THE EFFECT OF AN AEROBIC TRAINING PROGRAM ON CARDIOVASCULAR REACTIVITY TO THE COLD PRESSOR TEST

by

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(ABSTRACT)

Forty-two college age students enrolled in a Personal Health class at Virginia Tech with exercise capacity $\leq$ 16 METs and diastolic blood pressure (DBP) reactivity to the cold pressor test $\geq$ 5 mm Hg were randomly assigned to either an intervention group or a control group. The intervention group was asked to participate in an aerobic exercise session 4 d/wk for 8 weeks, consisting of walking/jogging for 30 minutes at or near their target heart rate range (75-85% of heart rate reserve).

There were no significant differences between groups in terms of initial fitness levels and any blood pressure (BP) and heart rate (HR) baseline or reactivity measures. After the training program, the average increase in exercise capacity for the intervention group was significantly greater (M=1.7, SEM=0.3) than the control group (M=0.6, SEM=0.2, $p \leq .05$). No significant differences were observed in BP and HR baselines at the post-intervention cold pressor test. Controlling for pre-intervention reactivity levels by using ANCOVAs, the post-intervention

reactivity scores were found to be unaffected by group assignment. HR recovery to the cold pressor test (in the first minute) was significantly faster in the intervention group at post-intervention ($p<.05$).

No relationship was demonstrated between reported compliance to exercise and changes in fitness (i.e. submaximal predicted METs). Thus, an analysis of 8 subjects known to comply with the exercise protocol (i.e. 26 sessions attended, 87% compliance) compared to the 34 remaining subjects was completed. A significant group effect was revealed in the modification of DBP reactivity ($p<.05$) but not SBP or HR reactivity. Based upon the original experimental analysis, results from the aerobic training study do not support the hypothesis that aerobic fitness moderates CVR to environmental stress. However, the re-analysis comparing known exercise compliers to all others did support the hypothesis that aerobic fitness reduces DBP reactivity to the cold pressor test. These findings suggest a potential role of aerobic fitness in modifying CVR to environmental stress.

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I would like to thank my family who have also encouraged and supported all my endeavors. My mother has been an extraordinary inspiration to me, believing in my ability to accomplish great things. Finally, I would like to dedicate this thesis in the memory of my father. I wish he could have been here to see me complete the degree he so longed for me to have, but I know he shares in my joy. Thanks Dad for everything you have made possible for me!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

Introduction

Twentieth century culture has brought about dramatic changes in the valuation of physical fitness. Today aerobic exercise is often considered to be an essential ingredient for both physical and mental health. Despite the flourishing exercise movement, however, many people remain inactive and demonstrate little concern toward exercise and nutrition. A chronic disease associated with a sedentary lifestyle has become the main threat to health today: coronary heart disease (CHD). This disease is undeniably complex in its etiology making both treatment and study a complicated and challenging task.

Since the 1970s, approximately fifteen prospective epidemiological studies have been reported regarding the relationship between inactivity and CHD. The majority have indicated an inverse relationship between myocardial infarction (MI) and physical activity. Aerobic exercise has been found to improve blood lipid profiles, decrease blood pressure, decrease weight, and alter hormonal responses which result in reduction of risk for CHD (Dimsdale, Alpert, & Schneiderman, 1986).

A spectrum of variables--genetic, dietary, environmental, behavioral, and sociocultural--interact in unknown proportions to influence the disease process (Weiss, 1986). However, the well-documented factors account for only 50% of the known cases of disease (Jenkins, 1976). Thus it is necessary to continue in the exploration for additional variables influencing the development and progression of CHD.

There is some evidence that cardiovascular reactivity (CVR) to environmental stressors is linked to the atherosclerotic process and possibly CHD. A major portion of one's lifetime is spent acting and reacting to the environment with profound influence on the cardiovascular system. To obtain a true risk profile, measurement of parameters associated with the cardiovascular system under dynamic conditions of physical and psychological challenge ("stressors") is appropriate although often only static (resting) measures are used.

Animal models have demonstrated that cynomolgus monkeys fed a moderately atherogenic diet that were "high" heart rate reactive to a laboratory stressor (threat of capture) had significantly more coronary artery atherosclerosis than their "low" reactor counterparts (Manuck, Kaplan, & Clarckson, 1983). There were no differences in baseline HR, BP, and serum lipids implicating a CVR-atherosclerotic association. In a pioneer study of risk factors for CHD, CVR to the cold pressor test (immersion of hand in cold water) was a more powerful predictor for CHD than any of the traditional risk factors (Keys et al., 1971). In this twenty year prospective study, CVR was defined as diastolic blood pressure (DBP) increases of greater than 20 mm Hg in response to the cold pressor test. One proposed mechanism linking excessive pressor responses to disease is that a hyper-responsive cardiovascular system promotes arterial injury through hemodynamic forces, such as turbulence and shear stress (Manuck et al., 1983). Although direct causality cannot yet be inferred, evidence for a linkage between CVR to physical and psychological stressors and CHD is accumulating.

