CPT, making the measurements of the first sessions with the trained subjects the most variable. Testing both groups together within the same time frame may have prevented the concentration of variability within one group and may have provided more beneficial results.

Another issue which deserves attention is the variability of the maximal aerobic capacity of subjects. Trained subjects were required to have a max MET capacity of > 13 and untrained subjects were required to have a max MET capacity of ≤ 13 in order to continue in the study. The actual range for the trained subjects was 13.1 to 19.9. The untrained subjects varied from 7.7 to 13.3. Both of these groups have substantially large ranges in terms of aerobic capacity and may have contributed to large variations in CVR to the CPT. In addition, there was distinct overlap in MET capacity between the trained and untrained subjects (13.1 and 13.3). This overlap may have statistically reduced the effectiveness of the stressor to determine differences in CVR between the two subject types. A final point about the maximal aerobic capacity tests is that a more rigid protocol should have been used to fully test the trained subjects. Two subjects were able to continue past the final stage, making the determination of the workload and HR at 70% VO_2 questionable.

An interesting consideration was presented when the fitness level of the subjects was examined. Subjects were initially recruited based on their training state, which was determined from their weekly activity. Subjects were then able to continue in the study if they met the maximal aerobic capacity criteria. Aerobic capacity is an indicator of fitness level as opposed to training state. In addition, the acute exercise session was determined for each individual by calculating 70% of their maximal aerobic capacity. Thus, the activity session performed was determined based on fitness level not training state. Future investigations that intend to examine the beneficial effects of acute exercise and training on CVR should attempt to establish the activity and criteria based on the subject's weekly regimen or other indicators of training state.

A final methodology concern was made evident upon examination of reliability estimates and Figures 1, 2, and 3. The mean resting values of the baseline session are substantially elevated compared with the resting values of the treatment session, supporting a moderate degree of learning effect taking place. A true baseline should have been determined within a fourth session following all of the treatment periods. This should be considered in future investigations in this area to develop a more accurate measure of CVR.

Although this study clearly contained methodological concerns, the trends that were observed within the results support the possible benefits of 30 minutes of acute exercise at 70% VO_2 max and the trained state in reducing CVR to stress. There does appear to be reduction in SBP, DBP, and HR at rest and peak during the CPT due to the acute bout of exercise. In addition, SBP, DBP, and HR appeared lower in the trained subjects during rest and peak during the CPT. The lower resting DBP and HR measures found in the trained subjects dependent upon the acute exercise session might indicate that acute exercise in combination with a trained state beneficially reduces the anticipatory response to stress. Although no significant positive effects were observed for BP reactivity throughout all of the results, the tendencies that were observed within this study clearly support the possible beneficial effects of an acute bout of exercise at 70% VO_2 max and the trained state and indicate the need for further investigation. Future research should continue to expand and investigate these possible benefits which have been observed here.

The results of this study have emphasized several important protocol limitations which should be considered in future research. In addition, future studies should further investigate the duration and intensity of the exercise required to reduce CVR. Workloads may be alternated by fluctuating the intensity throughout the session to enhance subject performance. The frequency of the acute exercise could also be considered. The activity should be appropriate for the subject population being studied and be concurrent with ACSM and clinical recommendations.

Other existing issues that were not considered in this study should be examined to expand the overall understanding of this area. Other populations should be investigated, such as those diagnosed with CVD or hypertension, females, different age groups outside of 18-25 years, and subjects other than college students. Another recommendation is further investigating the possible mechanisms causing alterations in CVR by employing a variety of stressors known to examine different pathways of action or using pharmacological agents (α and β blockers) to assess acute effects. Possible mechanisms may also be further understood by examining a variety of dependent measures, including cardiac output, stroke volume, and catecholamines. All of these recommendations should be explored to further develop an understanding of the effects of acute aerobic exercise on CVR to a non-exercise stressor.

Conclusions

Although the tendencies observed in this study were interesting, most of the findings were not supported statistically. While HR was significantly lower in trained subjects at rest and peak during the reactivity sessions, no positive effects were seen based on the change score. This study did not statistically support the effectiveness of 30 minutes of exercise at 70% VO_2 max in reducing CVR to the CPT in all individuals. In addition, this study did not statistically support that an individual who is trained has reduced CVR to the CPT compared with an untrained individual. This study did not statistically support differences in CVR to the CPT due to the interaction of exercising for 30 minutes at 70% VO_2 max with the trained and untrained states of individuals. The lower resting DBP and HR measures found in the trained subjects dependent upon the acute exercise session might indicate that acute exercise in combination with a trained state beneficially reduces the anticipatory response to stress. Although no significant positive effects were observed for BP reactivity throughout all of the results, the tendencies that were observed within this study clearly support the possible beneficial effects of an acute bout of exercise at 70% VO_2 max and the trained state and indicate the need for further investigation.

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Table 1. Subject Characteristics

	Trained (n=11)		Untrained (n=18)	
	M ±	SEM**	M ±	SEM
General Information:				
Age (yrs.)	22.36	0.38	19.66	0.30
Weight (kg)	71.80	3.25	79.85	2.54
Height (cm)	177.73	1.69	177.28	1.33
HR (bpm)	62.00	3.71	70.27	2.90
SBP (mm Hg)	110.73	2.92	113.78	2.28
DBP (mm Hg)	72.00	2.62	71.33	2.05
Flexibility (cm)*	31.21	2.38	24.25	1.96
% Fat++	8.98	1.27	12.14	1.00
Maximal Exercise Test Data:				
Max SBP (mm Hg)	200.82	6.01	194.83	4.70
Max DBP (mm Hg)	84.55	3.56	88.17	2.78
Max HR (bpm)	186.09	3.51	181.55	2.74
Max METs	16.45	0.59	11.05	0.46
Max VO_2 (ml/kg/min)	57.64	2.09	38.67	1.63
RER	1.16	0.04	1.13	0.03
Single Exercise Session:+				
SBP (mm Hg)	172.54	4.29	168.22	3.35
DBP (mm Hg)	75.18	2.00	80.00	1.57
HR (bpm)	149.94	3.35	146.04	2.62
RPE	13.45	0.69	13.55	0.54
Power (watts)	196.82	7.31	132.89	5.71

\+ based on average values of the 30 minute session
* based on highest sit-and-reach score
++ % fat = sum of chest, abdomen, and thigh skin folds
** M ± SEM = mean ± standard error of the mean

Table 2. Resting, Peak, Reactivity, and Recovery CPT Means for Trained and Untrained Subjects

	TRAINED (n=11)		UNTRAINED (n=18)	
	M	± SEM	M	± SEM
SBP				
Baseline				
Resting*	118.00	2.76	118.72	2.16
Peak+	125.91	3.21	126.78	2.51
Change Score**	7.91	1.76	8.06	1.38
Recovery++	7.09	2.40	9.50	1.87
Exercise Condition				
Resting	110.70	1.84	116.78	1.43
Peak	118.37	1.53	123.11	1.19
Change Score	7.67	2.19	6.33	1.71
Recovery	9.42	1.94	7.72	1.51
Control Condition				
Resting	110.87	1.84	117.50	1.43
Peak	121.67	1.53	123.83	1.19
Change Score	10.80	2.19	6.33	1.71
Recovery	6.20	1.94	8.28	1.51
DBP				
Baseline				
Resting	71.09	3.05	71.50	2.39
Peak	81.18	2.89	79.78	2.26
Change Score	10.09	2.70	8.28	2.11
Recovery	-7.45	3.19	0.72	2.49
Exercise Condition				
Resting	66.55	1.57	70.72	1.23
Peak	77.77	2.34	82.50	1.82
Change Score	11.22	1.98	12.00	1.54
Recovery	9.20	2.96	1.61	2.31
Control Condition				
Resting	69.90	1.57	68.39	1.23
Peak	82.43	2.34	81.61	1.82
Change Score	12.53	1.98	13.22	1.54
Recovery	1.50	2.96	4.00	2.31
HR				
Baseline				
Resting	62.67	2.98	66.78	2.33
Peak	66.55	4.42	71.84	3.45
Change Score	4.27	2.60	5.11	2.03
Recovery	-1.73	1.40	-5.94	1.09
Exercise Condition				
Resting	63.13	1.90	69.39	1.48
Peak	65.52	2.39	76.00	1.86
Change Score	2.88	1.78	6.61	1.38
Recovery	-2.92	1.74	0.22	1.36
Control Condition				
Resting	55.05	1.90	67.39	1.48
Peak	59.53	2.39	72.50	1.86
Change Score	4.48	1.78	5.17	1.38
Recovery	-2.42	1.74	-1.44	1.36

* rest = an average of five resting measures
\+ peak = measurements at approximately 50 seconds into the CPT
** change score = peak-rest
++ recovery values = minute 1 of recovery-resting

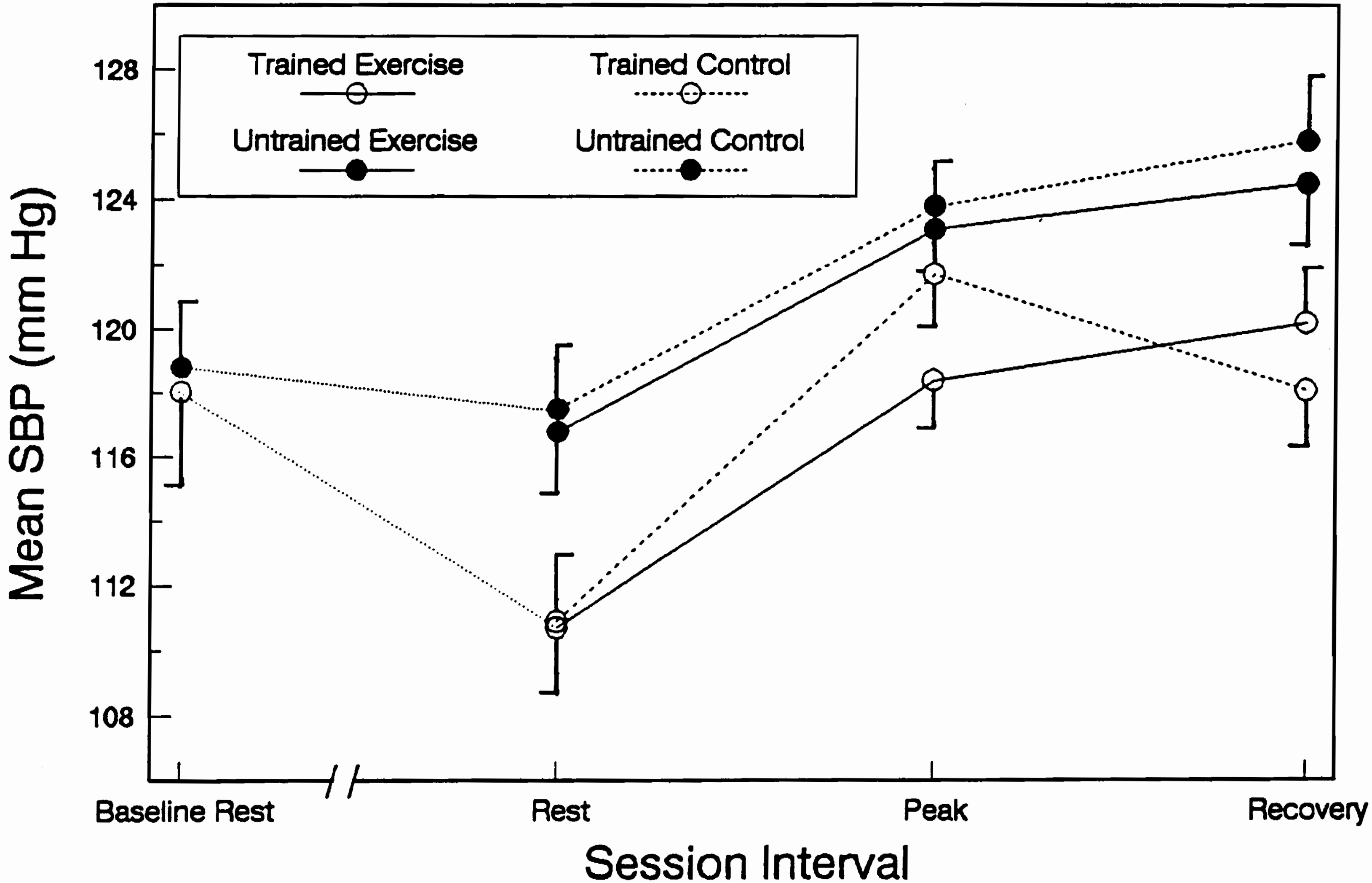

Figure 1. Systolic Blood Pressure Reactivity to the Cold Pressor Test

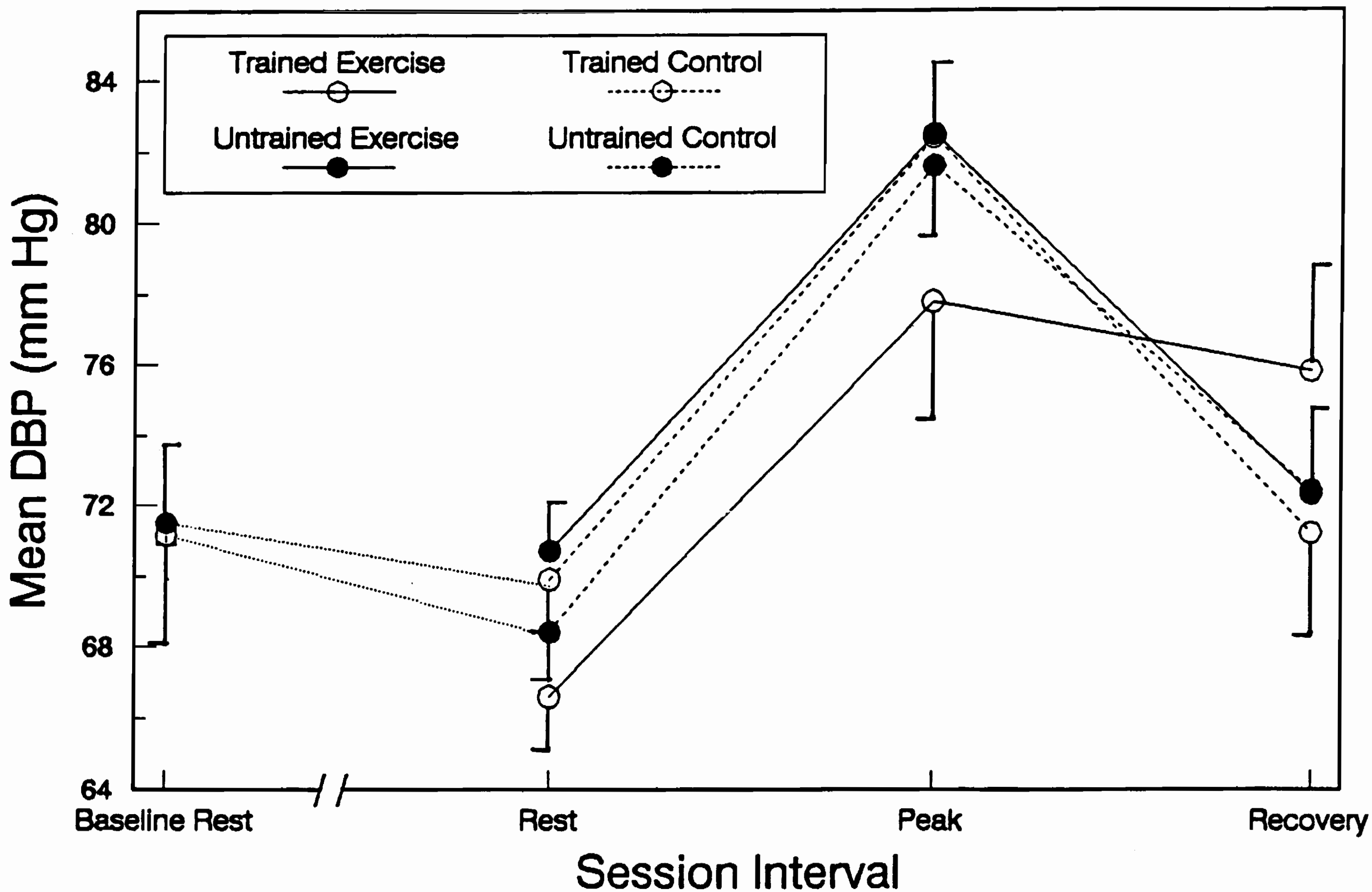

Figure 2. Diastolic Blood Pressure Reactivity to the Cold Pressor Test

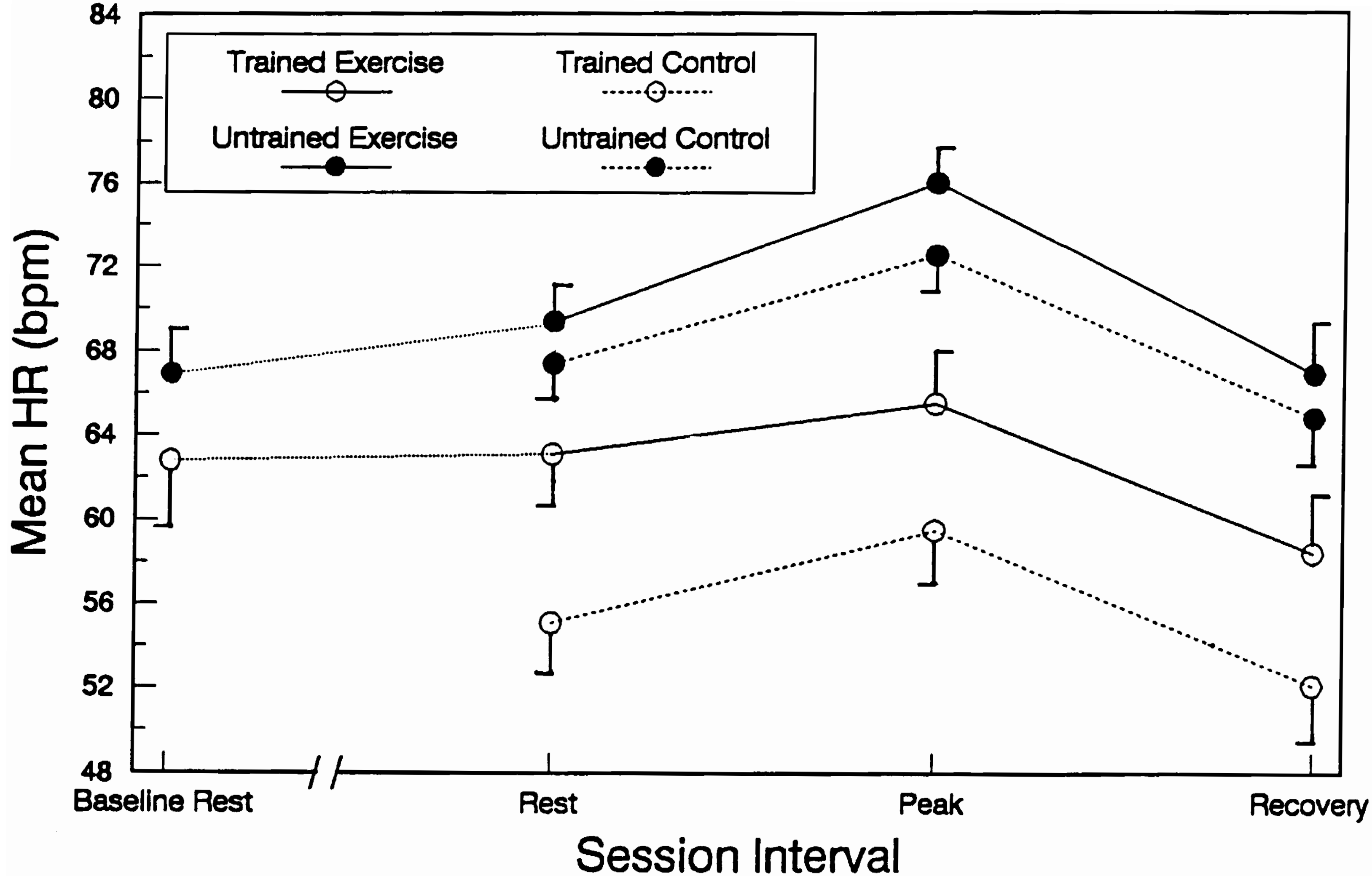

Figure 3. Heart Rate Reactivity to the Cold Pressor Test

CHAPTER IV

SUMMARY AND RESEARCH RECOMMENDATIONS

SUMMARY AND RESEARCH RECOMMENDATIONS

Summary

Purpose

The purpose of this study was to determine if acute aerobic exercise or being in a trained state reduces CVR to a non-exercise stressor and the interaction of acute exercise with the two types of subjects. More specifically, this study was conducted to examine the effects of 30 minutes of aerobic cycling at 70% VO_2 max on the SBP, DBP, and HR reactivity to the CPT in healthy, trained and untrained males.