It is commonly known that cardiovascular response to exercise is altered by an aerobic fitness training program (Blomqvist & Stalin, 1986). Some important adaptations occur with fitness such as reduction of heart rate and blood pressure at rest and exercise, higher oxygen consumption and higher cardiac output during exercise. What is not known is whether these CV adaptations to exercise generalize to other environmental stressors. Exercise programs are commonly used for stress management due to a belief that aerobic fitness results in decreased anxiety as well as improved coping resources despite limited supporting data (Dimsdale, Alpert, & Schneiderman, 1986). The question remains to be answered as to the consequences of aerobic fitness on CVR to physical and psychological stressors and the possible physiological mechanisms behind any changes.

The potential for aerobic fitness as a modulator of CVR to behavioral stressors is of paramount importance in its clinical intervention possibilities for CHD. The lack of data in this area warrants further research.

Statement of the Problem

The current research literature examining aerobic fitness and CVR has a number of methodological problems which prevent clear interpretation of their findings. A number of cross-sectional studies suggest that CVR to stressors may be reduced by an aerobic fitness training program. However, self-selection factors used to define this parameter limit the usefulness of these findings. Other studies have utilized an experimental design in which the variable of aerobic fitness is actually changed through the study. Unfortunately, these experimental studies either failed to assess CVR directly or utilized stressors other than the CPT. The purpose of this study is to rectify these methodological concerns by manipulating the independent variable of aerobic fitness and observing changes in the dependent measures of BP and HR during the cold pressor test. Thus, the study is designed to determine if participation in an aerobic fitness training program results in a reduction in CVR to the only known stressor predictive of CHD.

Research Hypotheses

Ho: There is no difference in CVR (SBP, DBP, HR) to the cold-pressor test between individuals who complete an 8-week aerobic fitness training program and those who do not.

H1: Individuals receiving the aerobic training will experience a reduction in CVR at the post-intervention assessment.

Significance of the Study

Presently, there has been relatively little research dealing with the effects of aerobic fitness on CVR to non-exercise stress. If aerobic fitness can be shown to decrease CVR in a sample of basically healthy individuals, then there will be positive implications for both the primary and secondary prevention of CHD. The results of this study therefore will have implications for the use of aerobic fitness training programs to modify CVR in both healthy and clinical populations. The results may also enhance our understanding of the mechanism by which aerobic fitness hinders the development and progression of CHD.

Another risk factor for CHD, the Type A behavior pattern, is also believed to be mediated by CVR (Rosenman et al., 1975). The Type A behavior pattern is characterized by a sense of time urgency, competitiveness, and hostility. Recent research suggests that Type A individuals tend to react with greater increases in BP and HR to laboratory stressors. There is also evidence that aerobic fitness may have some beneficial effect in lowering self-reported Type A behavior (Blumenthal, 1980). Hence, aerobic training may have value in moderating both the cognitive-behavioral as well as the physiological reactivity component of the Type A behavior pattern.

Delimitations

The following delimitations were incorporated into the design of the study:

1. The subjects were individuals of college-age.
2. The aerobic fitness training program consisted of running 30 minutes 4 times per week for a period of 8 weeks.
3. The dependent measures of CVR were the changes in SBP, DBP, and HR from resting, baseline measurement to peak measurement during the cold pressor test.
4. The cold pressor test was the only stressor used.

Limitations

The following limitations may have affected the outcome of this study:

1. The process of beginning an exercise program may have led to a decreased CVR via changes in traditional cardiovascular disease risk factors, social network or behavior which may confound the parameter of aerobic fitness.
2. Subjects were taken from a volunteer pool of college

Students.

3. Subjects did not fully comply to the aerobic fitness training program.

Definitions and Symbols

Definitions and symbols that are essential to understanding this study are as follows:cold pressor test

1. Aerobic Fitness: adaptation of the cardiovascular system to repeated physical stress in terms of reduction of heart rate and systolic blood pressure at rest and exercise, and increased oxygen consumption, cardiac output, and oxygen extraction from the blood during exercise (Matthews et al., 1986).

2. Cardiovascular Reactivity (CVR): changes in the physiologic cardiovascular measurable(s) under investigation in response to a specified stimulus (Matthews et al., 1986).

3. Cold-Pressor Test: immersion of the hand (or foot) in ice water (0-3 C.) for one minutes in order to elicit a vasoconstrictive response (Matthews et al., 1986).

Basic Assumptions

The following assumptions were made by the investigator:

1. The control subjects did not alter their exercise habits during the study.

2. BP and HR are relatively stable measures for predicting CVR during the cold pressor test.

Summary

Excessive CVR to environmental stressors may play an important role in the development of CHD. Evidence that certain people at increased risk for CHD (i.e. Type As) respond to psychosocial stressors with heightened CVR and that CVR promotes the pathology of CHD (through hemodynamic and neuroendocrine responses) has tentatively been established. Still in doubt, however, is the issue of whether aerobic fitness can alter this hyper-responsivity of the cardiovascular system to stress. With the substantiation of such a hypothesis, a powerful intervention technique for physical as well as psychosocial stressors could be established and possibly utilized to control the number one killer today: coronary heart disease.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

There is a strong belief today that aerobic fitness results in decreased stress and anxiety, as well as improved coping resources; however, little evidence exists which supports such a concept (Matthews et al., 1986). Several research questions seem to be inherent in this area: (1) Does aerobic fitness lead to decreases in HR and BP responses to non-exercise stressors? (2) If present, what physiological mechanisms could account for such decreased reactivity? (3) Does aerobic fitness lead to improved morale and coping with stressors? This study focuses on the effects of aerobic fitness on CVR, an area which clearly exhibits the need for further research, by addressing the first and most basic question above.