Methods

Eighteen untrained male volunteers aged 18-23 were recruited from the Introductory Psychology Experimental Pool at VPI & SU. Eleven trained male cyclists aged 21-25 were recruited from the Virginia Tech Cycling Team and the Blacksburg Cycling Club. Each subject participated in three experimental sessions. During an initiation session, the males were provided with oral instructions necessary for the experiment. Subjects willing to participate agreed not to ingest analgesics for 2 days prior to testing, and not to eat, drink (except water) during the 3 hours before their session. The subjects were also instructed to avoid exercise at least 48 hours prior to each experimental session. During this initial session, subjects also completed a medical history and health questionnaire. Individuals who were appropriate for the study were randomly assigned to a treatment sequence by groups of four in the order in which they signed up.

During the first experimental session, subjects reported to the Behavioral Physiology Laboratory for assessment of baseline HR, SBP and DBP. In order to establish a baseline CVR, the subjects performed the CPT. After each individual rested for 5 minutes, HR, SBP, and DBP were measured each minute. Following another 5 minutes, 5 minutes of resting measurements were recorded. After a total rest period of 15 minutes, the individual immersed his hand in a container of ice water (0-3°C) for 1 minute. The

HR, SBP, and DBP measurements were collected at approximately 50 seconds into the task. At the end of the task, the subject withdrew his hand from the water and five minutes of recovery measurements were then recorded. At the completion of the testing period, the subject answered a post-session questionnaire to determine their perception of the task.

A maximal exercise test followed the baseline reactivity test in the first session. Each subject performed a progressive cycling test until their maximum aerobic capacity was reached. Trained subjects were eliminated at MET values less than or equal to thirteen. Untrained subjects were eliminated at MET values greater than thirteen.

The following two sessions involved a bout of acute exercise or an attention control followed by the CPT. After being randomly assigned to a treatment sequence, half of the individuals initially experienced moderate work in which cycling was performed at 70% of VO_2 max for 30 minutes. The other half of the subjects initially participated in a 40 minute attention control session. BP, HR, %fat, frame size, height, weight and flexibility were determined at this time. Forty-eight hours later the subjects performed the second activity to which they were not originally assigned. Following the treatment sessions (exercise or control), the subjects relaxed for 1 hour. At the end of the hour, the subjects reported to the Behavioral Physiology Laboratory to perform the CPT which was used to measure baseline CVR.

The Statistical Analysis System (SAS) was used to conduct all statistical analyses (all tables are found within Appendix E). All analyses were one tailed and determination of significance was set at an alpha level of .05.

Results

Reliability Estimates

Test-retest reliability estimates for SBP, DBP, and HR reactivity during the CPT following the control session of the first testing period and the baseline session were determined by Pearson Product Moment Correlations. Estimates for these parameters were SBP: $r = .58$, $p = .14$; DBP: $r = .69$, $p = .12$; and HR: $r = .32$, $p = .21$. The test-retest reliability of HR was relatively low compared with the other two parameters and previous studies. The reliability estimates for SBP and DBP were comparable with previous studies (Berglund, 1989; Hemesath, 1990). Thus, the protocol used in this study was moderately effective in eliminating some of the individual variance which occurs during the CPT. The test-retest reliability estimates of baseline reactivity and first period control session reactivity were also calculated for each individual group. The reliability estimates for the trained subjects' reactivity were determined to be SBP: $r = .12$, $p = .36$; DBP: $r = .10$, $p = .41$; and HR: $r = .07$, $p = .47$. The reliability estimates for the untrained subjects, who participated in the study after the trained, were substantially higher at SBP: $r = .72$, $p = .08$; DBP: $r = .83$, $p \leq .05$; and HR: $r = .51$, $p = .15$. These differences in estimates for trained and untrained subjects suggests that the testing technique may have improved over time.

Due to the instability observed between baseline rest and treatment rest measures, the reliability estimates reported based on change scores may not have provided the most accurate estimate of the reliability of the CPT. Thus, reliability estimates for peak SBP, DBP, and HR measurements recorded during the CPT following the control session of the first testing period and the baseline session were also determined. Estimates for these parameters were SBP: $r = .77$, $p = .11$; DBP: $r = .86$, $p = .06$; and HR: $r = .78$, $p = .09$. These values were more acceptable than the change score estimates. The reliability estimates for the trained subjects' peak SBP, DBP, and HR measures were determined to be SBP: $r = .45$, $p = .28$; DBP: $r = .58$, $p = .13$; and HR: $r = .60$, $p = .11$. The estimates for the untrained subjects were SBP: $r = .87$, $p = .07$; DBP: $r = .94$, $p \leq .05$; and HR: $r = .91$, $p \leq .05$. Three subjects that had experience in performing the CPT were removed from both reliability estimates (change score and peak).

Subject Characteristics

To determine any existing differences between trained and untrained subjects, one-way ANOVAs were conducted on the following: age, max HR, max BP, max METs, RER, exercise session measurements (HR, BP, and RPE), baseline CPT (rest, peak, recovery, and perception), weight, height, flexibility, and % fat. Group means are presented within Table E1. Subjects did not significantly differ in peak SBP, DBP, or HR during the maximal exercise and acute exercise session. The two groups also did not differ in rest SBP, DBP, and HR during the control session. Significant differences were observed in maximum METs ($F_{1,27}$ = 50.79, p $\leq$ .001), flexibility based on the sit-and-reach test ($F_{1,27}$ = 5.29, p $\leq$ .05), exercise session workload ($F_{1,27}$ = 47.53, p $\leq$ .001), % fat ($F_{1,27}$ = 4.05, p $\leq$ .05), and baseline CPT recovery HR ($F_{1,27}$ = 5.66, p $\leq$ .05). These results are indicative of the better fitness level of the trained subjects.

Exercise Data

The VO_2 max values for the trained subjects ranged from 45.9 to 69.7 ml/kg/min. The trained subjects were average to excellent in their performance based on their age predicted VO_2 max standards. The VO_2 max values for the untrained subjects ranged from 26.8 to 46.7 ml/kg/min. These values indicate very poor to average performances based on their age predicted VO_2 max standards (Pollock & Wilmore, 1990). The mean maximum RER (VCO_2/VO_2) was 1.13 for the untrained subjects and 1.16 for the trained subjects. These values indicate a maximal effort within both groups (Brooks & Fahey, 1985). Mean maximum HR measures for the trained and untrained subjects were 186.09 and 181.55. The mean HR value that was calculated based on 70% of the VO_2 max measures was 151.35 for the trained and 147.93 for the untrained. The two groups actually exercised at mean HRs equal to 149.94 and 146.04. Figure 4 (Appendix G) demonstrates the mean HR responses from the 70% exercise sessions.

Treatment CPT Differences

Due to the variable sequence and unbalanced cells, each main effect required separate error terms. Thus, A split-plot GLM ANOVA was used to analyze resting, peak, change score, and recovery measures of session II and III (Tables E6-E9). Change scores calculated for RPP were also analyzed in this manner. This change score was used to determine change in myocardial oxygen demand. Least squares means were used to compensate for the unbalanced cells within this research design. Mean values of trained and untrained subjects are provided in Table 2.

Trained versus Untrained. Examination of the differences between CPT measures in each type of subject, trained versus untrained, demonstrated lower resting HR means in the trained subjects (M $\pm$ SEM = 59.09 $\pm$ 2.80, 68.39 $\pm$ 2.18; $F_{1,25}$ = 6.86, $p \leq .05$) compared to the untrained. Resting SBP also had a tendency to be lower in the trained subjects (M $\pm$ SEM = 110.78 $\pm$ 2.60, 117.14 $\pm$ 2.03; $F_{1,25}$=3.71, p = .07). Values calculated for peak HR measures were significantly lower in the trained subjects (M $\pm$ SEM = 62.53 $\pm$ 3.68, 74.25 $\pm$ 2.86; $F_{1,25}$ = 6.33, $p \leq .05$).

Exercise versus Control. Results regarding the differences in CPT measures following the acute exercise session and the attention control in all subjects revealed significantly lower resting HR measures after the attention control (M $\pm$ SEM = 61.22 $\pm$ 1.20, 66.26 $\pm$ 1.20; $F_{1,25}$ = 8.77, $p \leq .01$). Lower peak HR measures were also seen following the attention control (M $\pm$ SEM = 66.02 $\pm$ 1.52, 70.76 $\pm$ 1.52; $F_{1,25}$ = 4.89, $p \leq .05$).

Interactions of Training State and Treatment. Examination of the interaction between the treatment received and the training state of the subjects demonstrated a significant interaction for resting DBP ($F_{1,25}$ = 4.06, $p \leq .05$). Calculation of simple effects indicated significantly lower resting DBP in trained subjects dependent upon acute exercise (M $\pm$ SEM = 66.55 $\pm$ 1.57, 70.72 $\pm$ 1.23). A tendency for an interaction between the treatment received and the type of subject for resting HR was also seen ($F_{1,25}$=3.19, p = .09). Simple effects revealed three significant differences in means within the interaction. First, trained subjects had significantly lower resting HR dependent upon the acute exercise bout (M $\pm$ SEM = 63.13 $\pm$ 1.90, 69.39 $\pm$ 1.48). Second, trained subjects had significantly lower resting HR dependent upon the attention control session (M $\pm$ SEM = 55.05 $\pm$ 1.90, 67.39 $\pm$ 1.48). Third, the resting HR measures following the control session were significantly lower than those following the exercise session dependent upon the subjects being trained (M $\pm$ SEM = 55.05 $\pm$ 1.90, 63.13 $\pm$ 1.90). A tendency for an interaction between the treatment received and the type of subject was also seen for recovery DBP ($F_{1,25}$ = 3.61, p = .07). Significant simple effects were not observed; however, close examination of the mean values demonstrated a moderately lower recovery DBP (first minute of recovery minus rest) in untrained subjects (M $\pm$ SEM = 1.61 $\pm$ 2.31, 9.20 $\pm$ 2.96) dependent upon the exercise bout. An additional interaction was observed between the type of subject and the sequence of treatment for DBP recovery values ($F_{1,25}$ = 4.06, p $\leq$ .01). Noticable differences in mean values were not observed or calculated by simple effects for this interaction.

Contrasts. The specific contrast regarding the differences in CPT measures following the exercise and control condition within only the untrained subjects revealed no significant results or trends (Table E10). The specific contrast of the measures following the two treatment sessions within the trained subjects demonstrated significantly lower recovery DBP following the control condition (M $\pm$ SEM = 1.50 $\pm$ 2.96, 9.20 $\pm$ 2.96; $F_{1,25}$ = 4.90, p $\leq$ .05).

CPT Means

Comparisons of CPT means are presented in Figures 1, 2, and 3 on pages 51, 52 and 53. and demonstrate important tendencies. The first figure of SBP reactivity clearly shows reduced levels at rest and peak in trained subjects after acute exercise compared with the attention control session. The same appears to be true for the untrained. The trained subjects' SBP measures are shown to be lower in general compared with the untrained at rest, peak, and recovery. This tendency was demonstrated statistically for the resting values (M ± SEM = 110.78 ± 2.60, 117.14 ± 2.03; $F_{1,25}$ = 3.71, p = .07).

The second figure of DBP means displays the lowest means at rest and peak in the trained subjects after the acute aerobic exercise. The positive effect of the exercise session is not seen in the untrained subjects in this figure. The interaction of type of subject and treatment for resting DBP, more specifically the lower resting DBP in trained subjects dependent on the exercise bout, is also shown in this figure. The third figure of HR means emphasizes reduced values in all trained subjects compared with the untrained. The tendency for the interactions between type of subjects and treatments received are shown.

Within all of the figures presented, the response means for each treatment condition follow very similar patterns. Two exceptions are found in Figures 1 and 2. The trained subjects' recovery measurements appear to remain elevated following the exercise bout. Closer examination revealed an insignificant difference between this pattern and that of the other conditions.

Figures 1 and 2 illustrate a moderate reduction in DBP and SBP resting values from baseline to experimental sessions. These observed differences prompted a secondary analysis of CVR by calculating the change score by subtracting the baseline resting measure from the peak values. The relationship of interest is shown within Figures 5, 6, and 7 in Appendix G. Upon calculation of these second change scores, moderate differences between the exercise and control treatment change scores are apparent. The split plot GLM ANOVA was used for this analysis. The differences in SBP and DBP observed between treatments were not statistically significant; however, there was a trend toward lower SBP change scores after the exercise bout (M ± SEM = 4.46 ± 0.97, 2.44 ± 0.97; $F_{1,25}$ = 2.14, p = .16) in both groups. HR was significantly lower in the trained subjects (M $\pm$ SEM = 0.36 $\pm$ 2.61, 7.41 $\pm$ 2.04; $F_{1,25}$ = 4.64, p $\leq$ .05) regardless of condition (Table 18).

RPP Reactivity

Analysis of change score RPP (SBP x HR / 100) revealed no significant differences in both main effects and interactions (Table E11). Untrained subjects did appear to have a larger increase in RPP during the stressor compared with the trained subjects (M $\pm$ SEM = 11.77 $\pm$ 2.65, 9.79 $\pm$ 3.41), indicating a greater myocardial oxygen demand.

Correlational Analyses

Correlational analyses were used to determine any relationships between maximum METs and baseline CVR measures, as well as between resting baseline and resting experimental CPT measures. Correlations of maximum METs and baseline SBP, DBP, and HR reactivity resulted in nonsignificant relationships (Table E12). Correlations of baseline and experimental resting data demonstrated a closer relationship between baseline and control values than with exercise values for SBP and DBP (Table E13). Figures 1 and 2 clearly show these relationships.

Perception of CPT Differences

Examination of the differences in perception of the CPT between the two treatment sessions and the two subject types provided information regarding changes in the difficulty of the CPT. The split plot GLM model was used to determine differences in the subjects' perceptions of the CPT obtained from the post-session questionnaire following the treatment sessions (Table E16). The subjects' perceptions of the baseline CPT were analyzed by a one-way ANOVA (Table E15). This analysis revealed a tendency for differences in perception of how stressful the CPT was between the two treatment sequences ($F_{1,25}$ = 3.59, p = .07). Subjects performing the exercise session first perceived the task to be more stressful than those starting with the control session. In addition a tendency toward an interaction between treatment received and the sequence of the treatment ($F_{1,25}$=4.64, p = .07) was observed. Simple effects showed that the subjects performing the exercise session first found the CPT to be more stressful following the exercise session compared with the other sequence (M ± SEM = 2.28 ± 0.14, 1.48 ± 0.15). In addition, the subjects performing the sequence beginning with the exercise bout found the CPT to be more stressful following the control condition compared with the other sequence (M ± SEM = 2.44 ± 0.14, 1.10 ± 0.15).

In reviewing the experimental data for all subjects and comparing it to those who met the a priori inclusion criteria of baseline DBP reactivity < 5 mm Hg, it was found that the results were quite similar. Hence, to increase sample size and statistical power, all subjects were included in the results previously reported. Analyses of subjects who were deemed appropriate according to the a priori statement are included within Appendix H.

Research Implications

The results of this study did not statistically support that trained subjects have reduced CVR to stress compared with untrained subjects following acute exercise or an attention control. Examination of trained and untrained group means, regardless of condition, indicated that trained subjects had lower SBP and HR measurements at rest, peak, and recovery. The lower HR values at rest and peak were statistically significant. Examination of the mean change score RPP values revealed a higher change score in the untrained subjects indicating a larger myocardial oxygen demand. Trained subjects also appeared to have lower resting and peak DBP means.

The results of this study did not statistically support that 30 minutes of exercise at 70% of VO_2 max reduces CVR in all individuals regardless of training state. To the contrary, rest and peak HR values were lower following the attention control. The SBP means in Figure 1 appeared to be lower at rest and peak following the acute exercise session.