Cardiovascular Reactivity and Aerobic Fitness

Cross-sectional Studies.

One of the earliest studies to consider the relationship between aerobic fitness and CV response to psychosocial stressors failed to demonstrate any association between these variables (Cox, Evans, & Jamieson, 1979). Like many other studies, this research used college-aged subjects who were initially tested for aerobic fitness level. Because an increase in HR has been found to be a cognitive stress response independent of physical stressors (Blixx, Stromme, and Ursin, 1974), this was the chosen measurement of reactivity. Several psychosocial stressors were presented to the subjects, the most difficult of which was the Stroop Color and Word Test. This task involved naming the colors of ink in which the names of colors were printed in rapid succession (Stroop, 1935). There was no evidence that aerobic fitness was related to magnitude of HR response to psychosocial stress; however, those with high levels of fitness recovered more quickly (Cox et al., 1979).

The previous findings of Cox et al. (1979) were limited to a single response modality narrowing the overall scope of reactivity. Thus, to obtain an integrated picture, Sinyor and his colleagues (1983) compared reactivity to psychosocial stressors with simultaneous monitoring of cardiovascular (HR), biomechanical (catecholamines), and subjective (self-reports of arousal and anxiety) indices. Paid male volunteers from ages 20-30 years were recruited and divided into trained and untrained groups of 15 subjects each. Fitness level of each subject was estimated by a bicycle ergometer test, and three tasks of psychosocial stress were employed: mental arithmetic, a question-answer series, and the Stroop Color and Word Test. From baseline measurements both groups increased indistinguishably in

HR during the stressors with the trained group returning to normal levels more quickly (Sinyor et al., 1983). This discovery replicated the previous report of Cox et al. (1979) linking aerobic fitness with increased physiological recovery from psychosocial stress.

Another investigation by Hull, Young, and Ziegler (1984) also divided subjects by degree of fitness without manipulating the variable of aerobic fitness. Four stressors were administered to the men and women aged 21-66 years: (1) a film depicting industrial accidents, (2) the Stroop Color and Word Test, (3) the cold pressor test, and (4) exercising on a treadmill to exhaustion. The results showed no preferential generalization of fitness effects to the active psychological tasks with relative HR demonstrating a reduction only to exercise in fit subjects (Hull et al., 1984). These findings were similar to those of Cox et al. (1979) and Sinyor et al. (1983) in that fit individuals seemed to react no differently than unfit individuals to psychosocial stress, but their rate of recovery was not considered.

In an attempt to correct some of the methodological problems with these previous studies (i.e. no control for initial differences in baseline HR and "ceiling" effect of intense stressors), Holmes and Roth (1985) assessed pulse rates during a baseline period, three times during a mild memory stressor, and after a recovery period of two extreme fitness groups. Highly fit subjects evinced less of a pulse rate response (approximately 7 bpm) during the stress indicating a decreased CVR. Unlike other research, however (Cox et al., 1979), no differences were observed in recovery possibly due to the low level of stress used. This varying response depending on the intensity of the stressor might bring speculation of the intensity of stress at which aerobic fitness modifies CVR during the stress response (i.e. high stress may decrease reactivity during recovery; whereas low stress may decrease reactivity during the stress itself).

Because the only study to find a decrease in HR during behavioral stress used very small groups (n=10) of fitness extremes and assessed only HR (Holmes and Roth, 1985), another group of researchers decided to substantiate these findings by dividing their 174 subjects into three self-reported fitness groups (Light, Obrist, James, & Strogate, 1987). Both HR and BP responses to a mild exercise task, a reaction-time task, and the cold pressor test were measured. The results indicated that the more fit subjects showed less of a HR and SBP response (i.e. decreased B-adrenergic, sympathetic nervous system response) to the stressful behavioral task (Light et al.,1987). No group differences were found in DBP responses to the cold pressor test similar to Hull's (1984) findings which points to a possible decreased B-adrenergic stimulation being the factor which decreases CVR in high level exercisers (Light et al., 1987).

Another study which focused on the sympathetic nervous system activity involved in the cardiovascular response to stress measured HR and T-wave amplitude (TWA) of high and low fit subject categories (Schulan, Scher, and Furedy, 1986). It was hypothesized that due to its ventricular origins, TWA should be more sensitive to sympathetic nervous system fluctuations than HR. The results were consistent with the prior findings of Cox et al., (1979), Sinyor et al., (1983), and Hull et al., (1984) in reporting that HR response to a psychological stressor is not a feature that reliably distinguishes high from low aerobic fitness subjects. The TWA did however, discriminate high from low aerobic fitness subjects during difficult but not easy tasks. Thus, there appeared to be a "floor" effect present even in the more predictive measure of TWA. Easier trials did not produce sufficient cardiac changes to manifest differences in the sympathetic stimulation of the myocardium (Shulan et al., 1986).

One of the critical issues developed in this literature is the importance of establishing a stable baseline prior to the assessment of CVR. In their study of aerobic fitness and CVR, Plante and Karpowitz (1987) found that during the baseline period, anticipatory anxiety responses may have elevated HR to such a high level that CVR to psychosocial stressors was diminished due to a "ceiling effect". The authors caution future researchers to establish an adequate baseline before conducting the stressful procedures.