This study did not support differences in CVR to the CPT due to the interaction of exercising for 30 minutes at 70% VO_2 max with the trained and untrained states of individuals; however, interesting results regarding resting measures were observed. Significantly lower resting DBP measures were found in the trained subjects dependent upon the acute exercise session. There was also a tendency for this interaction for resting HR values. These findings might indicate that acute exercise in combination with a trained state beneficially reduces the anticipatory response to stress.

The results of this study did not statistically support that 30 minutes of exercise at 70% of VO_2 max reduces CVR in trained subjects. Closer examination of the different effects due to the acute exercise and control conditions within the trained subjects revealed a tendency for reduced DBP and SBP means at rest and peak following the acute exercise. The results of this study did not statistically support that 30 minutes of exercise at 70% of VO_2 max reduces CVR in untrained subjects. Examination of the two treatment sessions within the untrained subjects indicated a tendency for reduced SBP means at rest, peak, and recovery following acute exercise.

Although these observations were interesting, most of these findings were not statistically significant. While HR was significantly lower in trained subjects at rest and peak during the reactivity sessions, no positive effects were seen based on the change score (which most closely represents CVR). This study did not statistically support the effectiveness of 30 minutes of exercise at 70% VO_2 max in reducing CVR to the CPT in all individuals. In addition, this study did not statistically support that an individual who is trained has reduced CVR to the CPT compared with an untrained individual. This study did not statistically support differences in CVR to the CPT due to the interaction of exercising for 30 minutes at 70% VO_2 max with the trained and untrained states of individuals. The lower resting DBP and HR measures found in the trained subjects after the acute exercise session might indicate that acute exercise in combination with a trained state beneficially reduces the anticipatory response to stress. Although no significant positive effects were observed for BP reactivity throughout all of the results, the tendencies that were observed within this study clearly support the possible beneficial effects of an acute bout of exercise at 70% VO_2 max and the trained state and indicate the need for further investigation.

In general, this study attempted to improve and expand upon protocols of previous research in this area. Trained and untrained subjects were used to further understand the fitness level required to receive benefits from acute aerobic exercise. A more reasonable duration of exercise for trained untrained individuals was incorporated for more practical application (30 minutes). Although slightly higher than average, a reasonable intensity (70% VO_2 max) of exercise for trained and untrained subjects was used to further understand the degree of exercise required. Another beneficial change was the use of a non-exercise control session equal in length with the exercise session. This study limited the non-exercise stressors to the CPT, which is documented to be predictive of CVD in humans. In addition, the CPT protocol used was designed for minimal interactions. Despite these changes in protocol, CVR to the CPT was not significantly attenuated due to acute aerobic exercise. The trained state also showed no significant beneficial reductions in CVR.

The lack of positive results may be explained by several methodological concerns. Most important is the variability in CVR to the CPT which can occur due to effects such as past experience and individual pain tolerance. This study used a very strict protocol with minimal subject interaction and control of the subjects' food, fluid, and drug consumption. The test-retest reliability estimates for peak SBP, DBP, and HR during the CPT were very acceptable and supported that the protocol used was moderately effective in reducing variability from session to session. Reliability estimates calculated based on change scores compared with peak values support that stable resting measures are very important to accurately quantify CVR. Variability in reactivity due to past experience, class examinations following the session, and comfortability with the technician were noted throughout data collection. Future investigations should attempt to better control subject scheduling by further enquiring about class projects that might interfere with reactivity to the CPT. Subjects who have had past experience should be eliminated from the study. Allowing subjects to become more comfortable with the technician through time should be prevented if possible.

The sequence of treatment sessions may have also been a contributing factor. The analysis of the post-session questionnaire showed a tendency for the sequence to effect the subject's perception of how stressful the CPT was. The subjects performing the exercise session first perceived the CPT to be more stressful than those performed the control session first. In addition, the interaction between treatment received and the sequence of sessions showed that the subjects performing the exercise session first found the CPT to be more stressful following exercise compared with the other sequence. The possible effect that sequence of treatment might have on the effectiveness of the stressor should be considered in the future.

The ordering of subjects groups appears to also be a methodology concern. Due to the different recruiting methods used for both groups, the trained subjects participated in the study before the untrained, instead of being tested simultaneously. A closer examination of the test-retest reliability estimates of baseline reactivity and first period control session reactivity in each individual group was prompted by this consideration. The reliability estimates for the trained subjects were substantially lower than untrained, who participated in the study after the trained, for both change score and peak SBP, DBP, and HR measurements. This may demonstrate that measurements became more stable with practice of the CPT, making the measurements of the first sessions with the trained subjects the most variable. Testing both groups together within the same time frame may have prevented the concentration of variability within one group and may have provided more beneficial results.

Another issue which deserves attention is the variability of the maximal aerobic capacity of subjects. Trained subjects were required to have a max MET capacity of > 13 and untrained subjects were required to have a max MET capacity of ≤ 13 in order to continue in the study. The actual range for the trained subjects was 13.1 to 19.9. The untrained subjects varied from 7.7 to 13.3. Both of the groups had substantially large ranges in terms of aerobic capacity and may have contributed to large variations in CVR to the CPT. In addition, there is distinct overlap in MET capacity between the trained and untrained subjects (13.1 and 13.3). This overlap may have statistically reduced the effectiveness of the stressor to determine differences in CVR. A final point about the maximal aerobic capacity tests is that a more rigid protocol was required to fully test the trained subjects. To subjects were able to continue past the final stage, making the determination of the workload and HR at 70% VO_2 questionable.

An interesting consideration was presented when the fitness level of the subjects was examined. Subjects were initially recruited based on their training state, which was determined from their weekly activity. Subjects were then able to continue in the study if they met the maximal aerobic capacity criteria. Aerobic capacity is an indicator of fitness level as opposed to training state. In addition, the acute exercise session was determined for each individual by calculating 70% of their maximal aerobic capacity. Thus, the activity session performed was determined based on fitness level not training state. Future investigations that intend to examine the beneficial effects of acute exercise and training on CVR should attempt to establish the activity and criteria based on the subject's weekly regimen or other indicators of training state.

A final methodology concern was made evident upon examination of reliability estimates and Figures 1, 2, and 3. The mean resting values of the baseline session are substantially elevated compared with the resting values of the treatment session, supporting some degree of learning effect taking place. A true baseline should have been determined within a fourth session following all of the treatment periods. This should be considered in future investigations in this area to develop a more accurate measure of CVR.

Although this study clearly contained methodological concerns, the trends that were observed within the results support the possible benefits of 30 minutes of acute exercise at 70% VO_2 max and the trained state in reducing CVR to stress. Though not statistically significant, there does appear to be reduction in SBP, DBP, and HR at rest and peak during the CPT due to the acute bout of exercise. In addition, SBP, DBP, and HR appeared lower in the trained subjects during rest and peak during the CPT. The lower resting DBP and HR measures found in the trained subjects dependent upon the acute exercise session might indicate that acute exercise in combination with a trained state beneficially reduces the anticipatory response to stress. Although no significant positive effects were observed for BP reactivity throughout all of the results, the tendencies that were observed within this study clearly support the possible beneficial effects of an acute bout of exercise at 70% VO_2 max and the trained state and indicate the need for further investigation. Future research should continue to expand and investigate these possible benefits which have been observed here.

Recommendations for Future Research

The results of this study have emphasized several important protocol limitations which should be considered in future research. There is a need for further examination of the relationships between a trained state, acute exercise, and CVR. A variety of areas which may assist in the understanding of this area are recommended for future research.

The selection of subjects is a very important variable. The variability in the data of this study may be highly attributed to the small sample sizes. A power analysis supported this statement. The calculated sample size was N = 28 (n = 14 within each group of subjects). A larger sample size was required for trained subjects, to ensure more statistical power. In addition, better definition of trained and untrained subjects is required to determine the type of individual for which an acute bout of exercise is most beneficial.

In studies using the CPT, a strict protocol should be designed, like the one in this study. This study did show that improved control over individual and environmental considerations are necessary to reduce individual variation in the degree of stress elicited by the CPT. To better understand the beneficial effects of acute exercise and the length of time that these effects continue to work, the CPT could be administered at several different times following the exercise session. The attenuation of CVR has been shown to last up to 3 hours in the past (Ebbesen et al., 1989). The effects on CVR which may occur immediately after exercise up to 3 hours should be more closely evaluated.

An additional concern regarding the stressors used to determine CVR is the test-retest reliability of their measures. Future research should focus on the reliability of the reactivity measures acquired from stressors frequently employed. Studies that further investigate this area may also consider the use of a combination of accepted cardiovascular stressors to possibly develop a more accurate measure of CVR as opposed to relying on one particular test. These beneficial considerations could help to improve the stressors employed to test CVR and lead researchers to the development of acceptable standards.

Although no statistical significance was seen within this study, future studies should further investigate the duration and intensity of the exercise required to reduce CVR. The activity should be appropriate for the subject population being studied and be concurrent with ACSM and clinical recommendations. Because no significance was seen here and previously (Hemesath, 1990) at 30 minutes of exercise and significance has been seen at 60 minutes of exercise (Ebbesen et al., 1989; Rejeski et al., 1990), researchers may want to concentrate on a time interval between these two. Depending on the training status of the subjects, research should use various durations within this range as well as intensities from 50-80% VO_2 max based on the findings of previous studies. To enhance the workload of the exercise session, intensity could be fluctuated. Alternating the workload could improve the performance of the subjects, especially those not trained. The frequency of the acute exercise could also be considered.

Other existing issues that were not considered in this study should be examined to expand the overall understanding of this area. Studies have concentrated on males, other populations should be investigated. Several groups which need attention are those diagnosed with CVD or hypertension, females, different age groups outside of 18-25 years, and subjects other than college students. A second recommendation is further investigating the possible mechanisms causing alterations in CVR by employing a variety of stressors known to examine different pathways of action. Possible mechanisms may also be further understood by examining a variety of dependent measures, including cardiac output, stroke volume, and catecholamines. Pharmacological agents (α and β blockers) may also be used to assess acute effects and the possible mechanisms involved. A final recommendation is the use of ambulatory monitoring to develop a better understanding of individual reactivity to everyday stress and the effectiveness of exercise or training in the reduction of CVR to these stressors. All of these recommendations should be explored to further develop an understanding of the effects of acute aerobic exercise on CVR to a non-exercise stressor.

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APPENDIX A

METHODOLOGY

METHODOLOGY

Subject Selection

Eighteen untrained male volunteers were recruited from the Introductory Psychology Experimental Pool at VPI & SU. Each of the selected subjects received one extra point per hour of participation toward their final psychology class grade. After completing the study, subjects acquired a total of six extra credit points. The subjects who initially completed the health questionnaire but were inappropriate for the study received one extra point for their time. The untrained state was defined as presently participating in an aerobic or anaerobic activity less than twice a week for 30 minutes or less each session. Untrained subjects were also at a maximal aerobic capacity of 13 METs or less.

Eleven trained male cyclists were recruited from the Virginia Tech Cycling Team and the Blacksburg Cycling Club. The trained state was defined as currently cycling four days a week or more for at least 30 minutes each session. Trained subjects were also at a maximal aerobic capacity of greater than 13 METs.

The subject's health and training status was determined through a health questionnaire. The males were free of any relative or absolute contraindications to graded exercise or reactivity testing. It was necessary for the subjects to be nonsmokers to reduce variations in the CVR to the stress tasks. In addition, the subjects were required to be:

1. 18-25 years old;
2. normotensive (i.e., $<$ 140/90 mm Hg resting BP);
3. free of contraindications to participate in a 30 minute cycling session;
4. free of a history of CVD, diabetes, and Raynaud's Syndrome.

Approval to conduct this experiment and to use human subjects was obtained by the Human Subjects Committee of VPI & SU.

Instructional Procedures

Each subject attended a meeting in which the nature of the study was described briefly. Possible risks and benefits of the study were explained through written and oral exchange. Each subject completed a detailed medical history questionnaire (Appendix C) to ensure that they were at minimal risk for exercise or stress induced problems. The questionnaire provided other information about the subjects' CVD risk factors and family history to the researchers. An informed consent form, approved by the Human Subjects Committee of VPI & SU, was signed by all subjects that were deemed appropriate for the study (Appendix B).

During the initial questionnaire session of the study, the males were provided with oral instructions necessary for the experiment. Subjects willing to participate agreed not to ingest analgesics for 2 days prior to testing, and not to eat, drink (except water) during the 3 hours before their session. The subjects were also instructed to avoid exercise at least 48 hours prior to each experimental session.

Prior to the initiation of the experimental sessions, the individuals who are were willing to comply with the protocol were telephoned to receive further instruction regarding research protocol (Appendix D) and to set up the meeting times for the testing. These individuals were randomly assigned to a treatment sequence by groups of four in the order in which they signed up.

Baseline CVR

During the first session, subjects reported to the Behavioral Physiology Laboratory for assessment of baseline HR, SBP and DBP. HR, SBP and DBP were recorded for each subject using an automated BP system (Industrial and Biomedical Sensors Corporation Model SD-700A).

In order to establish a baseline CVR, the subjects performed the CPT. Upon arrival to the lab, subjects were seated comfortably in the easy chair with the BP cuff wrapped around the non-dominant arm just superior to the antecubital fossa. The subject placed both arms on the arm rests. Subjects were asked several questions to determine their adherence to the pre-session protocol (Appendix C). Before the lab technician left the room, the subject was told to follow the directions given on the audiotape. The technician observed the subject in a nearby office via camera and monitored physiological responses via a computer link to the automated BP system. After each individual rested for 5 minutes, the technician returned to start the cycling of the cuff inflation and left again without interacting with the individual. HR, SBP, and DBP were measured each minute. Following another 5 minutes, 5 minutes of resting measurements were recorded. Each subject had a total rest time of 15 minutes.

After the rest period, the CPT was administered. The individual was directed by the audiotaped instructions to gently immerse his dominant hand up to the wrist in the container of ice water (0-3°C) and to keep it there for 1 minute (Appendix D). The HR, SBP, and DBP measurements were collected at approximately 50 seconds into the task. At the end of the task, the subject was told to withdraw his hand from the water, to place it gently on the towel on the armrest, and to sit quietly through the recovery measurements. Five minutes of recovery measurements were then recorded. At the completion of the testing period, the subject answered a post-session questionnaire to determine their perception of the task (Appendix C). A more detailed protocol can be found in Appendix D.

Determination of VO_2 Max

A maximal exercise test followed the baseline reactivity test in the first session. Using a Bodyguard Model 990 cycle ergometer, each subject performed a progressive cycling test until their maximum aerobic capacity was reached (ACSM, 1991). Pedalling rate was maintained by a metronome at 50 rpm's. The test began with a 2 minute warm-up with no tension on the ergometer. External work was initiated at 25 watts and increased by 25 watts for the first stage, then 50 watts each stage there after. The duration of each stage was 2 minutes (Appendix C). For recovery, intensity was reduced and pedalling continued for 5 minutes. HR, BP, and EKG changes were monitored each stage, from warm-up through recovery. HR and EKG changes were monitored by a 3 lead Physio-Control Lifepak 6 EKG system. BP was observed by a mercurial sphygnomometer. Ratings of perceived exertion (RPE) were recorded using the Borg 6-20 point scale. By pointing to the number on the scale, subjects related the level of effort felt with each exercise stage.

Determination of VO_2 max involved the subject breathing through a Hans Rudolf low-resistance low dead-space valve with a noseclip to prevent air leakage. Inspired gas volumes were measured by a Parkinson-Cowan Dry Gas Meter. The gas meter was electrically integrated with a visual display which reported measurements to the nearest 0.1 liter, reporting minute ventilation and total ventilation. After expired air passed through Aquasorb absorbant, oxygen and carbon dioxide were determined through Ametek CD3A and S3A analyzers. The analyzers were equipped with a paramagnetic oxygen sensor and an infrared carbon dioxide sensor. These measures were acquired every minute throughout each stage. Calibration of this system and the other equipment used was performed according to manufacturer's specifications before each testing session.

Maximal aerobic capacity was reached when a combination or one of the following was reached: RPE was 19 or 20, age-predicted maximal HR was achieved (based on the Karvonen method), the subject was unable to continue cycling at 50 rpm, and/or oxygen consumption did not change or decreased at a higher workload. The actual computation of VO_2 max was performed on the IBM PC in the human performance laboratory. Subjects were eliminated based on the MET values discussed within the subject selection.

Acute Exercise and CVR

The following sessions involved a bout of acute exercise or an attention control followed by the stressor. After being randomly assigned to a treatment sequence, half of the individuals initially experienced moderate work in which cycling was performed at 70% of VO_2 max for 30 minutes. The subjects free wheeled for 5 minutes working up to the targeted intensity which was determined during the first period. The exercise was followed by a 5 minute free wheeling cool-down period. A metronome maintained the pedalling rate at 50 rpm's. The same Bodyguard cycle from the maximal testing session was used throughout these exercise trials. BP, RPE, and HR were measured each minute for the first 5 minutes and then every 5 minutes thereafter (Appendix C). HR and EKG changes were observed by a three lead Physio-Control Lifepak EKG monitor. BP was assessed with a mercurial sphygnomometer.

The other half of the subjects initially participated in a 40 minute attention control session. BP, HR, %fat, frame size, height, weight and flexibility were determined at this time (Appendix C). Flexibility was determined by the sit-and-reach test and %fat was determined using skin folds (chest, abdomen, and thigh). Frame size was estimated by height and elbow width. Forty-eight hours later the subjects performed the second activity to which they were not originally assigned.

Following the treatment sessions (exercise or control), the subjects relaxed for 1 hour. The subjects were allowed to leave the laboratory, but they were instructed to not eat or drink (except for water), take medication, or exercise. At the end of the hour, the subjects reported to the Behavioral Physiology Laboratory to test their reactivity with the CPT which was used to measure baseline CVR. The same equipment was used throughout each of these sessions.

Research Design

A within-subject design was used in this study. Each subject performed exercise at 70% VO_2max for 30 minutes and participated in an attention control for 40 minutes. Each subject was randomly assigned to a treatment sequence.

Statistical Analyses

External Validity. The characteristics (i.e., males, untrained) of the subjects participating in this study allowed the experimental findings to be generalized only to a population possessing such characteristics.