Another recent study based on the premise that exercise training may decrease cardiovascular and sympathetic responses to non-exercise daily stress focused on BP and HR responses to the cold pressor test of individuals with varying levels of aerobic fitness (Rogers, Bove, Squires, & Bailey, 1988). No change in HR from rest to the cold pressor test was found, but the mean arterial pressure increased in all groups. This increase, however, was reduced in subjects engaged in cardiac rehabilitation and low level exercise and further reduced in well-trained subjects. Such a finding contradicts many of the previous studies in demonstrating an improved mean arterial response to non-exercise stress with training. Thus a trained individual may respond to cold stress with an attenuated rise in BP, producing a more favorable rate pressure product (SBP x HR) and reducing myocardial oxygen demand (Rogers et al., 1988). Once again, the authors advise of the limitations of their study pointing out that subjects volunteering for an exercise study are by definition a select group, regardless of degree of fitness.

Aerobic fitness and CVR studies have been limited by the intensity of the stressor as well as great individual variations in the stress response. To approach these problems, Claytor, Cox, Howley, Lawler and Lawler (1989) utilized an intense stressor (i.e. electric shock) to compare subjects different in CVR for differences in aerobic fitness as well as compare trained versus untrained subjects for differences in CVR. They found no significant differences between the trained and untrained groups in catecholamine levels or HR changes produced by stress (Claytor et al., 1989). This is consistent with the specificity of training theory. Also, no differences in fitness levels were found to account for differences in CVR (Claytor et al., 1989). These authors suggested focusing future research on only the most reactive of individuals.

Experimental Studies

The previous studies all dealt with aerobic fitness in a cross-sectional, static manner in which subjects were stratified by fitness levels already achieved. Keller and Seraganian (1984) conducted some of the first research manipulating the variable of aerobic fitness. Their study demonstrated the importance of determining the longitudinal effects a changed fitness level may have on CVR to psychosocial stress. In a powerful design feature, they randomized 10 male and 10 female subjects ranging between 17 and 40 years of age to one of three 10-week programs: aerobic exercise, music appreciation, or meditation. Fluctuation of electrodermal activity was used as an indirect measure of reactivity. At the beginning of this 10-week period there were no significant differences among the groups' responses to various psychological stressors (six 5-minute tasks which are explained in detail by the study). However, by the sixth week the exercise group exhibited much lower fluctuation of electrodermal activity during stress (Keller & Seraganian, 1984). This strong design could have been further enhanced by more direct measures of physiological reactivity (Matthews et al., 1986).

The only other study using an experimental design to conduct their research was the Montreal Type A Intervention Project (Roskies, Seraganian, Oseasohn, Hanley, & Collu, 1986). This investigation randomly assigned 107 male managers deemed as Type A by the Structured Interview to three 10-week treatment groups: aerobic exercise, weight-lifting, and stress-management. Of all the available studies addressing the issue of AF and its relation to CVR, Roskies' et al. (1986) demonstrates the most impressive research design. Subjects were randomly assigned to each of the three conditions. To be included in the data analysis, subjects in the exercise group were required to participate in 27 of 30 scheduled exercise sessions. Considerable effort was devoted to establishing stable baseline physiological measurements and the order of stressors was counter-balanced across treatment groups. Results however, were non-significant. All treatment groups experienced a significant reduction in CVR from pre to post intervention assessment; however, none of the treatments (aerobic exercise, weight training, stress management) was significantly superior to the others. The primary explanation given for this change in reactivity was related to the effects of habituation to the test situation. In examining the group aerobic exercise means more closely, however, it appears that the pre-post DBP reactivity was the most modifiable variable (Pre-test: x=26.2, SD=14; Post-test: x=21.4, SD= 13). This suggests that aerobic fitness may have its greatest effect on DBP reactivity which is consistent with its importance in the Keys et al. (1971) prospective study of risk factors for CHD.

Regardless of these seemingly insignificant findings, there are problems which this study did not confront which still makes aerobic fitness an important variable to investigate in terms of CVR modification. First there is the fact that although the stressors were counterbalanced, they were not the same stressors both pre and post-test. This was planned to avoid any habituation problems, but may have caused a new and larger set of problems by making the results largely un-interpretable. Also, it is known that the only stressor directly linked to CHD through CVR is the cold pressor test (Keys et al., 1971), however, this was not even one of the stressors presented in this study. Finally, rather than using a random sample of apparently normal individuals, this study focused on a very specific sample (i.e. Type A individuals). This could have skewed the results by contaminating the reactivity measures with some other factor which may be present in this group.

Cardiovascular Reactivity in Specific Populations: The Type A Behavior Pattern

Early studies focused on cardiovascular response in individuals with the Type A behavior pattern due to this behavior pattern's association with the development of CHD (Friedman and Rosenman, 1959). Since most new cases of CHD were not fully predicted by the combination of standard risk factors (Jenkins, 1976; Keys et al., 1972; Rosenman, 1977), the Type A construct gained importance in its additional predictive value for CHD (Friedman & Rosenman, 1959). It is plausible that specific behaviors of Type A individuals produce and sustain physiologic states associated with the pathological processes of CHD (Dembroski et al., 1978). In 1978, Dembroski and his colleagues attempted to establish the link between Type A behavior, arousal of the cardiovascular system, and CHD through the use of psychomotor performance challenges. Male volunteer college students ranging in age from 18-22 years completed the Jenkins Activity Survey (JAS) to determine behavior pattern prior to undergoing performance challenges. Three tasks were presented in sequence to the subjects: (1) a reaction-time task, (2) an electronic television handball game, and (3) a series of difficult anagrams. Results of this study indicated that the degree of CVR (measured by HR and BP) in response to these performance challenges was associated with the Type A behavior pattern.