Internal Validity. Variance in measurements was minimized by: 1) calibrating the exercise equipment before the actual testing sessions, 2) administering the same stress task and exercise protocols for each individual, and 3) exercising subjects on the same equipment on which they were maximally tested.

Reliability Estimates. Test-retest reliability estimates for SBP, DBP, and HR responses to the CPT (change score and peak) were calculated using the initial baseline sessions and the control sessions that were performed in the first treatment session. Test-retest reliability estimates were also calculated for each individual subject group.

Data Analysis. All statistical analyses were conducted on the Statistical Analysis System (SAS) (all tables are found within Appendix E). To determine any existing differences between the trained and untrained groups, a series of one-way ANOVAs were conducted on the following: age, max HR, max BP, max METs, RER, exercise session measurements (HR, BP, RPE), baseline CPT measurements (rest, peak, perception based on questionnaire), weight, height, flexibility (sit-and-reach data), and % fat.

In order to adjust for variable sequence and uneven group sizes, a split-plot GLM ANOVA was used to compare rest, peak, and change scores from rest to peak during the CPT. Change scores calculated for RPP were also analyzed in this manner. This change score was used to determine change in myocardial oxygen demand. A split-plot design was used to examine the first minute of recovery BP and HR measurements (recovery measurements minus resting). In addition, this model was used to determine the differences in perception of the experimental CPT sessions obtained from the post-session questionnaire. Least squares means were used to compensate for the unbalanced cells within this research design. Contrast statements were implemented to individually examine each group with each treatment.

Correlational analyses were used to determine any relationships between maximum METs and baseline CVR measures, as well as between resting baseline and resting experimental CPT values.

Determination of significance of all analyses was set at an alpha level of .05. Each analysis was one tailed.

In reviewing the experimental data for all subjects and comparing it to those who met the a priori inclusion criteria of baseline DBP reactivity < 5 mm Hg, it was found that the results were quite similar. Hence, to increase sample size and statistical power, all subjects were included in the following results. Analyses of subjects who were deemed appropriate according to the a priori statement are included within Appendix H.

Results

Subject Characteristics

Subjects did not differ significantly in peak SBP, DBP, or HR during the maximal exercise and acute exercise sessions (Table E1). They also did not differ in rest SBP, DBP, and HR during the control session. Significant differences were observed in maximum METs ($F_{1,27} = 50.79$, $p \leq .001$), flexibility based on the sit-and-reach test ($F_{1,27} = 5.29$, $p \leq .05$), exercise workload ($F_{1,27} = 47.53$, $p \leq .001$), and % fat ($F_{1,27} = 4.05$, $p \leq .05$). These results are indicative of the better fitness level of the trained subjects.

Exercise Data

The VO_2 max values for the trained subjects ranged from 45.9 to 69.7 ml/kg/min. The trained subjects were average to excellent in their performance based on their age predicted VO_2 max standards. The VO_2 max values for the untrained subjects ranged from 26.8 to 46.7 ml/kg/min. These values indicate very poor to average performances based on their age predicted VO_2 max standards (Pollock & Wilmore, 1990). The mean maximum RER (VCO_2/VO_2) was 1.13 for the untrained subjects and 1.16 for the trained subjects. These values indicate a maximal effort within both groups (Brooks & Fahey, 1985). Mean maximum HR measures for the trained and untrained subjects were 186.09 and 181.55. The mean HR value that was calculated based on 70% of the VO_2 max measures was 151.35 for the trained and 147.93 for the untrained. The two groups actually exercised at mean HRs equal to 149.94 and 146.04. The exercise HR response is shown in Figure 4 (Appendix G).

Reliability Estimates

Test-retest reliability estimates for SBP, DBP, and HR reactivity during the CPT following the control session of the first testing period and the baseline session were determined by Pearson Product Moment Correlations. Estimates for these parameters were SBP: $r = .58$, $p = .14$; DBP: $r = .69$, $p = .12$; and HR: $r = .32$, $p = .21$. The test-retest reliability of HR was relatively low compared with the other two parameters and previous studies. The reliability estimates for SBP and DBP were comparable with previous studies (Berglund, 1989; Hemesath, 1990). Thus, the protocol used in this study was moderately effective in eliminating some of the individual variance which occurs during the CPT. The test-retest reliability estimates of baseline reactivity and first period control session reactivity were also calculated for each individual group. The reliability estimates for the trained subjects' reactivity were determined to be SBP: $r = .12$, $p = .36$; DBP: $r = .10$, $p = .41$; and HR: $r = .07$, $p = .47$. The reliability estimates for the untrained subjects, who participated in the study after the trained, were substantially higher at SBP: $r = .72$, $p = .08$; DBP: $r = .83$, $p \leq .05$; and HR: $r = .51$, $p = .15$.

These differences in estimates for trained and untrained subjects suggests that the testing technique may have improved over time.

Due to the instability observed between baseline rest and treatment rest measures, the reliability estimates reported based on change scores may not have provided the most accurate estimate of the reliability of the CPT. Thus, reliability estimates for peak SBP, DBP, and HR measurements recorded during the CPT following the control session of the first testing period and the baseline session were also determined. Estimates for these parameters were SBP: $r = .77$, $p = .11$; DBP: $r = .86$, $p = .06$; and HR: $r = .78$, $p = .09$. These values were more acceptable than the change score estimates. The reliability estimates for the trained subjects' peak SBP, DBP, and HR measures were determined to be SBP: $r = .45$, $p = .28$; DBP: $r = .58$, $p = .13$; and HR: $r = .60$, $p = .11$. The estimates for the untrained subjects were SBP: $r = .87$, $p = .07$; DBP: $r = .94$, $p \leq .05$; and HR: $r = .91$, $p \leq .05$. Three subjects that had experience in performing the CPT were removed from both reliability estimates (change score and peak).

Baseline CPT

Analysis of the baseline (session I) CPT resting, peak, change score, and recovery measures did not indicate significant differences between trained and untrained subjects for BP measures. The groups did significantly differ in recovery HR values ($F_{1,27} = 5.66$, $p \leq .05$) with the untrained subjects recovering more rapidly (M $\pm$ SEM = -5.62 $\pm$ 1.35, -1.57 $\pm$ 1.84) (Table E5).

Treatment CPT Differences

A split-plot GLM ANOVA was used to analyze resting, peak, change score, and recovery measures of session II and III (Tables E6-E9).

Trained versus Untrained. Mean values of the trained and untrained subjects are provided in Table 2. Examination of the differences between CPT measures in each type of subject, trained versus untrained, demonstrated lower resting HR means in the trained subjects (M ± SEM = 59.09 ± 2.80, 68.39 ± 2.18; $F_{1,25}$ = 6.86, p ≤ .05) compared to the untrained. Resting SBP also had a tendency to be lower in the trained subjects (M ± SEM = 110.78 ± 2.60, 117.14 ± 2.03; $F_{1,25}$=3.71, p = .07). Values calculated for peak HR measures were significantly lower in the trained subjects (M ± SEM = 62.53 ± 3.68, 74.25 ± 2.86; $F_{1,25}$ = 6.33, p ≤ .05).

Exercise versus Control. Results regarding the differences in CPT measures following the acute exercise session and the attention control in all subjects revealed significantly lower resting HR measures after the attention control (M ± SEM = 61.22 ± 1.20, 66.26 ± 1.20; $F_{1,25}$ = 8.77, p ≤ .01). Lower peak HR measures were also seen following the attention control (M ± SEM = 66.02 ± 1.52, 70.76 ± 1.52; $F_{1,25}$ = 4.89, p ≤ .05).

Interactions of Training State and Treatment. Examination of the interaction between the treatment received and the training state of the subjects demonstrated a significant interaction for resting DBP ($F_{1,25}$ = 4.06, p ≤ .05). Calculation of simple effects indicated significantly lower resting DBP in trained subjects dependent upon acute exercise (M ± SEM = 66.55 ± 1.57, 70.72 ± 1.23). A tendency for an interaction between the treatment received and the type of subject for resting HR was also seen ($F_{1,25}$=3.19, p = .09). Simple effects revealed three significant differences in means within the interaction. First, trained subjects had significantly lower resting HR dependent upon the acute exercise bout (M ± SEM = 63.13 ± 1.90, 69.39 ± 1.48). Second, trained subjects had significantly lower resting HR dependent upon the attention control session (M ± SEM = 55.05 ± 1.90, 67.39 ± 1.48). Third, the resting HR measures following the control session were significantly lower than those following the exercise session dependent upon the subjects being trained (M ± SEM = 55.05 ± 1.90, 63.13 ± 1.90). A tendency for an interaction between the treatment received and the type of subject was also seen for recovery DBP ($F_{1,25}$=3.61, p = .07). Significant simple effects were not observed; however, close examination of the mean values demonstrated a moderately lower recovery DBP (first minute of recovery minus rest) in untrained subjects (M ± SEM = 1.61 ± 2.31, 9.20 ± 2.96) dependent upon the exercise bout. An additional interaction was observed between the type of subject and the sequence of treatment for DBP recovery values ($F_{1,25}$ = 4.06, p ≤ .01). Noticable differences in mean values were not observed or calculated by simple effects for this interaction.

Contrasts. The specific contrast regarding the differences in CPT measures following the exercise and control condition within only the untrained subjects revealed no significant results or trends (Table E10). The specific contrast of the measures following the two treatment sessions within the trained subjects demonstrated significantly lower recovery DBP following the control condition (M ± SEM = 1.50 ± 2.96, 9.20 ± 2.96; $F_{1,25}$ = 4.90, p ≤ .05).

RPP Reactivity

Analysis of change score RPP (SBP x HR / 100) revealed no significant differences in both main effects and interactions (Table E11). Untrained subjects did appear to have a larger increase in RPP during the stressor compared with the trained subjects (M ± SEM = 11.77 ± 2.65, 9.79 ± 3.41), indicating a greater myocardial oxygen demand.

Correlational Analyses

Correlations of maximum METs and baseline SBP, DBP, and HR reactivity resulted in nonsignificant relationships (Table E12). Correlations of baseline and experimental resting data demonstrated a closer relationship between baseline and control values than exercise values for SBP and DBP which is demonstrated in Figures 1 and 2 on pages 51 and 52.

Perception of CPT Differences

Examination of the differences in perception of the CPT between the two treatment sessions and the two subject types provided information regarding changes in the difficulty of the CPT (Table E16). This analysis revealed a tendency for differences in perception of how stressful the CPT was between the two treatment sequences ($F_{1,25}$ = 3.59, p = .07). Subjects performing the exercise session first perceived the task to be more stressful than those starting with the control session (M ± SEM = 2.36 ± 0.10, 1.29 ± 0.10). In addition a tendency toward an interaction between treatment received and the sequence of the treatment ($F_{1,25}$ = 3.66, p = .07) was observed. Simple effects showed that the subjects performing the exercise session first found the CPT to be more stressful following the exercise session compared with the other sequence (M ± SEM = 2.28 ± 0.14, 1.48 ± 0.15). In addition, the subjects performing the sequence beginning with the exercise bout found the CPT to be more stressful following the control condition compared with the other sequence (M ± SEM = 2.44 ± 0.14, 1.10 ± 0.15).

Conclusions

The trends that were observed within the results support the possible benefits of 30 minutes of acute exercise at 70% VO_2 max and the trained state in reducing CVR to stress. There does appear to be reduction in SBP, DBP, and HR at rest and peak during the CPT due to the acute bout of exercise. In addition, SBP, DBP, and HR appeared lower in the trained subjects during rest and peak during the CPT. The lower resting DBP and HR measures found in the trained subjects dependent upon the acute exercise session might indicate that acute exercise in combination with a trained state beneficially reduces the anticipatory response to stress. Although no significant positive effects were observed for BP reactivity throughout all of the results, the tendencies that were observed within this study clearly support the possible beneficial effects of an acute bout of exercise at 70% VO_2 max and the trained state and indicate the need for further investigation. Future research should continue to expand and investigate these possible benefits which have been observed here.

APPENDIX B

INFORMED CONSENT FORMS

Division of Health and Physical Education
Virginia Polytechnic Institute and State University

Informed Consent

Title of Study: The Effects of Acute Aerobic Exercise on Cardiovascular Reactivity to Two Different Stressors in Healthy, Untrained Males

Purpose of the Study: Exercise has been linked to a number of health benefits, including improved heart function and reduced psychological distress. The purpose of this study is to examine the influence of exercise on the reactivity of the cardiovascular system to a stressful stimulus.

Study Requirements:

1. Completing a detailed medical history form including information such as family history of heart disease and hypertension (high blood pressure), any personal past or present illnesses, injuries or problems requiring medical attention, and current exercise habits.

2. Performing a maximal aerobic capacity test (i.e., a progressive exercise test which requires the subject to attain the point of maximal physical exertion) on a cycle ergometer with continuous monitoring of physiological parameters (heart rate and expired gases).

3. Performing a 40 minute attention control session (measurement of % fat, blood pressure, frame size) and a 40 minute cycling session at 70% of maximal aerobic capacity.

4. Performing a stress reactivity test, taking place 1 hour after each activity session and just prior to the maximal exercise test. The stressor will involve immersing one's hand in ice water for 1 minute or the stressor will be a visual perception task lasting 3 minutes. Heart rate and blood pressure will be measured throughout the task.

5. Abstaining from analgesics, food, beverages, and tobacco for predesignated durations prior to each experimental session.

Risks Associated with Participation:

This study will be supervised by Dr. Douglas R. Southard, a licensed clinical psychologist, and conducted by Jennifer Young, a graduate student in exercise physiology. The exercise protocol has been reviewed by faculty members in exercise physiology. Although all procedures will be performed by trained technicians under laboratory conditions, there is always the possibility of adverse effects due to participation in this study. Possible risks and discomforts include strains, fractures, delayed muscle soreness, infections, and even the remote possibility of death. Other types of injuries may also occur and it is not possible to specifically state each and every individual risk. A standardized emergency protocol is present in the Human Performance and Behavioral Medicine Laboratories to notify and secure medical services. However, no direct medical treatment or compensation is available if injury is incurred. It is understood that subjects reserve the right to abstain from participation in any part of the experiment or withdraw from the experiment should he/she feel that the activities might be injurious to his health.

All subjects will be requested to fill out a medical history form. It is the subject's responsibility to advise the researchers of any pre-existing medical problem that may affect his participation. Based upon responses to the medical history form, the experimenter reserves the right to terminate a subject's participation should the experimenter feel that the activities may be injurious to his health. It is also the responsibility of the subject to notify the experimenter of any discomforts, injuries, or any other adverse experiences occurring during the course of the experiment. All subjects will be debriefed by the experimenter at the completion of the study.

Benefits Associated with Participation:

Subjects may request feedback regarding their aerobic fitness level based on their maximal exercise tests as well as feedback regarding the magnitude of their cardiovascular reactivity to the stressful stimuli. Subjects may also request information regarding a target heart rate range for aerobic exercise training based upon the information gathered during the study.

Subjects will earn a total of 6 credit points towards their grade in Introductory Psychology for completing the 6 hour research protocol. Subjects are free to discontinue participation at any point and will receive partial credit for their participation.

Alternative Procedures: The stress reactivity information collected in this study is unique and not available elsewhere. Information regarding maximal exercise tolerance and suggested training heart rate range is available at various fitness centers for a fee.

Confidentiality: I understand that any data of a personal nature will be held in confidence and will be used for research purposes only. I also understand that this data may only be used when not identifiable with me.

I have read and understood the above statements and have had the opportunity to ask questions. I understand that the researchers will, at any time, answer my inquiries concerning the procedures used in this experiment.

Date__________________ Signature____________________________

Date__________________ Signature____________________________

Date__________________ Signature____________________________

Witness____

Project Coordinator: Jennifer Young (231-5006)
Project Supervisor: Dr. Douglas R. Southard (231-4254)
HPE Human Subjects Chairperson: Dr. Charles Baffi (231-8284)
Psychology Human Subjects Chairperson: Dr. Helen Crawford (231-6520)
University Human Subjects Chairperson: Dr. Ernie Stout (231-5281)

Division of Health and Physical Education
Virginia Polytechnic Institute and State University

INFORMED CONSENT

I, ____________________________, do hereby voluntarily agree and consent to participate in a research project conducted by ____________________________ of the Division of Health and Physical Education of Virginia Polytechnic Institute and State University.

Title of Study:
The effects of acute aerobic exercise on cardiovascular reactivity in response to psychological stressors on trained cyclists.

The purposes of this study include:
Aerobic exercise has been suggested to reduce cardiovascular reactivity and thereby provide a possible non-pharmacological intervention to reduced cardiovascular risk and disease. The purposes of this study will be to examine the effects of acute aerobic exercise on diastolic blood pressure (DBP), systolic blood pressure (SBP) and heart rate (HR) following the cold pressor (CP) and Stroop Color Word (SCW) psychological stressors. Previous methodological problems will be addressed and adjusted for in order to help determine possible mechanisms involved.

I voluntarily agree to participate in this research study. It is my understanding that my participation will include:

1. Participation in an organizational meeting. The purpose of this meeting will be to explain the procedures of the study, sign an informed consent form, fill out a health history questionnaire.

2. Participation of the Cold Pressor (CP) or Stroop Color Word (SCW) psychological stressors on three seperate occasions in which heart rate and blood pressure will be continually monitored. The CP test will involve placement of the dominant hand up to the wrist in cold water (0-3 degrees Celsius) for one minute. Blood pressure and HR will be recorded 50 seconds into the minute via the Industrial and Biomedical Sensors Corporation blood pressure system, Model SD-700 A. Readings will be displayed on a monitor with the blood pressure cuff is on the non-dominant arm. The SCW test will be a 3-minute stressor in which words of colors will flash on a computer screen at 1.5 second intervals. The colored word will appear on the screen in a color different color than the actual word. In addition, a cassette tape playing in the background will verbally be announcing a different color than the other two. This is to cause confusion (and thus changed CVR) as correct responses of the color of the word will be recorded. Appropriate responses

will be recorded by pressing the correct computer button. Resulting CVR (HR and BP) will be measured via the Industrial and Biomedical Sensors Corporation blood pressure system, Model SD-700 A at one minute intervals.

3. Participation in a maximal exercise test on a bicycle ergometer in which heart rate and blood pressure will be continually monitored and in which expired gases will be taken to determine VO2 Max.

4. Participation in an exercise session on a bicycle ergometer for 30 minutes at 70% VO2 Max. Heart rate and blood pressure will be continually monitored.