A subsequent study by Corse et al. (1982) using both healthy and CHD patients as subjects, was based on this earlier investigation by Dembroski and others (1978). They found greater HR and BP elevations in Type A individuals under challenging situations. This further emphasized the potential role of CVR to stressors in linking Type A behavior to CHD (Herd, 1981; Williams, 1978).

In contrast to the negative impact of Type A behavior on the cardiovascular system are the positive adaptations brought about via long-term aerobic conditioning (Fox & Matthews, 1981). Several epidemiological studies have found physical activity to promote protection against mortality related to CHD (Kannel & Sorlie, 1979; Morris et al., 1980; Paffenbarger et al., 1978). The unknown relationship between Type A behavior, physical fitness, and CHD prompted another study using Type A/B classification as well as activity level in studying CV responses to stressful tasks. By this time, however, studies had been performed dealing with physiological reactivity to psychosocial stressors as a function of fitness (Cox et al., 1979; Hull et al., 1984; Sinyor et al., 1983). None had dealt with the interaction between aerobic fitness and Type A/B dimensions and its impact upon reactivity. Sixty-one college students were categorized as Type A or B and fit or sedentary and were challenged with 5 very different stressors (Lake, Suarez, Schneiderman, & Tocci, 1985). Lake and her co-workers (1985) found that the Type A and sedentary groups exhibited higher BP and HR responses in general. Sedentary Type As had a greater SBP response than fit Type As or both groups of Type Bs during an interpersonal communication stressor. The reactivity of fit Type As did not differ from either group of Bs during this same task possibly indicating AF as a protective mechanism against CHD.

The most recent study to examine the relationship between Type A behavior and CVR evaluated the long-term effects of several Type A intervention strategies (Schaeffer et al., 1988). Counseling, aerobic exercise, and a brief stress awareness workshop were evaluated singly and in combination for their effects on the components of Type A behavior (through the structured interview) as well as CVR (through a mental arithmetic challenge). After one year none of the groups differed on "global" Type A; however, the data suggested that the benefit of intervention was dependent on the particular component of Type A behavior in which change is desired (Schaeffer et al., 1988). Hostility and verbal competition was moderated by Type A counseling whether or not exercise was included in the intervention; however, the anger-in component was most effectively decreased by exercise. Although there was not a significant reduction in CVR with any of the interventions, a slight trend was found between aerobic fitness and a decreased physiologic stress reactivity (Schaeffer et al., 1988).

<u>Summary</u>

The current literature in this area fails to conclusively demonstrate the potential modulating role of aerobic fitness on stress-induced CVR. Early studies focused on Type A behavior and CVR, whereas physical fitness was only a secondary consideration. Most of the research completed in the area of aerobic fitness examined pre-defined groups in terms of fitness without manipulating the variable over a period of time. Only two studies have utilized an experimental design with AF as the independent variable. One study did not measure CVR directly through HR or BP. The second study was restricted to Type A individuals and did not utilize the cold pressor test, the only documented stressor for CHD risk. Further experimental studies are needed with careful attention to selection of the environmental stressor and use of appropriate CVR outcome measures. Only in this manner will it be possible to elucidate intervention techniques likely to be the most effective in reducing CVR to environmental challenges. Due to the important role exercise plays in modifying so many risk factors for CHD (blood lipids, hypertension, obesity), its role in modifying CVR, yet another potential risk factor for CHD, should be fully explored.

CHAPTER III

JOURNAL MANUSCRIPT

THE EFFECT OF AN AEROBIC TRAINING PROGRAM ON CARDIOVASCULAR REACTIVITY TO THE COLD PRESSOR TEST

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Forty-two college age students enrolled in a Personal Health class at Virginia Tech with exercise capacity $\leq$ 16 METs and diastolic blood pressure (DBP) reactivity to the cold pressor test $\geq$ 5 mm Hg were randomly assigned to either an intervention group or a control group. The intervention group was asked to participate in an aerobic exercise session 4 d/wk for 8 weeks, consisting of walking/jogging for 30 minutes at or near their target heart rate range (75-85% of heart rate reserve).

There were no significant differences between groups in terms of initial fitness levels and any blood pressure (BP) and heart rate (HR) baseline or reactivity measures. After the training program, the average increase in exercise capacity for the intervention group was significantly greater (M=1.7, SEM=0.3) than the control group (M=0.6, SEM=0.2, $p \leq .05$). No significant differences were observed in BP and HR baselines at the post-intervention cold pressor test. Controlling for pre-intervention

reactivity levels by using ANCOVAs, the post-intervention reactivity scores were found to be unaffected by group assignment. HR recovery to the cold pressor test (in the first minute) was significantly faster in the intervention group at post-intervention ($p<.05$).

No relationship was demonstrated between reported compliance to exercise and changes in fitness (i.e. submaximal predicted METs). Thus, an analysis of 8 subjects known to comply with the exercise protocol (i.e. 26 sessions attended, 87% compliance) compared to the 34 remaining subjects was completed. A significant group effect was revealed in the modification of DBP reactivity ($p<.05$) but not SBP or HR reactivity. Based upon the original experimental analysis, results from the aerobic training study do not support the hypothesis that aerobic fitness moderates CVR to environmental stress. However, the re-analysis comparing known exercise compliers to all others did support the hypothesis that aerobic fitness reduces DBP reactivity to the cold pressor test. These findings suggest a potential role of aerobic fitness in modifying CVR to environmental stress.

Introduction

Cardiovascular reactivity (CVR) to environmental stressors may be etiologically involved in the pathogenesis of coronary heart disease (CHD) (1). Repeated elicitation of the stress response involving excessive heart rate (HR) and blood pressure (BP) responses to environmental stress may promote arterial damage directly via hemodynamic shear forces and indirectly via the associated increases in serum cholesterol and neuroendocrine responses (2). Individuals exhibiting the most pronounced psychophysiologic reactivity (i.e. hyper-reactors) to behavioral stress may be at greatest risk (1). Animal models developed from cynomolgus monkeys fed a moderately atherogenic diet have supported this hypothesis. Those who were "high" HR reactors to a laboratory stressor (threat of capture) had significantly more coronary artery atherosclerosis than their "low" reactor counterparts (3). Since there were no differences in pre-treatment HR, BP, and serum lipids, the findings suggest an association between cardiovascular reactivity (CVR) and atherogenesis. In one prospective study involving a human population, those with 20 mm Hg or greater diastolic blood pressure (DBP) increase to the cold pressor test (immersion of the hand in ice water) were found to be 2.4 times more likely to manifest CHD in a 23 year follow-up study (4). Thus, there is some empirical evidence for a linkage between CVR to environmental stimuli and the development of CHD.

Although it is commonly accepted that physical exercise results in positive adaptations in aerobic fitness (i.e. reduction of HR and BP at rest and exercise; and higher VO2 and cardiac output during exercise), generalization of its modulating effect to other stressors has not been well documented (5). Most of the research has examined predefined groups in terms of aerobic fitness. One study reported that differences in aerobic power did not affect or account for differences in CVR to an environmental stressor (6). Several of these studies have reported no reduction in the magnitude of reactivity in the "fit" group, but demonstrated a faster return to baseline following stressor termination (7,8,9). However, other studies controlling for pre-treatment differences in HR and the "ceiling" effect which occurs upon exposure to intense stressors, have demonstrated that subjects with higher exercise capacities experience a decreased HR response to a mild memory stressor. They also exhibit a decreased HR and SBP response but not DBP response to the cold pressor test (10). The most recent cross-sectional study of CVR to the cold pressor test found that mean arterial reactivity blood pressure was reduced in aerobically trained subjects in a dose-response manner (11).

Only three studies have utilized an experimental design with aerobic fitness as the independent variable. Keller and Seraganian (12) reported a decline in electrodermal reactivity, a measure of autonomic nervous system function, by the sixth week of a 10 week aerobic training program. The other two studies focused on CVR but in individuals possessing the Type A behavior pattern due to the association of this behavior with the development of CHD (13). Such individuals tend to experience more extensive CVR under challenging, competitive circumstances which may form the physiological link between the Type A behavior pattern and the development of CHD (14,15,16). In the Montreal Type A Intervention Project all treatment groups (aerobic exercise, weight lifting, and stress management) experienced a significant reduction in CVR to a variety of stressors; however, the results were attributed to test-retest habituation (17). Also utilizing aerobic exercise as a Type A intervention, Schaeffer et al. (18) found no significant reduction in CVR after one year.

A number of methodological problems, however, are present in these experimental designs. None of these studies used the cold pressor test, the only stressor documented to be associated with the development of CHD in humans (4). One study did not measure CVR directly through HR or BP (12) while the others were restricted to Type A individuals (17,18). In addition, several studies made no attempt to ensure that subjects exhibited even modest levels of CVR to the experimental stressors (12,18).

In summary, the inconsistent findings noted in the studies above prevent conclusive statements regarding the ability of aerobic exercise to modify CVR to environmental stressors. Physical activity is thought to decrease CHD risk by improving blood lipids, decreasing BP, and reducing weight. Its role in reducing CVR, another possible risk factor for CHD should be explored more fully. This study utilized an experimental design to manipulate the variable of aerobic fitness. The direct effects of an aerobic training program were measured through HR and BP responsivity to the only known predictor of CHD, the cold pressor test. DBP responsivity was the parameter of focus due to its predictive relationship to CHD in the prospective study by Keys et al. (4). Thus, this study was designed to test the hypothesis that aerobic training will lower DBP reactivity to the cold pressor test.

Methodology

Design

Subjects randomly assigned to the intervention group received an 8 week aerobic training program. Control subjects were asked to maintain their usual levels of physical activity. Assessment of CVR to the cold pressor test and level of aerobic fitness were performed pre and post-intervention.