5. Participation in an attention control session in which several health assessments will be taken.

6. Adherence to guidelines such as abstinence from alcohol, food, beverages, and tobacco for pre-designated periods prior to the study.

I understand that participation in this experiment may produce certain discomforts and risks. These discomforts and risks include:

Possible discomforts during the CP task may occur as the subject places his hand in cold water up to the wrist (0-3 degrees Celsius) fot one minute. This may involve some discomfort or pain. The maximal exercise test may produce some discomfort as the subject cycles until volitional fatigue. Possible risks may include, but are not limited to strains, fractures, immediate and/or delayed muscle soreness and a small possibility of death.

I understand that certain personal benefits may also be expected from participation in his experiment. These include:

I will gain knowledge related to my personal health via several health assessments such as blood pressure measurements, percent body fat, body girth measurements, height, and weight. In addition, aerobic capacity will be determined via a VO_2 Max cycle ergometer test. This is especially beneficial as these tests are expensive in hospitals or other settings. Also, information regarding ventilatory equivalent. This is relevant as this has been suggested to be possible indicator of anaerobic threshold, thus providing information pertaining to one's training level.

I will gain insight into my cardiovascular and hypertension risk factors.

I may also request results of the study.

I understand that there may be one or more appropriate alternative procedures that might be advantageous to me. These include:

I may participate in stress tests at other facilities (ie., hospitals, fitness centers) on a cycle ergometer or treadmill. In addition, health history information via questionnaires as well as other health information is possible, however a fee is probable. Psychological stress testing is unique to our study and I am unaware of other places where this precedure is available.

I understand that any data of a personal nature will be held confidential and will be used for research purposes only. I also understand that these data may only be used when not identifiable with me.

I understand that I may abstain from participation in any part of the experiment or withdraw from the experiment should I feel the activities might be injurious to my health. The experimenter may also terminate my participation should he feel that the activities might be injurious to my health.

I understand that it is my personal responsibility to advise the researchers of any preexisting medical problem that may affect my participation or of any medical problems that might arise in the course of this experiment and that no medical treatment or compensation is available if injury is suffered as a result of this research. A telephone is available which would be used to call the local hospital for emergency service.

I have read the above statements and have had the opportunity to ask questions. I understand that the researchers will, at any time, answer my iniquiries concerning the procedures used in this experiment.

Date________________________ Time______________a.m./p.m.

Participant signature______________________________________

Witness____

Project Director__________________________ Telephone____________

HPE Human Subjects Chairman___Dr. Charles Baffi___ Telephone_231-6284___

Dr. Ernie Stout, 301 Burruss Hall, 231-5281.

To receive the results of this investigation, please indicate this choice by marking in the appropriate space provided below. A copy will then be distributed to you as soon as the results are made available by the investigator. Thank you for making this important contribution.

______ I request a copy of the results of this study.

APPENDIX C

SUBJECT DATA FORMS

HEALTH STYLE QUESTIONNAIRE

Name:_______________________________ ID#:____________________

Sex:_______________ Age:__________ Phone #:_________________

Please circle year in school: 1 = Freshman 2 = Sophomore
3 = Junior 4 = Senior

Medical History

Have you ever had:	YES	NO
Heart disease or heart problems	______	______
Lung disease or difficulty breathing	______	______
Difficulty with cold hands or feet	______	______
Stroke	______	______
Kidney disease	______	______
High cholesterol	______	______
High triglycerides	______	______
Diabetes	______	______
Raynaud's syndrome	______	______
Any operations (Type/Date:__________ ____________________________________ ____________________________________	______	______
Have you ever had a blood pressure reading above normal (140/90)?	______	______
Have you ever been diagnosed as having hypertension?	______	______

Please list any medications you are currently taking:____________
____

Are you allergic to any medications, drugs or foods? Please list:
____

Has anyone in your family been diagnosed as having:	YES	NO	RELATIONSHIP	AGE AT ONSET
High blood pressure/ hypertension	____	____	______________	______
Heart attack or heart disease	____	____	______________	______
Stroke	____	____	______________	______
Diabetes	____	____	______________	______
Kidney disease	____	____	______________	______

Health Habits

	NO	YES	
Drink caffeinated tea, coffee or soda	( )	____	cups/day
Drink alcohol	( )	____	drinks/day
Add salt to meal before tasting	( )	____	
Smoke cigarettes	( )	____	cigarettes/d
Sleep	( )	____	hours/night

Exercise Habits

During the past 3 months have you engaged in physical exercise?
YES_______ NO_______

If yes, please list below any activities in which you participated during an average week in the past month (please include competitive, recreational or leisure time activities). Also include frequency and duration (or number of laps, miles, sets, games, etc.) of the activity.
BE AS SPECIFIC AS POSSIBLE!!!

Activity	Frequency (times/week)	Duration
1.______		
2.______		
3.______		
4.______		
5.______		

(If you need more space, continue on the back)

Do you have any orthopedic problems which may restrict your ability to participate in exercise consisting of stationary cycling?
YES______ NO______

If so, please explain:____
____
____

The majority of the testing for this study will be taking place Monday through Saturdays, mostly during the days. Do you forsee a problem with being able to participate on these days?
YES________ NO__________

If so, please indicate any specific days and/or times during which you are not available____________________________________
____
____

This study requires the ability to abstain from food, beverages (except water), tobacco products and analgesics (aspirin, etc.) for up to three hours prior to all experimental sessions. Do you feel capable and willing to abide by these requests?
YES_______ NO_______

EXPERIMENTAL SESSION #_____

NAME/ID______________________
DATE/TIME____________________

1. Exercise today? Y N How much and when?_______________

2. Alcohol today? Y N How much and when?_______________

3. Caffeine today? Y N How much and when?_______________

4. Tobacco today? Y N How much and when?_______________

5. Cold medication? Y N How much and when?_______________
(and/or analgesics)

6. Any food w/in the past 3 hours? Y N How much and when?_______________

BASELINE 1

Time	SBP	DBP	HR

2

Time	SBP	DBP	HR

STRESSOR 1

Time	SBP	DBP	HR

POST SESSION QUESTIONNAIRE

NAME/ID______________________________________

DATE____

SESSION #____________________________________

1. How stressful did you perceive this task?

   0------1------2------3------4------5------6

2. How well did you cope during this task?

   0------1------2------3------4------5------6

3. Do you have a fear of computers/cold?

   yes   no

BICYCLE EXERCISE TEST

Name: ______________________

SSN : ______________________

Date: ______________________

PRE-TEST MEASURES:

PBar_____mmHg   Wt_____kg   Rest HR_____BPM   Baseline VO_2_____%O_2

Room Temp_____ C   Rest BP_____mmHg   _____%CO_2

EXERCISE MEASURES

MIN	WKLOAD	HR	BP	VIATPS(L)	FeO_2	$FeCO_2$	RPE
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

POST EXERCISE MEASURES

MIN	WKLOAD	HR	BP	VIATPS(L)	FeO_2	$FeCO_2$	RPE
1							
2							
3							
4							
5							
6							

Name: ______________________________

SSN: ______________________________

Date: ______________________________

Pre-Exercise Measures

PBar ____________mmHg   Weight __________kg   Rest HR_________

Temp ____________C   BP_________

Exercise Session

MIN	WKLD	HR	BP	VIATPS	FeO2	FeCO2	RPE	VO2
1	____	____	____	______	____	_____	___	_____
2	____	____	____	______	____	_____	___	_____
3	____	____	____	______	____	_____	___	_____
4	____	____	____	______	____	_____	___	_____
5	____	____	____	______	____	_____	___	_____
9	____	____	____	______	____	_____	___	_____
10	____	____	____	______	____	_____	___	_____
15	____	____	____	______	____	_____	___	_____
19	____	____	____	______	____	_____	___	_____
20	____	____	____	______	____	_____	___	_____
29	____	____	____	______	____	_____	___	_____
30	____	____	____	______	____	_____	___	_____

SUBJECT HEALTH ASSESSMENT

NAME ______________________________

ID ______________________________

HEIGHT (CM/IN) ____________________

WEIGHT (KG/LB) ____________________

HEART RATE ________________________

BLOOD PRESSURE ____________________

FLEXIBILITY (CM) __________________

FRAME SIZE ________________________

HT/WT REC _________________________

% BODY FAT: TRICEP ______________

BICEP ______________

CHEST ______________

THIGH ______________

ABDOMEN ______________

SUPRAIL. ______________

SUBSCAP. ______________

% BODY FAT ________________________

APPENDIX D

PROTOCOLS

CARDIOVASCULAR REACTIVITY PROTOCOL
(for all sessions)

1. Seat the subject comfortably in the easy chair with their arms resting on the armrests and their feet flat on the floor.

2. Ask the subject the questions regarding compliance to the protocol.

3. Determine the subject's dominant arm and place the ice bath next to it.

4. Using the nondominant arm, palpate the brachial artery. Correctly place the BP cuff around the arm. Make sure the correct cuff size is used. Set the automated BP system for 1 minute intervals and 150 mm Hg inflation pressure.

5. Turn on the camera and make sure both the subject and the ice bath are in view. Begin recording.

6. Inform the subject that he will be hearing a tape recorded message with instructions that he is to follow then, leave the room and immediately start timing. View the subject from the observation room.

7. Begin the audiotaped instructions:

   What we want to do first of all is collect what we call baseline information; that is, how your physiological reactions are when you are at ease and resting. So what we want you to do for the next few minutes is just sit back quietly with your arms resting on the armrests, because movement interferes with the recording of physiologic reactions. At the conclusion of these instructions, we will begin collecting data. Please sit quietly until further instructed.

   When I give you the signal, I want you to place your dominant hand up to the wrist in the container of ice water and hold it there. I would like you to keep it there for 1 minute. During this time you will likely experience some discomfort. I will tell you when the minute is completed and when you may remove your hand. Remember, when I say to, place your dominant hand in the ice water and remain still. When I say to stop, gently remove your hand from the water and place it on the towel. Do not shake your hand since this movement will interfere with the measurements. Once your hand is placed gently on the towel, this task will be completed. We will now begin taking resting measurements.

8. Stop the recording and let the subject relax.

9. At the end of 5 minutes, return to the testing room to turn on the automated BP system.

10. Quickly return to the observation room. Just observe the first 5 minutes of BP and HR measurements as they appear on the computer screen as the subject stabilizes. Record the next 5 minutes of measurements. Watch the TV monitor and record any significant movements of the subject.

11. After the fifth measurement appears, restart the taped instructions:

    Please place your dominant hand up to the wrist in the water, now.

    Continue playing the tape. Record the peak measurement.

12. After one minute has been completed, the recording instructs the subject:

    Please withdraw your hand from the water. Gently place it on the towel, and remain still until final measurements for this task are completed.

    Stop the tape.

13. Continue to monitor and record recovery measurements for 5 minutes

14. Discontinue monitoring and disconnect the subject. Have the subject answer the post-session questionnaire.

15. Make print out of the data from the computer and place it along with the subject's data sheet and the completed questionnaire in the subject's folder.

MAXIMAL AEROBIC CAPACITY EXERCISE TEST

Cycle Ergometer Protocol

Stage	Minutes	Workload
I	2	25 W
II	2	50 W
III	2	100 W
IV	2	150 W
V	2	200 W
VI	2	250 W
VII	2	300 W
VIII	2	350 W

* All subjects cycled at a rate of 50 rpm until test completion.

APPENDIX E

STATISTICAL ANALYSES OF ALL SUBJECTS

Table 1. Subject Characteristics

	Trained (n=11)		Untrained (n=18)	
	M ±	SEM**	M ±	SEM
General Information:				
Age (yrs.)	22.36	0.38	19.66	0.30
Weight (kg)	71.80	3.25	79.85	2.54
Height (cm)	177.73	1.69	177.28	1.33
HR (bpm)	62.00	3.71	70.27	2.90
SBP (mm Hg)	110.73	2.92	113.78	2.28
DBP (mm Hg)	72.00	2.62	71.33	2.05
Flexibility (cm)*	31.21	2.38	24.25	1.96
% Fat++	8.98	1.27	12.14	1.00
Maximal Exercise Test Data:				
Max SBP (mm Hg)	200.82	6.01	194.83	4.70
Max DBP (mm Hg)	84.55	3.56	88.17	2.78
Max HR (bpm)	186.09	3.51	181.55	2.74
Max METs	16.45	0.59	11.05	0.46
Max VO_2 (ml/kg/min)	57.64	2.09	38.67	1.63
RER	1.16	0.04	1.13	0.03
Single Exercise Session:+				
SBP (mm Hg)	172.54	4.29	168.22	3.35
DBP (mm Hg)	75.18	2.00	80.00	1.57
HR (bpm)	149.94	3.35	146.04	2.62
RPE	13.45	0.69	13.55	0.54
Power (watts)	196.82	7.31	132.89	5.71

+ based on average values of the 30 minute session
* based on highest sit-and-reach score
++ % fat = sum of chest, abdomen, and thigh skin folds
** M ± SEM = mean ± standard error of the mean

Table 2. Resting, Peak, Reactivity, and Recovery CPT Means for Trained and Untrained Subjects

	TRAINED (n=11)		UNTRAINED (n=18)	
	M	± SEM	M	± SEM
SBP				
Baseline				
Resting*	118.00	2.76	118.72	2.16
Peak+	125.91	3.21	126.78	2.51
Change Score**	7.91	1.76	8.06	1.38
Recovery++	7.09	2.40	9.50	1.87
Exercise Condition				
Resting	110.70	1.84	116.78	1.43
Peak	118.37	1.53	123.11	1.19
Change Score	7.67	2.19	6.33	1.71
Recovery	9.42	1.94	7.72	1.51
Control Condition				
Resting	110.87	1.84	117.50	1.43
Peak	121.67	1.53	123.83	1.19
Change Score	10.80	2.19	6.33	1.71
Recovery	6.20	1.94	8.28	1.51
DBP				
Baseline				
Resting	71.09	3.05	71.50	2.39
Peak	81.18	2.89	79.78	2.26
Change Score	10.09	2.70	8.28	2.11
Recovery	-7.45	3.19	0.72	2.49
Exercise Condition				
Resting	66.55	1.57	70.72	1.23
Peak	77.77	2.34	82.50	1.82
Change Score	11.22	1.98	12.00	1.54
Recovery	9.20	2.96	1.61	2.31
Control Condition				
Resting	69.90	1.57	68.39	1.23
Peak	82.43	2.34	81.61	1.82
Change Score	12.53	1.98	13.22	1.54
Recovery	1.50	2.96	4.00	2.31
HR				
Baseline				
Resting	62.67	2.98	66.78	2.33
Peak	66.55	4.42	71.84	3.45
Change Score	4.27	2.60	5.11	2.03
Recovery	-1.73	1.40	-5.94	1.09
Exercise Condition				
Resting	63.13	1.90	69.39	1.48
Peak	65.52	2.39	76.00	1.86
Change Score	2.88	1.78	6.61	1.38
Recovery	-2.92	1.74	0.22	1.36
Control Condition				
Resting	55.05	1.90	67.39	1.48
Peak	59.53	2.39	72.50	1.86
Change Score	4.48	1.78	5.17	1.38
Recovery	-2.42	1.74	-1.44	1.36

* rest = an average of five resting measures
\+ peak = measurements at approximately 50 seconds into the CPT
** change score = peak-rest
++ recovery values = minute 1 of recovery-resting

Table 3. Reliability Estimates on SBP, DBP, and HR Reactivity for Control Sessions Performed First +
(Pearson Product Moment Correlations)

Reactivity*	r	p
SBP	.58	.14
DBP	.69	.12
HR	.32	.21

* calculated based on change scores from the CPTs during baseline sessions and control sessions performed during the first treatment period.