Subjects

Forty-two college age students were selected from a group of volunteers enrolled in Personal Health classes in the Fall of 1988. Subjects were awarded up to five percentage points of extra credit for participation in this experiment. To participate in the study, subjects were required to be: (1) 17-23 years of age, (2) normotensive (i.e., BP < 140/90 mm Hg), (3) free of significant orthopedic problems, (4) free of diabetes, Raynaud's Syndrome, or cardiovascular disease.

Procedures

The pre-intervention assessment was performed in three parts. Part I involved a mass testing session in which subjects completed an informed consent form and a health history form to provide information concerning possible physical limitations to participation in the study. Part II entailed a pre-intervention assessment which served as both an orientation to the laboratory environment as well as a screening procedure to eliminate those subjects with a DBP response $\leq$ 5 mm Hg. The subject was seated quietly in a video-monitored room while HR and BP was taken each minute by an automated BP monitor (Model SD-700A, Industrial & Biomedical Sensors Corporation). A stable baseline was considered to have been established when DBP had not changed more than 5 mm Hg. These three readings were averaged and utilized as the baseline level to which BP readings during the cold pressor test stressor were compared. The subjects were then administered the cold pressor test to determine CVR. After receiving verbal instructions via an intercom system from the experimenter, the subject immersed his or her left hand in ice water (0-3 C) for one minute with HR and BP being recorded at approximately 50 seconds into the task. During the task the subject received feedback regarding the amount of time remaining every 15 seconds. The subject was allowed to withdraw his or her hand from the water while HR and BP continued to be monitored at 1 minute intervals. Reactivity scores were calculated by subtracting average baseline levels from the peak level during the cold pressor test. Finally, a graded exercise treadmill test was given to estimate the subjects' baseline exercise tolerance and determine target heart rate (THR) range for exercise training. A submaximal fixed HR of 150 bpm was used to determine a predicted MET value for comparisons in this study. Those with DBP reactivity $\leq$ 5 mm Hg and an exercise tolerance > 16 METs (predicted) were eliminated from the study.

The third part of the assessment was initiated immediately prior to randomization and consisted of a second cold pressor test for those who met the initial reactivity and fitness requirements. The same protocol was followed with several modifications: a) instructions were read to the subjects for standardization purposes, b) the subjects received no time feedback from the experimenter, c) and the recovery readings were monitored until the subject's DBP was within 5 mm Hg of the initial reading or a minimum of three readings. A total of 44 subjects maintained DBP reactivity $\geq$ 5 mm Hg and were subsequently randomized to either the intervention or control group. In anticipation of a slightly greater number of drop-outs in the intervention group, 24 subjects were randomized to the intervention group while 20 were assigned to the control group.

All subjects were instructed to keep a log of all exercise performed during the intervention period. Individuals in the intervention group were also asked to participate in a group aerobic exercise session led by the first author 4 days/wk for 8 weeks. Each session lasted 40 minutes consisting of 5-minute warm-up and cool-down periods, and walking, jogging, or running for approximately 30 minutes at or near their THR range. The THR range was calculated by estimating maximum heart rate and calculating the THR range of 75-85% HR reserve using the Karvonen method (19). Subjects in the control group were asked to maintain their usual level of physical activity throughout the duration of the study.

During the 8 week training portion of the study, nine exercise sessions were offered each week to accommodate various scheduling difficulties. Intervention subjects were asked to attend a total of 4 sessions each week; however, not all subjects exercised with the group. In addition, two subjects in the intervention group were unable to complete the study due to injury and illness. After the 8-week training period, the cold pressor test was again administered in both groups to determine if there were any reductions in the magnitude or duration of CVR post-intervention.

Test-retest reliability estimates for CVR to the cold pressor test were calculated by two methods. A 1 week test-retest reliability was determined by comparing SBP, DBP, and HR from the screening to pre-intervention assessment. An 8 week test-retest reliability was determined by comparing pre to post-intervention measures for the control group only.

Statistical analyses included a series of t-tests for each of the dependent measures on SBP, DBP, and HR. Independent t-tests were calculated across groups on pre-intervention measures of aerobic fitness and CVR to determine any mean differences immediately pre-intervention. The main analysis compared change scores representing pre-intervention to post-intervention reductions in CVR to the cold pressor test. This procedure utilized analysis of covariance (ANCOVA) to adjust for any pre-intervention differences in CVR. Significance was set a priori at an alpha level of .05.

Results

The average age in both the intervention and control groups was 20 years. The control group was composed of six males

males and fourteen females while the intervention group had seven males and fifteen females. Pre-intervention mean predicted METs at a submaximal heart rate of 150 bpm in the intervention group (6.8 $\pm$ 1.9) and control group (7.3 $\pm$ 1.4) were not significantly different.

The 1-week and 8-week reliability estimates for CVR scores ranged from .47-.68 with HR demonstrating the least consistency at one week and DBP the least consistency at eight weeks. Overall, the measures of CVR appear to be only moderately reliable with no clear evidence of a degradation effect over an 8 week interval.

In order to quantify and determine any changes in aerobic fitness, independent t-tests were used to analyze submaximal MET levels pre and post-intervention. The average increase in METs for the intervention group was significantly greater (M=1.7, SEM=0.3) than the control group (M=0.6, SEM=0.2, $p < .05$). This demonstrates that the intervention group experienced some training effect although there is no way to determine the extent motivation played in changing aerobic fitness.