\+ n = 14

Table 4. Reliability Estimates on Peak SBP, DBP, and HR Measures for Control Sessions Performed First +
(Pearson Product Moment Correlations)

Reactivity*	r	p
SBP	.77	.11
DBP	.86	.06
HR	.78	.09

* calculated based on the CPTs during baseline sessions and control sessions performed during the first treatment period.
\+ n = 14

Table 5. Baseline ANOVA Table: Trained vs. Untrained

Measure	Source+++	DF	SS	F	p
Resting*					
SBP	TYPE	1	3.5613	0.04	.8385
DBP			1.1426	0.01	.9168
HR			138.5691	1.42	.2445
Peak+					
SBP	TYPE	1	5.1522	0.05	.8330
DBP			13.4594	0.15	.7051
HR			194.9432	0.91	.3490
Change Score++					
SBP	TYPE	1	0.1464	0.00	.9482
DBP			22.4453	0.28	.6009
HR			4.7990	0.06	.8014
Recovery**					
SBP	TYPE	1	39.6254	0.63	.4355
DBP			9.4547	0.08	.7735
HR			121.4255	5.66	.0247

* resting = an average of five resting measurements
\+ peak = measurements at approximately 50 seconds during the CPT
++ change score = peak-rest
** recovery = measure 1 minute post-CPT - resting
+++ TYPE = trained vs. untrained

Table 6. Treatment ANOVA Table: Resting CPT Measurements+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	548.5317	3.71	.0654
DBP			23.9676	0.21	.6517
HR			1174.1289	6.86	.0148
SBP	SEQ*	1	9.3145	0.06	.8037
DBP			31.4413	0.27	.6054
HR			36.5875	0.21	.6479
SBP	TYPE*SEQ*	1	4.5350	0.03	.8623
DBP			3.7443	0.03	.8581
HR			4.9360	0.03	.8665
SBP	TRT	1	2.6834	0.07	.7898
DBP			3.5104	0.13	.7216
HR			345.3066	8.77	.0066
SBP	TYPE*TRT	1	1.0482	0.03	.8676
DBP			109.6991	4.06	.0548
HR			125.6840	3.19	.0862
SBP	TRT*SEQ	1	1.5094	0.04	.8415
DBP			0.4705	0.02	.8961
HR			1.3863	0.04	.8527
SBP	TYPE*TRT*SEQ	1	9.4340	0.26	.6179
DBP			52.3951	1.94	.1761
HR			42.2668	1.07	.3102

\+ resting = an average of five resting measurements just prior to the CPT
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 7. Treatment ANOVA Table: Peak CPT Measurements+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	163.0656	1.13	.2983
DBP			51.3215	0.27	.6110
HR			1871.2549	6.33	.0186
SBP	SEQ*	1	7.3465	0.05	.8234
DBP			72.0186	0.37	.5473
HR			0.2042	0.00	.9792
SBP	TYPE*SEQ*	1	34.7774	0.24	.6280
DBP			81.9136	0.42	.5212
HR			36.3649	0.12	.7287
SBP	TRT	1	54.9451	2.11	.1560
DBP			48.4696	0.81	.3754
HR			305.4349	4.89	.0364
SBP	TYPE*TRT	1	22.5677	0.88	.3575
DBP			104.8218	1.76	.1964
HR			20.9443	0.34	.5678
SBP	TRT*SEQ	1	56.7815	2.21	.1495
DBP			70.4822	1.18	.2868
HR			0.7221	0.01	.9153
SBP	TYPE*TRT*SEQ	1	1.6117	0.06	.8042
DBP			26.2055	0.44	.5130
HR			51.8039	0.83	.3713

\+ peak = measurements approximately 50 seconds into the CPT
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 8. Treatment ANOVA Table: Change Score
CPT Measurements+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	113.4447	1.59	.2192
DBP			7.1599	0.06	.8041
HR			66.8682	0.62	.4383
SBP	SEQ*	1	0.1166	0.00	.9681
DBP			6.0439	0.05	.8197
HR			30.1356	0.28	.6016
SBP	TYPE*SEQ*	1	64.4294	0.90	.3513
DBP			56.6274	0.50	.4874
HR			82.2846	0.76	.3906
SBP	TRT	1	33.3434	0.63	.4331
DBP			21.8919	0.51	.4810
HR			0.0822	0.00	.9614
SBP	TYPE*TRT	1	33.3434	0.63	.4331
DBP			0.0303	0.00	.9790
HR			31.4784	0.91	.3483
SBP	TRT*SEQ	1	39.7753	0.76	.3925
DBP			65.9171	1.54	.2260
HR			1.3149	0.04	.8467
SBP	TYPE*TRT*SEQ	1	18.8444	0.36	.5546
DBP			6.3951	0.15	.7023
HR			0.1073	0.00	.9559

\+ change score = peak-rest
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 9. Treatment ANOVA Table: Recovery CPT Measurements+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	0.5246	0.01	.9424
DBP			90.5489	1.37	.2523
HR			57.1025	0.94	.3420
SBP	SEQ*	1	45.2335	0.46	.5045
DBP			116.0803	1.76	.1966
HR			165.6941	2.72	.1114
SBP	TYPE*SEQ*	1	12.1888	0.12	.7281
DBP			710.7774	10.78	.0030
HR			18.4906	0.30	.5864
SBP	TRT	1	24.0504	0.58	.4523
DBP			95.8004	1.00	.3270
HR			4.6226	0.14	.7116
SBP	TYPE*TRT	1	48.3271	1.17	.2895
DBP			345.6872	3.61	.0691
HR			15.9434	0.48	.4937
SBP	TRT*SEQ	1	59.1196	1.43	.2425
DBP			195.0205	2.03	.1661
HR			52.8407	1.60	.2177
SBP	TYPE*TRT*SEQ	1	31.8240	0.77	.3882
DBP			31.0205	0.32	.5745
HR			29.4444	0.89	.3543

\+ recovery = the first minute of recovery - rest
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 10. Summary of Selected Contrast Statements Based upon A Priori Hypotheses

Measure	Exercise vs. Control Contrast	DF	Type III SS	F	p
Resting*					
SBP	TRAINED	1	0.1515	0.00	.9747
DBP			61.2136	0.53	.4721
HR			356.4015	2.08	.1615
SBP	UNTRAINED	1	4.6944	0.03	.8599
DBP			49.0000	0.43	.5195
HR			36.0000	0.21	.6505
Peak+					
SBP	TRAINED	1	59.4000	0.41	.5273
DBP			118.7879	0.61	.4406
HR			195.2742	0.66	.4239
SBP	UNTRAINED	1	4.6944	0.03	.8584
DBP			7.1111	0.04	.8495
HR			110.2500	0.37	.5468
Change Score++					
SBP	TRAINED	1	53.5515	0.75	.3948
DBP			9.4561	0.08	.7757
HR			13.9636	0.13	.7219
SBP	UNTRAINED	1	0.0000	0.00	.9999
DBP			13.4444	0.12	.7341
HR			18.7778	0.17	.6800
Recovery**					
SBP	TRAINED	1	56.4379	0.57	.4565
DBP			323.4000	4.90	.0361
HR			1.3636	0.02	.8822
SBP	UNTRAINED	1	2.7778	0.03	.8681
DBP			51.3611	0.78	.3859
HR			25.0000	0.41	.5274

* resting = an average of five resting measurements
\+ peak = measurements at approximately 50 seconds during the CPT
++ change score = peak-rest
** recovery = measure 1 minute post-CPT - resting

Table 11. Treatment ANOVA Table: RPP Change Scores+

Source**	DF	Type III SS	F	p
TYPE*	1	54.2279	0.21	.6474
SEQ*	1	67.9186	0.27	.6090
TYPE*SEQ*	1	211.2793	0.83	.3696
TRT	1	12.9849	0.14	.7072
TYPE*TRT	1	136.4559	1.52	.2296
TRT*SEQ	1	24.3163	0.27	.6077
TYPE*TRT*SEQ	1	18.1191	0.20	.6575

\+ RPP change score = the Rate Pressure Product at peak - rest
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 12. Correlations of Maximal METs and Baseline CPT Reactivity* (Pearson Product Moment Correlations)

Reactivity	r	p
SBP	-.10	.15
DBP	.07	.19
HR	-.20	.16

* N = 29

Table 13. Correlations of Baseline Resting and Experimental Resting Data
(Pearson Product Moment Correlations)

	Reactivity	r	p
Control (N=29):			
	SBP	.67	.10
	DBP	.53	.07
	HR	.73	.09
Exercise (N=29):			
	SBP	.45	.15
	DBP	.35	.18
	HR	.76	.07

Table 14. Perception of CPT: Means

SESSION* Perception	TRAINED M	± SEM	UNTRAINED M	± SEM
I Stressfulness+	2.27	0.41	1.83	0.32
Coping Ability**	1.82	0.40	1.28	0.31
II Stressfulness	2.15	0.16	1.61	0.12
Coping Ability	2.07	0.22	1.78	0.18
III Stressfulness	1.93	0.16	1.61	0.12
Coping Ability	1.97	0.22	1.39	0.18

* session I = baseline
II = post-exercise
III = post-attention control

\+ how stressful the subject perceived the task on a scale of 0-6 (0=not stressful, 6=very stressful)

** how well the subject perceived himself to cope with the CPT on a scale of 0-6 (0=well, 6=not well)

Table 15. Perception of CPT: Baseline ANOVA

Perception	Source	DF	Type III SS	F	p
Stressfulness*	TYPE	1	1.3182	0.72	.4024
Coping Ability+			1.9939	1.14	.2952

* how stressful the subject perceived the task on a scale of 0-6 (0=not stressful, 6=very stressful)

\+ how well the subject perceived himself to cope with the CPT on a scale of 0-6 (0=well, 6=not well)

Table 16. Perception of CPT: ANOVA Table for Treatment Sessions

Perception	Source	DF	Type III SS	F	p
Stressfulness*	TYPE	1	2.5205	0.58	.4546
Coping Ability+			2.4697	0.58	.4535
Stressfulness	SEQ	1	15.6896	3.59	.0697
Coping Ability			12.1259	2.85	.1040
Stressfulness	TYPE*SEQ	1	0.0026	0.00	.9807
Coping Ability			1.2226	0.29	.5968
Stressfulness	TRT	1	0.1594	0.57	.4581
Coping Ability			0.8117	1.47	.2364
Stressfulness	TYPE*TRT	1	0.1594	0.57	.4581
Coping Ability			0.2834	0.51	.4801
Stressfulness	TRT*SEQ	1	1.0274	3.66	.0672
Coping Ability			0.0340	0.06	.8060
Stressfulness	TYPE*TRT*SEQ	1	0.1594	0.57	.4581
Coping Ability			0.0340	0.06	.8060

* how stressful the subject perceived the task on a scale of 0-6 (0=not stressful, 6=very stressful)

\+ how well the subject perceived himself to cope with the CPT on a scale of 0-6 (0=not well, 6=well)

Table 17. Secondary Analysis: Means

Parameter	TRAINED M	± SEM*	UNTRAINED M	± SEM
SBP	2.15	2.42	4.75	1.88
DBP	8.83	3.94	10.55	3.07
HR	0.36	2.61	7.47	2.04

* means = change scores calculated by subtracting baseline rest from peak

Table 18. Secondary Analysis: Summary ANOVA Table of Change Score+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	92.4851	0.73	.4025
DBP			40.4209	0.12	.7329
HR			691.4898	4.64	.0411
SBP	SEQ*	1	176.4521	1.38	.2505
DBP			113.7808	0.34	.5678
HR			0.1683	0.00	.9735
SBP	TYPE*SEQ*	1	38.2407	0.30	.5888
DBP			2.6834	0.01	.9299
HR			185.1406	1.24	.2758
SBP	TRT	1	54.9451	2.14	.1560
DBP			48.4696	0.81	.3754
HR			305.4349	4.89	.0364
SBP	TYPE*TRT	1	22.5677	0.88	.3575
DBP			104.8218	1.76	.1964
HR			20.9443	0.34	.5678
SBP	TRT*SEQ	1	56.7816	2.21	.1495
DBP			70.4822	1.18	.2868
HR			0.7221	0.01	.9153
SBP	TYPE*TRT*SEQ	1	1.6117	0.06	.8042
DBP			26.2055	0.44	.5130
HR			51.8039	0.83	.3713

\+ change score = peak-baseline resting
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

APPENDIX F

RAW DATA

Table of Subject Characteristics

					Control Session Data				
Sub	Type+	Age	WT (kg)	HT (cm)	HR	SBP	DBP	Flex (cm)*	%Fat**
1	T	22	66.0	172.5	54	112	60	29.0	7.0
2	T	22	72.1	179.0	54	116	78	28.0	10.7
3	T	22	82.5	181.5	78	102	66	31.0	11.6
4	T	22	69.0	178.5	60	112	78	32.3	8.0
5	T	25	70.2	180.5	66	92	60	37.3	7.6
6	T	21	80.0	180.0	72	120	74	32.5	12.5
7	T	25	76.7	176.5	72	110	84	22.0	11.3
8	T	22	71.0	183.5	76	128	78	24.0	8.9
9	T	22	62.0	172.0	44	104	80	43.0	6.1
10	T	22	70.8	176.0	52	114	72	38.0	7.0
11	T	21	69.5	175.0	54	108	62	26.2	7.0
12	U	19	74.4	180.0	60	100	62	0.0	10.7
13	U	21	91.7	178.0	78	112	60	25.5	16.0
14	U	19	71.8	180.0	66	110	68	30.5	9.8
15	U	19	73.3	176.5	76	106	78	41.0	8.0
16	U	21	106.8	184.0	84	120	70	23.5	24.7
17	U	21	61.3	166.5	78	126	90	27.0	12.5
18	U	19	82.6	178.0	75	118	78	22.5	8.9
19	U	20	68.5	174.0	86	110	70	26.5	7.0
20	U	19	69.8	180.0	54	124	64	29.5	8.9
21	U	20	79.9	182.5	60	102	78	28.5	8.9
22	U	18	93.5	180.5	60	110	62	26.0	13.4
23	U	20	92.4	186.0	78	110	64	15.5	16.0
24	U	18	84.5	177.0	84	132	74	16.0	19.3
25	U	19	68.5	164.0	60	126	82	28.0	12.5
26	U	19	76.0	167.5	96	124	72	23.5	18.5
27	U	19	78.5	180.0	54	108	64	24.5	10.7
28	U	20	63.5	170.3	60	98	64	33.0	6.1
29	U	23	100.3	186.3	56	112	84	15.5	6.6

+ T = trained U = untrained
* Flex = flexibility determined by the sit-and-reach in centimeters
** % Fat determined by chest, abdomen, and thigh skin folds

Table of Subject Maximum and Treatment Exercise Data

		Maximal Exercise Data+						Exercise Session Data*			
Subj	Type	MaxHR	MaxSBP	MaxDBP	MaxVO2	MaxMET	RER	EXHR	EXSBP	EXDBP	EXRPE
1	T	175	196	88	52.0	14.9	1.23	145.3	150	73	19
2	T	180	210	104	64.4	18.4	1.15	151.6	182	73	12
3	T	192	208	86	45.9	13.1	1.19	149.2	175	73	11
4	T	184	208	98	63.7	18.2	1.07	146.3	188	78	13
5	T	163	206	70	65.1	18.6	1.09	136.3	170	64	14
6	T	196	200	84	48.8	13.9	1.01	159.4	179	87	14
7	T	195	194	96	55.9	15.9	1.18	168.0	178	86	13
8	T	189	228	98	58.0	16.6	1.01	153.4	183	83	14
9	T	203	185	73	69.7	19.9	1.09	154.4	162	72	14
10	T	190	184	70	61.9	17.7	1.22	138.7	173	69	12
11	T	180	190	63	52.4	14.9	1.52	146.7	158	69	12
12	U	195	164	86	35.9	10.3	0.99	146.5	159	82	17
13	U	174	184	86	31.8	9.1	1.08	132.8	161	73	17
14	U	190	180	82	43.3	12.4	1.17	167.7	157	79	13
15	U	186	182	82	44.7	12.8	1.11	165.9	169	76	15
16	U	183	196	94	33.2	9.5	1.23	146.9	166	84	14
17	U	177	146	80	28.8	8.2	1.06	132.8	166	78	11
18	U	172	204	94	42.8	12.2	1.08	115.5	189	88	17
19	U	177	193	73	42.0	12.0	1.11	143.0	159	74	14
20	U	183	220	80	41.1	11.7	1.24	139.3	177	78	11
21	U	209	184	78	40.2	11.5	1.28	160.4	151	74	13
22	U	170	205	82	31.9	9.1	1.01	152.2	179	79	13
23	U	165	244	112	26.8	7.7	1.08	143.0	184	85	9
24	U	171	218	94	41.3	11.8	1.11	145.3	193	80	14
25	U	190	208	96	45.6	13.0	1.10	147.8	174	86	10
26	U	162	220	110	36.0	10.3	1.13	152.2	186	93	16
27	U	186	192	90	43.1	12.3	1.21	142.4	166	73	13
28	U	195	172	80	46.7	13.3	1.21	148.8	128	71	15
29	U	183	195	88	41.0	11.7	1.09	146.3	164	87	12

\+ Maximal Exercise Data: MaxHR = maximum heart rate (bpm)
MaxSBP = maximum systolic blood pressure
MaxDBP = maximum diastolic blood pressure
MaxVO2 = maximum VO2 (ml/kg/min)
RER = respiratory exchange ratio

* Treatment Exercise Data: EXHR = average heart rate (bpm) during 30 minute cycling session
EXSBP = average systolic blood pressure during 30 minute cycling session
EXDBP = average diastolic blood pressure during 30 minute cycling session
EXRPE = average rate of perceived exertion during 30 minute cycling session

Table of Resting Cardiovascular Measurements**

Subj	Status+	Type*	Seq++	BASELINE			EXERCISE			CONTROL		
				SBP	DBP	HR	SBP	DBP	HR	SBP	DBP	HR
1	R	T	C-->E	125	58	64	119	56	73	112	67	55
2	R	T	E-->C	113	76	47	103	71	52	93	67	42
3	R	T	E-->C	111	67	73	120	69	82	110	69	62
4	R	T	C-->E	123	67	63	113	66	61	99	61	55
5	R	T	C-->E	108	69	58	108	74	63	104	69	51
6	N	T	E-->C	134	80	78	115	69	77	123	74	65
7	N	T	C-->E	108	79	75	105	76	70	111	83	79
8	N	T	E-->C	125	77	68	112	67	62	120	79	60
9	N	T	E-->C	116	95	54	101	60	58	104	75	40
10	R	T	E-->C	117	57	60	109	63	51	118	68	52
11	R	T	C-->E	118	63	45	112	61	46	126	59	43
12	R	U	E-->C	108	69	61	111	72	59	106	55	72
13	R	U	C-->E	102	66	48	120	54	63	111	61	65
14	N	U	C-->E	119	72	75	105	76	83	107	73	75
15	N	U	E-->C	112	69	60	106	66	68	104	70	64
16	R	U	C-->E	117	68	67	115	74	72	118	69	61
17	N	U	C-->E	115	79	69	123	85	67	122	89	69
18	N	U	E-->C	129	79	70	125	70	60	128	78	56
19	N	U	E-->C	115	80	70	105	70	72	111	70	79
20	R	U	E-->C	133	60	64	116	70	69	118	63	54
21	R	U	E-->C	106	64	73	118	84	75	96	65	63
22	R	U	C-->E	118	63	64	125	54	80	122	55	73
23	R	U	C-->E	136	92	77	126	77	75	137	70	76
24	R	U	E-->C	125	70	65	121	60	64	128	57	74
25	R	U	C-->E	122	67	63	118	73	61	121	65	55
26	R	U	E-->C	135	82	81	132	76	78	136	72	90
27	R	U	C-->E	113	67	64	119	62	64	119	65	59
28	R	U	C-->E	114	59	82	104	69	76	109	72	77
29	R	U	E-->C	118	81	49	113	81	63	122	82	51

\+ R = reactive based on a priori of ≥ 5 mmHg DBP reactivity during baseline CVR
N = nonreactive based on a priori of < 5 mmHg DBP reactivity during baseline CVR
* T = trained U = untrained
++ Seq = sequence of treatment sessions
E = 30 minutes exercise
C = attention control
** resting = average of 5 minutes of resting measurements

Table of Peak Cardiovascular Measurements**

Subj	Status+	Type*	Seq++	BASELINE SBP	BASELINE DBP	BASELINE HR	EXERCISE SBP	EXERCISE DBP	EXERCISE HR	CONTROL SBP	CONTROL DBP	CONTROL HR
1	R	T	C-->E	135	72	80	126	70	81	134	74	60
2	R	T	E-->C	122	91	44	107	91	47	115	98	44
3	R	T	E-->C	117	83	75	124	72	80	120	76	66
4	R	T	C-->E	142	85	63	127	79	66	130	81	62
5	R	T	C-->E	111	77	58	114	81	62	102	69	55
6	N	T	E-->C	141	83	103	125	84	91	135	87	90
7	N	T	C-->E	125	79	80	109	82	68	118	88	82
8	N	T	E-->C	127	80	75	114	71	67	131	92	58
9	N	T	E-->C	120	93	59	110	60	62	104	76	37
10	R	T	E-->C	118	82	54	118	92	48	123	91	51
11	R	T	C-->E	127	68	41	126	74	49	126	79	48
12	R	U	E-->C	115	80	73	112	93	77	114	69	93
13	R	U	C-->E	110	83	51	123	60	65	115	72	60
14	N	U	C-->E	111	63	76	104	77	79	114	80	78
15	N	U	E-->C	125	69	67	118	62	68	116	90	71
16	R	U	C-->E	128	92	76	130	95	88	132	100	69
17	N	U	C-->E	127	83	89	132	101	87	139	97	84
18	N	U	E-->C	136	80	78	126	76	83	131	82	72
19	N	U	E-->C	129	76	88	118	95	86	124	86	79
20	R	U	E-->C	131	71	73	124	84	69	125	77	60
21	R	U	E-->C	117	82	60	117	88	61	116	84	66
22	R	U	C-->E	126	70	57	130	67	83	125	65	75
23	R	U	C-->E	145	104	77	130	87	81	114	81	74
24	R	U	E-->C	140	77	67	124	68	59	130	67	75
25	R	U	C-->E	130	86	65	127	92	55	124	90	57
26	R	U	E-->C	150	96	90	138	90	94	145	87	95
27	R	U	C-->E	116	72	59	117	69	65	121	68	59
28	R	U	C-->E	122	66	89	122	99	81	116	78	81
29	R	U	E-->C	124	86	59	124	82	87	128	96	57

\+ R = reactive based on a priori of ≥ 5 mmHg DBP reactivity during baseline CVR
N = nonreactive based on a priori of < 5 mmHg DBP reactivity during baseline CVR
* T = trained U = untrained
++ Seq = sequence of treatment sessions
E = 30 minutes exercise
C = attention control
** peak = measurements taken at approximately 50 seconds into the CPT

Table of Recovery Cardiovascular Measurements**

				BASELINE			EXERCISE			CONTROL		
Subj	Status+	Type*	Seq++	SBP	DBP	HR	SBP	DBP	HR	SBP	DBP	HR
1	R	T	C-->E	140	58	52	138	54	57	133	56	50
2	R	T	E-->C	120	75	42	118	84	44	95	81	38
3	R	T	E-->C	117	74	75	123	76	81	109	69	61
4	R	T	C-->E	149	70	57	122	68	57	115	66	50
5	R	T	C-->E	116	70	55	103	76	61	109	70	49
6	N	T	E-->C	144	67	75	134	107	70	123	66	64
7	N	T	C-->E	105	79	67	103	75	66	122	77	64
8	N	T	E-->C	131	77	65	114	63	63	132	91	64
9	N	T	E-->C	105	59	68	113	103	47	103	80	37
10	R	T	E-->C	127	56	65	117	68	50	124	69	52
11	R	T	C-->E	122	92	53	136	67	47	130	63	45
12	R	U	E-->C	117	71	56	115	78	65	104	50	82
13	R	U	C-->E	111	66	46	124	55	63	107	52	59
14	N	U	C-->E	126	72	69	113	79	80	120	74	72
15	N	U	E-->C	118	62	55	107	55	62	110	67	65
16	R	U	C-->E	137	80	57	133	75	72	137	83	58
17	N	U	C-->E	126	78	61	137	96	69	144	102	62
18	N	U	E-->C	134	76	67	127	71	65	127	84	66
19	N	U	E-->C	137	81	58	121	76	69	134	75	63
20	R	U	E-->C	145	62	59	121	68	57	119	58	48
21	R	U	E-->C	106	62	67	117	79	51	108	74	68
22	R	U	C-->E	126	65	60	125	62	76	125	59	74
23	R	U	C-->E	137	86	70	130	75	74	139	86	71
24	R	U	E-->C	140	85	65	121	56	55	135	56	80
25	R	U	C-->E	139	70	55	129	70	77	136	90	48
26	R	U	E-->C	149	89	71	164	91	74	151	72	78
27	R	U	C-->E	117	66	54	129	66	61	125	66	54
28	R	U	C-->E	110	49	77	106	69	76	114	72	72
29	R	U	E-->C	133	80	48	122	81	59	129	83	46

\+ R = reactive based on a priori of ≥ 5 mmHg DBP reactivity during baseline CVR
N = nonreactive based on a priori of < 5 mmHg DBP reactivity during baseline CVR

* T = trained U = untrained

++ Seq = sequence of treatment sessions
E = 30 minutes exercise
C = attention control

** recovery = first minute of 5 minutes of recovery

APPENDIX G

ADDITIONAL FIGURES

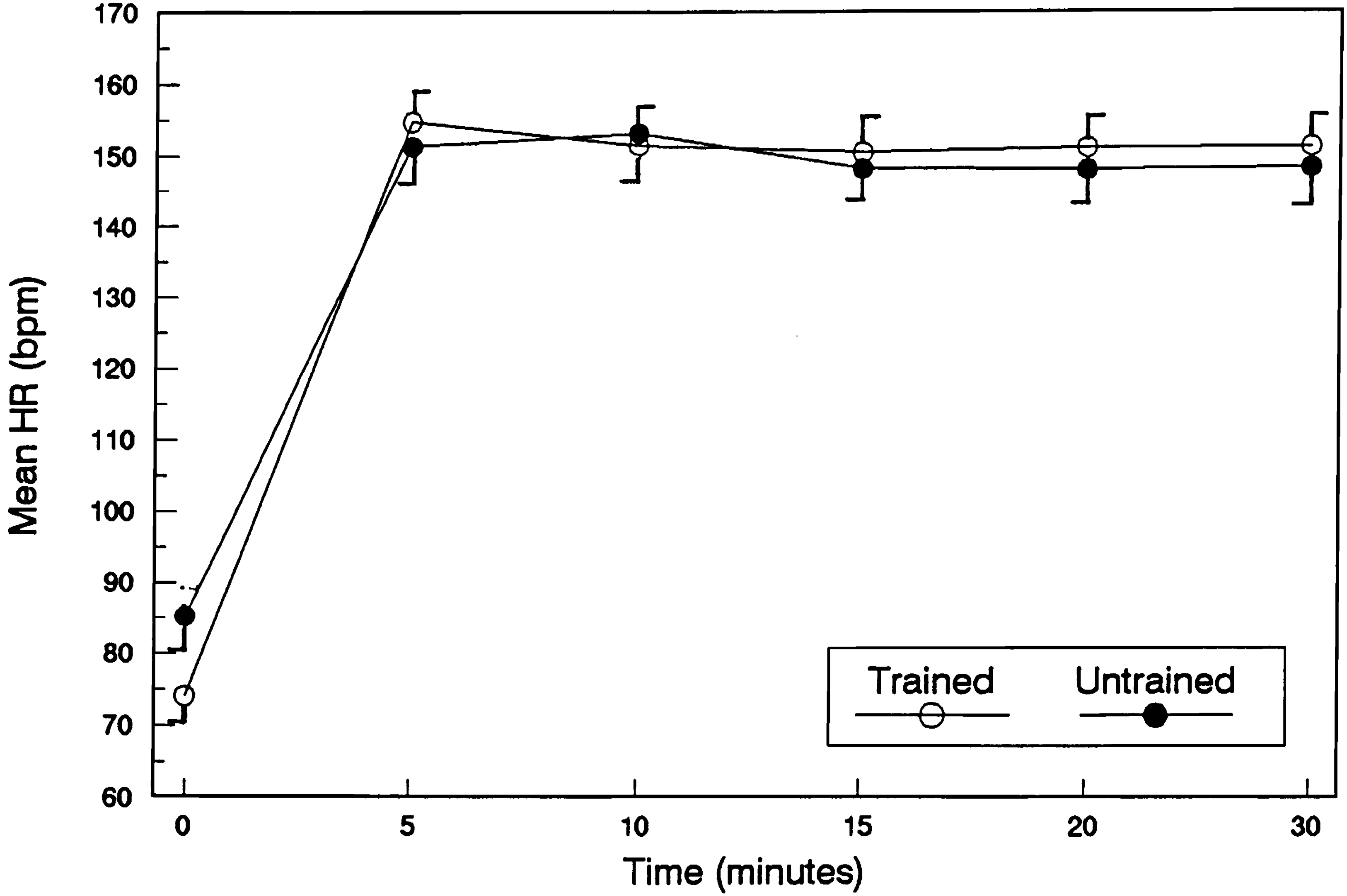

Figure 4. Heart Rate Response During Treatment Exercise

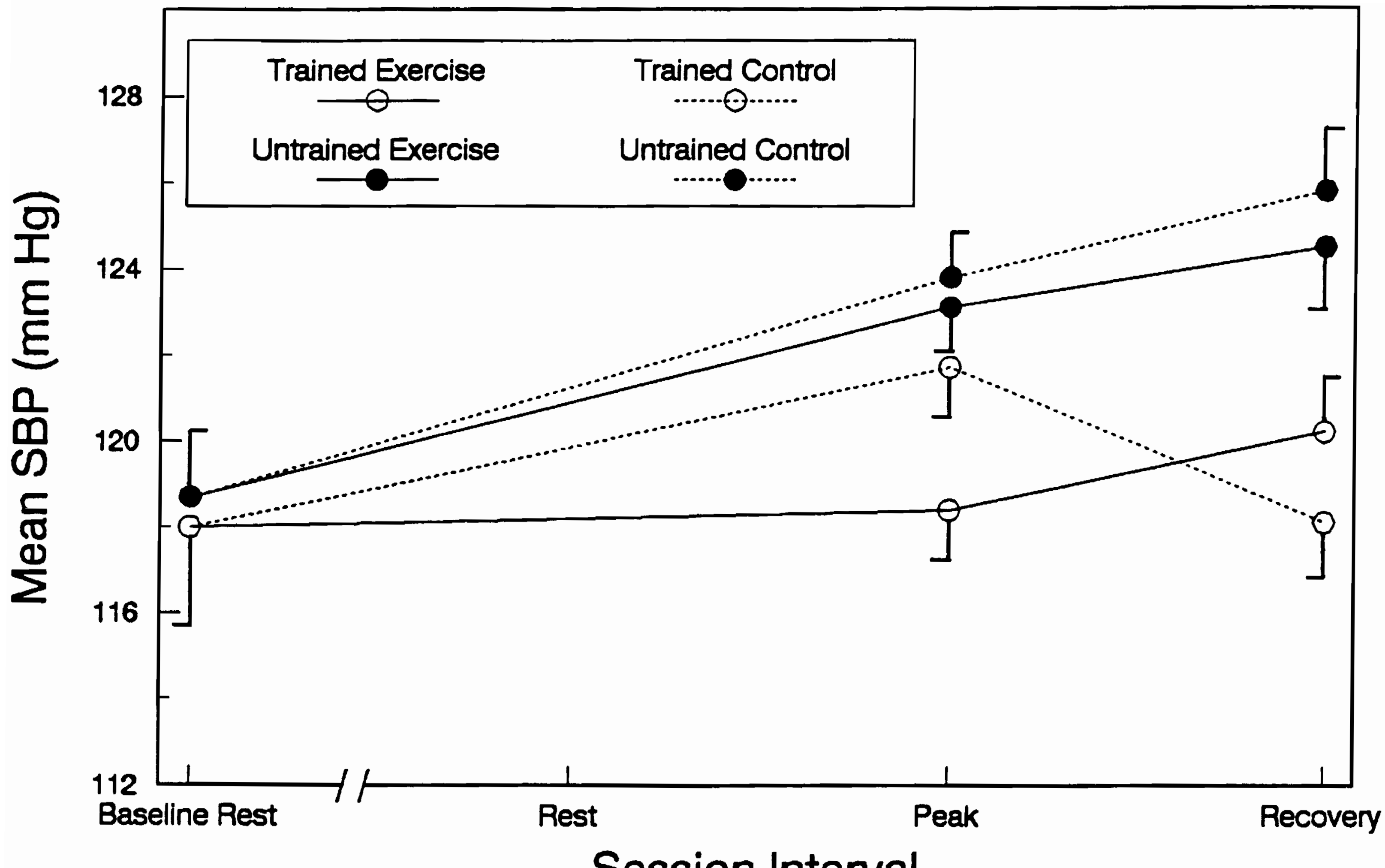

Figure 5. Secondary Analysis of Systolic Blood Pressure Using Baseline Rest Measures

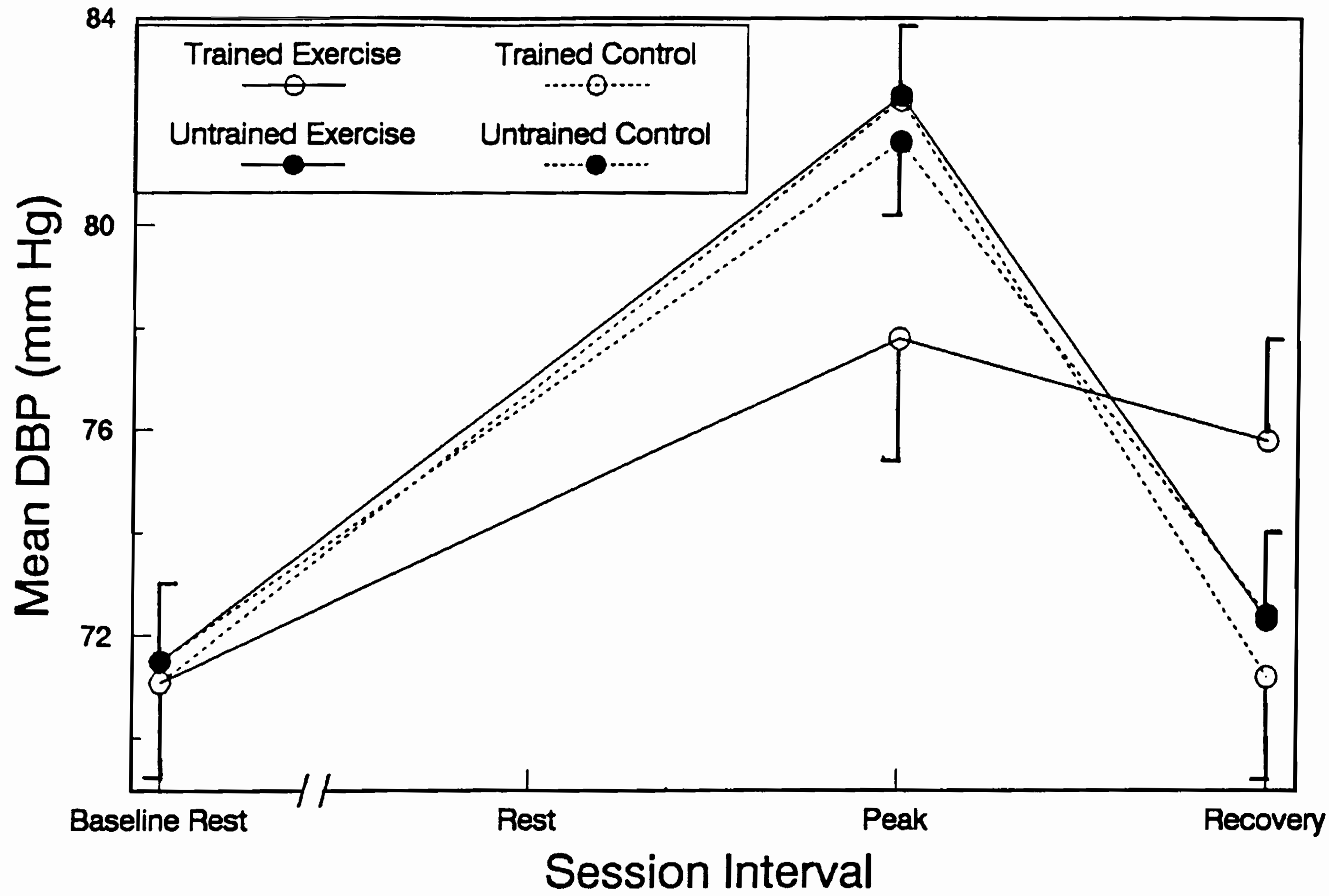

Figure 6. Secondary Analysis of Diastolic Blood Pressure Using Baseline Rest Measures

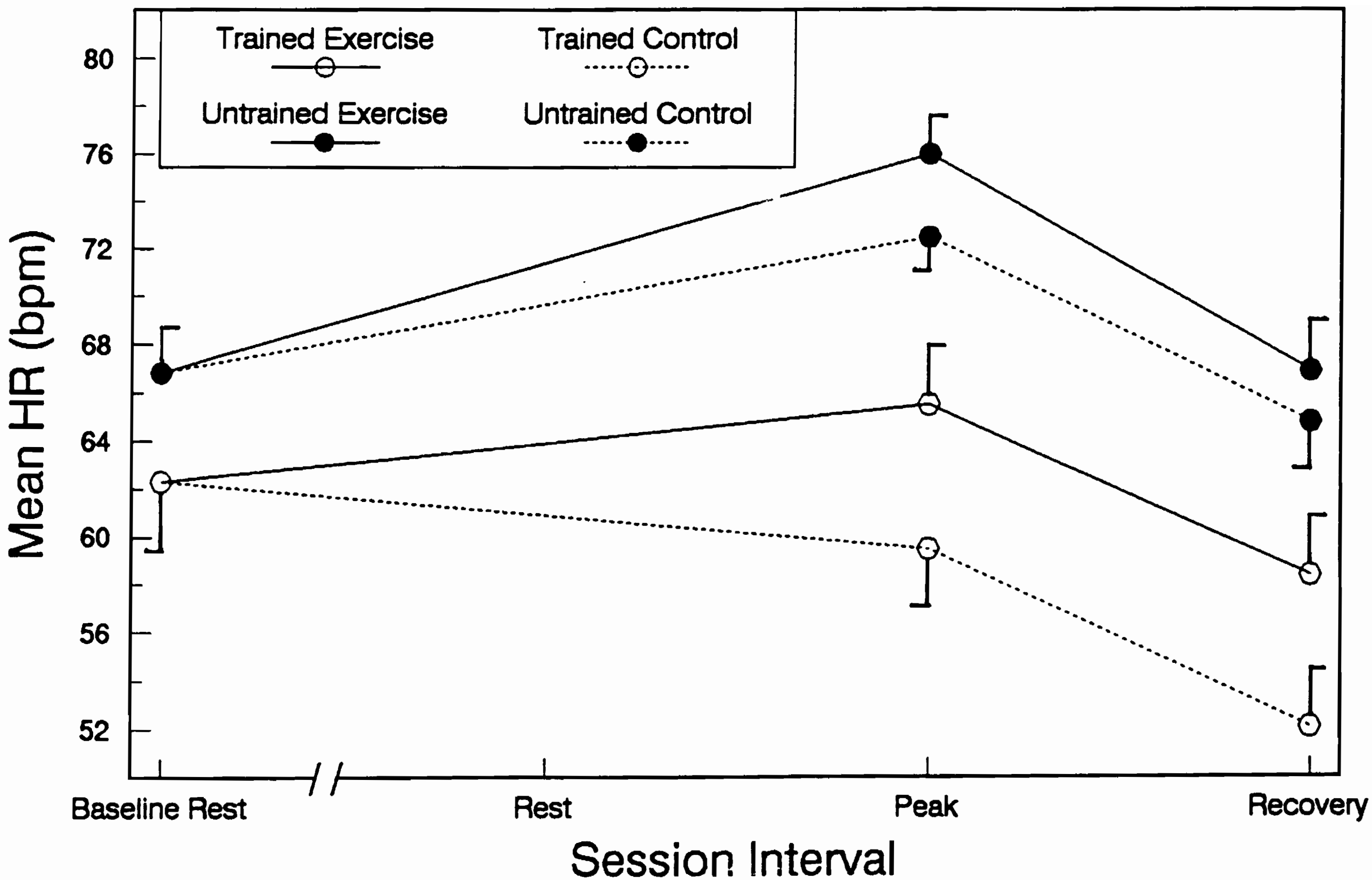

Figure 7. Secondary Analysis of Heart Rate Using Baseline Rest Measures

APPENDIX H

STATISTICAL ANALYSES OF REACTIVE SUBJECTS

Table 1. Subject Characteristics

	Trained (n=7)		Untrained (n=13)	
	M ±	SEM**	M ±	SEM
General Information:				
Age (yrs.)	22.29	0.50	19.69	0.37
Weight (kg)	71.44	4.20	83.06	3.08
Height (cm)	177.57	2.25	178.16	1.65
HR (bpm)	59.71	4.78	68.00	3.51
SBP (mm Hg)	108.00	3.78	113.69	2.77
DBP (mm Hg)	68.00	3.05	69.23	2.24
Flexibility (cm)*	31.69	2.85	22.23	2.09
% Fat++	8.41	1.74	13.25	1.27
Maximal Exercise Test Data:				
Max SBP (mm Hg)	200.29	7.17	200.15	5.26
Max DBP (mm Hg)	82.71	4.74	90.46	3.48
Max HR (bpm)	180.57	4.66	187.00	3.42
Max METs	16.39	0.75	10.87	0.55
Max VO_2 (ml/kg/min)	57.37	2.65	38.05	1.94
RER	1.21	0.04	1.14	0.03
Acute Exercise Data:+				
SBP (mm Hg)	170.86	5.99	168.31	4.40
DBP (mm Hg)	71.29	2.24	80.38	1.65
HR (bpm)	144.87	2.38	146.45	1.75
RPE	13.29	0.97	13.38	0.71
Power (watts)	194.14	9.63	132.77	7.07

\+ based on average values of the 30 minute session
* based on highest sit-and-reach score
++ % fat = sum of chest, abdomen, and thigh skin folds
** M ± SEM = mean ± standard error of the mean

Table 2. Resting, Peak, Reactivity, and Recovery CPT Means for Trained and Untrained Subjects

	TRAINED (n=7)		UNTRAINED (n=13)	
	M	± SEM	M	± SEM
SBP				
Baseline				
Resting*	116.43	3.63	119.00	2.67
Peak+	124.57	4.41	127.23	3.23
Change Score**	8.14	1.89	8.23	1.39
Recovery++	10.86	2.78	9.23	2.04
Exercise Condition				
Resting	111.83	2.67	118.32	1.94
Peak	119.79	1.66	124.27	1.21
Change Score	7.96	3.17	6.05	2.31
Recovery	10.21	2.36	7.58	1.72
Control Condition				
Resting	108.63	2.67	118.62	1.94
Peak	121.17	1.66	123.67	1.21
Change Score	11.71	3.17	5.05	2.31
Recovery	5.67	2.36	6.62	1.72
DBP				
Baseline				
Resting	64.43	3.43	69.85	2.52
Peak	79.71	3.82	81.92	2.80
Change Score	15.29	2.59	12.08	1.90
Recovery	6.29	3.07	1.77	2.25
Exercise Condition				
Resting	65.96	1.84	69.99	1.34
Peak	80.50	2.69	82.73	1.96
Change Score	9.71	2.41	13.02	1.76
Recovery	5.17	2.84	1.48	2.07
Control Condition				
Resting	66.00	1.84	65.48	1.34
Peak	82.04	2.69	79.57	1.96
Change Score	12.38	2.41	14.10	1.76
Recovery	2.63	2.84	3.56	2.07
HR				
Baseline				
Resting	58.57	3.87	66.00	2.84
Peak	59.29	4.91	68.92	3.61
Change Score	0.71	2.82	2.92	2.07
Recovery	-1.57	1.84	-5.62	1.35
Exercise Condition				
Resting	61.24	2.55	69.07	1.86
Peak	61.42	3.15	74.25	2.29
Change Score	2.00	2.29	5.18	1.67
Recovery	-4.29	2.38	0.65	1.73
Control Condition				
Resting	51.50	2.55	66.95	1.86
Peak	54.56	3.15	71.10	2.29
Change Score	3.13	2.29	4.14	1.67
Recovery	-2.08	2.38	-2.31	1.73

* rest = an average of five resting measures
\+ peak = measurements at approximately 50 seconds into the CPT
** change score = peak-rest
\++ recovery values = minute 1 of recovery-resting

Table 3. Reliability Estimates on SBP, DBP, and HR Reactivity for Control Sessions Performed First+ (Pearson Product Moment Correlations)

Reactivity*	r	p
SBP	.60	.20
DBP	.69	.19
HR	.31	.16

* calculated based on the CPTs during baseline sessions and control sessions performed during the first treatment period.
\+ n = 11

Table 4. Reliability Estimates on Peak SBP, DBP, and HR measures for Control Sessions Performed First+ (Pearson Product Moment Correlations)

Reactivity*	r	p
SBP	.72	.15
DBP	.70	.18
HR	.33	.22

* calculated based on peak measures of the CPTs during baseline sessions and control sessions performed during the first treatment period.

\+ n = 11

Table 5. Baseline ANOVA Table: Trained vs. Untrained

Measure	Source+++	DF	SS	F	p
Resting*					
SBP	TYPE	1	30.0851	0.33	.5754
DBP			133.5434	1.62	.2195
HR			251.0857	2.39	.1394
Peak+					
SBP	TYPE	1	32.1780	0.24	.6324
DBP			22.1984	0.22	.6467
HR			422.5984	2.50	.1312
Change Score++					
SBP	TYPE	1	0.0352	0.00	.9705
DBP			46.8484	0.99	.3320
HR			22.1984	0.40	.5357
Recovery**					
SBP	TYPE	1	12.0352	0.22	.6424
DBP			92.8137	1.40	.2514
HR			74.4088	3.15	.0927

* resting = an average of five resting measurements
\+ peak = measurements at approximately 50 seconds during the CPT
++ change score = peak-rest
** recovery = measure 1 minute post-CPT - resting
+++ TYPE=trained vs. untrained

Table 6. Treatment ANOVA Table: Resting CPT Measurements+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	608.3293	4.15	.0585
DBP			27.5497	0.29	.5995
HR			1224.6408	7.29	.0158
SBP	SEQ*	1	27.8448	0.19	.6687
DBP			137.9278	1.44	.2480
HR			0.0938	0.00	.9814
SBP	TYPE*SEQ*	1	9.1207	0.06	.8061
DBP			0.2401	0.00	.9607
HR			6.0896	0.04	.8514
SBP	TRT	1	18.9779	0.39	.5417
DBP			44.7620	1.93	.1835
HR			513.3467	7.04	.0174
SBP	TYPE*TRT	1	27.5334	0.56	.4635
DBP			46.4464	2.01	.1759
HR			129.6179	2.90	.1080
SBP	TRT*SEQ	1	5.6579	0.12	.7379
DBP			25.3353	1.09	.3111
HR			5.0001	0.11	.7414
SBP	TYPE*TRT*SEQ	1	1.0154	0.02	.8872
DBP			34.8864	1.51	.2374
HR			0.4579	0.10	.7557

\+ resting = an average of five resting measurements just prior to the CPT
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 7. Treatment ANOVA Table: Peak CPT Measurements+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	109.2764	0.86	.3675
DBP			0.0249	0.00	.9913
HR			1870.6724	7.01	.0176
SBP	SEQ*	1	29.0347	0.23	.6391
DBP			347.1455	1.69	.2114
HR			0.7567	0.00	.9582
SBP	TYPE*SEQ*	1	102.2401	0.80	.3830
DBP			178.3334	0.87	.3646
HR			138.4953	0.52	.4818
SBP	TRT	1	1.0134	0.05	.8199
DBP			5.8287	0.12	.7362
HR			207.0020	3.04	.1003
SBP	TYPE*TRT	1	9.6667	0.51	.4850
DBP			49.4064	1.00	.3331
HR			24.4464	0.36	.5573
SBP	TRT*SEQ	1	67.6134	3.57	.0769
DBP			1.3620	0.03	.8705
HR			51.1753	0.75	.3986
SBP	TYPE*TRT*SEQ	1	11.2801	0.60	.4512
DBP			17.6064	0.35	.5596
HR			3.2064	0.05	.8309

\+ peak = measurements approximately 50 seconds into the CPT
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 8. Treatment ANOVA Table: Change Score CPT Measurements+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	168.5017	1.93	.1834
DBP			57.3668	0.49	.4949
HR			36.9033	0.47	.5030
SBP	SEQ*	1	1.7507	0.02	.8891
DBP			35.0473	0.30	.5926
HR			0.7628	0.01	.9227
SBP	TYPE*SEQ*	1	69.5314	0.80	.3850
DBP			2.4029	0.02	.8881
HR			193.8864	2.47	.1358
SBP	TRT	1	16.9400	0.25	.6264
DBP			31.3003	0.79	.3887
HR			0.0179	0.00	.9825
SBP	TYPE*TRT	1	50.5400	0.73	.4040
DBP			5.7003	0.14	.7103
HR			10.4579	0.29	.5970
SBP	TRT*SEQ	1	87.5000	1.27	.2760
DBP			70.1270	1.76	.2033
HR			13.0179	0.36	.5557
SBP	TYPE*TRT*SEQ	1	31.5000	0.46	.5082
DBP			0.1537	0.00	.9513
HR			0.9779	0.03	.8710

\+ change score = peak-rest
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 9. Treatment ANOVA Table: Recovery CPT Measurements+

Measure	Source**	DF	Type III SS	F	p
SBP	TYPE*	1	6.9487	0.06	.8035
DBP			15.3695	0.34	.5706
HR			50.0461	0.68	.4201
SBP	SEQ*	1	37.2335	0.34	.5667
DBP			6.2056	0.14	.7177
HR			18.8491	0.26	.6185
SBP	TYPE*SEQ*	1	67.9067	0.63	.4405
DBP			184.5734	4.03	.0620
HR			0.0287	0.00	.9844
SBP	TRT	1	67.9067	1.78	.2004
DBP			0.4706	0.01	.9277
HR			1.2807	0.63	.8581
SBP	TYPE*TRT	1	28.6667	0.75	.3984
DBP			47.9150	0.86	.3664
HR			59.9334	1.55	.2317
SBP	TRT*SEQ	1	12.1334	0.32	.5803
DBP			49.6572	0.90	.3580
HR			8.2801	0.21	.6502
SBP	TYPE*TRT*SEQ	1	3.5334	0.09	.7646
DBP			21.8750	0.39	.5388
HR			20.2401	0.52	.4804

\+ recovery = the first minute of recovery - rest
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 10. Summary of Selected Contrast Statements Based upon A Priori Hypotheses

Measure	Contrast Exercise vs. Control	DF	Type III SS	F	p
Resting*					
SBP	TRAINED	1	35.2917	0.24	.6302
DBP			0.0060	0.00	.9938
HR			323.1488	1.92	.1844
SBP	UNTRAINED	1	0.5723	0.00	.9508
DBP			131.5394	1.37	.2588
HR			29.0147	0.17	.6832
Peak+					
SBP	TRAINED	1	6.4821	0.05	.8242
DBP			8.1488	0.04	.8444
HR			143.0060	0.54	.4749
SBP	UNTRAINED	1	3.1871	0.03	.8761
DBP			64.3086	0.31	.5830
HR			64.3086	0.24	.6303
Change Score++					
SBP	TRAINED	1	48.2143	0.55	.4678
DBP			24.3810	0.21	.6550
HR			4.3393	0.06	.8172
SBP	UNTRAINED	1	6.4615	0.07	.7889
DBP			7.4176	0.06	.8049
HR			6.9313	0.09	.7703
Recovery**					
SBP	TRAINED	1	70.7202	0.65	.4314
DBP			22.1488	0.48	.4969
HR			16.7202	0.23	.6389
SBP	UNTRAINED	1	6.0082	0.06	.8170
DBP			28.0449	0.61	.4455
HR			56.7775	0.78	.3911

* resting = an average of five resting measurements
\+ peak = measurements at approximately 50 seconds during the CPT
++ change score = peak-rest
** recovery = measure 1 minute post-CPT - resting

Table 11. Treatment ANOVA Table: RPP Change Scores+

Source**	DF	Type III SS	F	p
TYPE*	1	20.6566	0.10	.7502
SEQ*	1	3.7314	0.02	.8922
TYPE*SEQ*	1	500.3945	2.54	.1305
TRT	1	21.7128	0.22	.6421
TYPE*TRT	1	149.6069	1.55	.2316
TRT*SEQ	1	153.0744	1.58	.2265
TYPE*TRT*SEQ	1	15.9182	0.16	.6904

\+ RPP change score = the Rate Pressure Product at peak - rest
* uses error term SUBJ(TYPE*SEQ)
** SUBJ=subject
TYPE=trained vs. untrained
SEQ=sequence of treatment
TRT=treatment

Table 12. Correlations of Maximal METs and Baseline CPT Reactivity*
(Pearson Product Moment Correlations)

Reactivity	r	p
SBP	-.06	.24
DBP	.23	.21
HR	-.18	.18

* n = 20

Table 13. Correlations of Baseline Resting and Experimental Resting Data
(Pearson Product Moment Correlations)

	Reactivity	r	p
Control (n=20):			
	SBP	.67	.13
	DBP	.35	.17
	HR	.74	.11
Exercise (n=20):			
	SBP	.48	.17
	DBP	.51	.13
	HR	.78	.07

Table 14. Perception of CPT: Means

SESSION*	TRAINED		UNTRAINED	
Perception	M	± SEM	M	± SEM
I Stressfulness+	2.43	0.56	1.73	0.41
Coping Ability**	2.14	0.44	1.15	0.32
II Stressfulness	2.17	0.23	1.38	0.17
Coping Ability	2.50	0.21	1.59	0.16
III Stressfulness	1.79	0.23	1.50	0.17
Coping Ability	2.38	0.21	1.28	0.16

* session I = baseline
II = post-exercise
III = post-attention control

\+ how stressful the subject perceived the task on a scale of 0-6 (0=not stressful, 6=very stressful)

** how well the subject perceived himself to cope with the CPT on a scale of 0-6 (0=well, 6=not well)

Table 15. Perception of CPT: Baseline ANOVA

Perception	Source	DF	Type III SS	F	p
Stressfulness*	TYPE	1	2.2155	1.00	.3314
Coping Ability+			4.4505	3.26	.0876

* how stressful the subject perceived the task on a scale of 0-6 (0=not stressful, 6=very stressful)

\+ how well the subject perceived himself to cope with the CPT on a scale of 0-6 (0=well, 6=not well)

Table 16. Perception of CPT: ANOVA Table for Treatment Sessions

Perception	Source	DF	Type III SS	F	p
Stressfulness*	TYPE	1	2.6507	0.52	.4828
Coping Ability+			9.0497	1.77	.2017
Stressfulness	SEQ	1	5.7947	1.13	.3038
Coping Ability			11.1493	2.18	.1589
Stressfulness	TYPE*SEQ	1	0.0622	0.01	.9137
Coping Ability			0.0041	0.00	.9777
Stressfulness	TRT	1	0.1400	0.39	.5435
Coping Ability			0.4114	1.32	.2677
Stressfulness	TYPE*TRT	1	0.5600	1.54	.2323
Coping Ability			0.0714	0.23	.6388
Stressfulness	TRT*SEQ	1	0.0056	1.54	.2323
Coping Ability			0.0714	0.23	.6388
Stressfulness	TYPE*TRT*SEQ	1	0.1400	0.39	.5435
Coping Ability			0.0114	0.04	.8506

* how stressful the subject perceived the task on a scale of 0-6 (0=not stressful, 6=very stressful)

\+ how well the subject perceived himself to cope with the CPT on a scale of 0-6 (0=not well, 6=well)

VITA

Jennifer M. Young was born in 1966 in Portsmouth, Virginia. Being the daughter of a naval officer, Jennifer grew up in several different states. Her family eventually settled in Manassas, Virginia where she graduated from Osborn Park High School in 1984. She continued her education at Virginia Polytechnic Institute and State University where she received her B.S. degree in Biology.

Throughout college, Jennifer spent a lot of her time as a volunteer in the Physical Therapy Department at Montgomery County Regional Hospital. Following graduation she pursued her interest in rehabilitation at Virginia Polytechnic Institute and State University. She entered the M.S. program in Education concentrating in Adult Fitness/Cardiac Rehabilitation. After 3 years, Jennifer received her degree in June, 1991.

Jennifer hopes to develop her career within a clinical setting. Eventually, she would like to be program director of a cardiac rehabilitation center.