Mean baseline and change (reactivity) scores during the pre and post-intervention cold pressor tests are presented in Table 1. No significant group differences were observed at the outset of the study on any BP and HR baseline (SBP: $t=-1.46$, $p > .05$; DBP: $t=-0.64$, $p > .05$; HR: $t=-1.36$, $p > .05$) or reactivity measures (SBP: t=-0.21, $p > .05$; DBP: t=-0.13, $p > .05$; HR: t=-1.56, $p > .05$). The intervention group, however, demonstrated a non-significant trend toward higher baseline SBP and HR measures as well as slightly higher HR reactivity. The BP and HR baselines at the post-intervention cold pressor test once again exhibited no significant group differences (SBP: t=-1.41, $p > .05$; DBP: t=-0.21, $p > .05$; HR: t=-1.03. $p > .05$); however, the trend for slightly higher SBP and HR measures in the intervention group remained. Controlling for pre-intervention reactivity levels in an ANCOVA, the post-intervention reactivity scores were found to be unaffected by group assignment (SBP: $F(1,1)=0$, $p>.05$; DBP: $F(1,1)=.02$, $p > .05$; HR: $F(1,1)=.57$, $p > .05$).

The only finding of statistical significance was revealed by ANCOVAs generated on the post-intervention recovery data. Recovery was assessed at each minute after the cold pressor test by taking the differences in the CVR measures from the baseline (i.e. one minute recovery - baseline, two minute recovery - baseline, etc.). Using the pre-intervention recovery as the covariate, ANCOVAs were generated on all three CVR parameters for each minute of recovery. All the findings for SBP and DBP were non-significant. Only the first minute recovery HR was found to be significantly better in the exercise group rebounding approximately 5.8 bpm below their baseline ($F(1,1)=8.70$, $p < .05$).

Table 1: Pre and Post-Intervention Baseline* and Reactivity+ Measures in the Intervention and Control Group

	Intervention		Control	
SBP Measures	M	SD	M	SD
Pre-baseline	119.0	12.6	113.5	12.0
Pre-reactivity	13.6	10.5	13.0	8.2
Post-baseline	119.0	12.0	113.8	11.8
Post-reactivity	11.1	9.3	10.7	7.2
DBP Measures				
Pre-baseline	71.6	6.7	70.2	7.8
Pre-reactivity	20.8	11.8	20.3	11.3
Post-baseline	71.4	10.8	70.8	7.6
Post-reactivity	16.6	10.8	16.0	8.1
HR Measures				
Pre-baseline	75.2	12.5	70.5	9.5
Pre-reactivity	11.8	10.0	7.1	9.1
Post-baseline	75.8	10.4	71.8	14.3
Post-reactivity	5.9	7.6	4.8	10.0

* Baseline = average of three resting measures
+ Reactivity = Peak - Baseline
Note: BP measured in mmHg, HR in beats per minute.

There was a significant relationship between baseline METs and pre-intervention baseline DBP and HR indicating that those with higher submaximal predicted METs exhibited lower entry DBP and HR measures (DBP: $r=-.31$, $p<.05$; HR: $r=-.50$, $p<.05$). However, there was a lack of relationship between change in METs and change in CVR in the intervention group from pre to post-intervention (SBP: $r=-.02$, $p>.05$; DBP: $r=.11$, $p>.05$; HR: $r=-.27$, $p>.05$). In addition, there was no relationship between reported compliance to the aerobic fitness training program in the intervention group and improvement in METs ($r=.06$, $p>.05$) or reduction in CVR (SBP: $r=.27$, $p>.05$; DBP: $r=-.17$, $p>.05$; HR: $r=-.22$, $p>.05$).

The lack of a relationship between reported compliance to exercise and changes in exercise capacity (i.e. submaximal predicted METs) was alarming and suggested that the failure to detect an effect of the aerobic fitness training program on CVR might have been due to poor compliance to the training regimen. To explore the possibility, 8 individuals from the intervention group known to comply with the exercise protocol by direct observation were compared to the remaining 34 individuals including those in both intervention and control groups. This analysis defined the intervention group as those subjects with at least 87% compliance (a minimum of 26 on-site sessions attended) who worked in their THR range and remained injury free. Once again ANCOVA using pre-reactivity measures as the covariate was utilized for the data analysis. This analysis revealed a significant group effect in the modification of DBP reactivity (see Figure 1) ($F(1,1)=5.82$, $p < .05$) but not SBP or HR reactivity (SBP: $F(1,1)=.08$, $p > .05$; HR: $F(1,1)=1.34$, $p > .05$). However, all the post-intervention CVR means for the exercise compliers were lower than those of the comparison group and exhibited more impressive declines (see Table 2). Due to the substantial difference in sample size, an F'-test generated by the SAS independent t-test procedure was utilized to test the hypothesis that the variances in both groups were equal for DBP reactivity. The null hypothesis that the variances between the two groups was equal could not be rejected ($F'(7,33)=2.05$, $p > .16$); therefore the assumption of equal variances was met in the ANCOVA.

This post-hoc analysis of exercise compliers versus all others was also completed for the recovery data at minute intervals. No significant differences were found except at the third minute of DBP recovery ($F(1,1)=5.02$, $p < .05$); while there was a trend for increased DBP recovery overall in the exercise compliers.

Differences in Diastolic Blood Pressure: Effects of Exercise Compliance

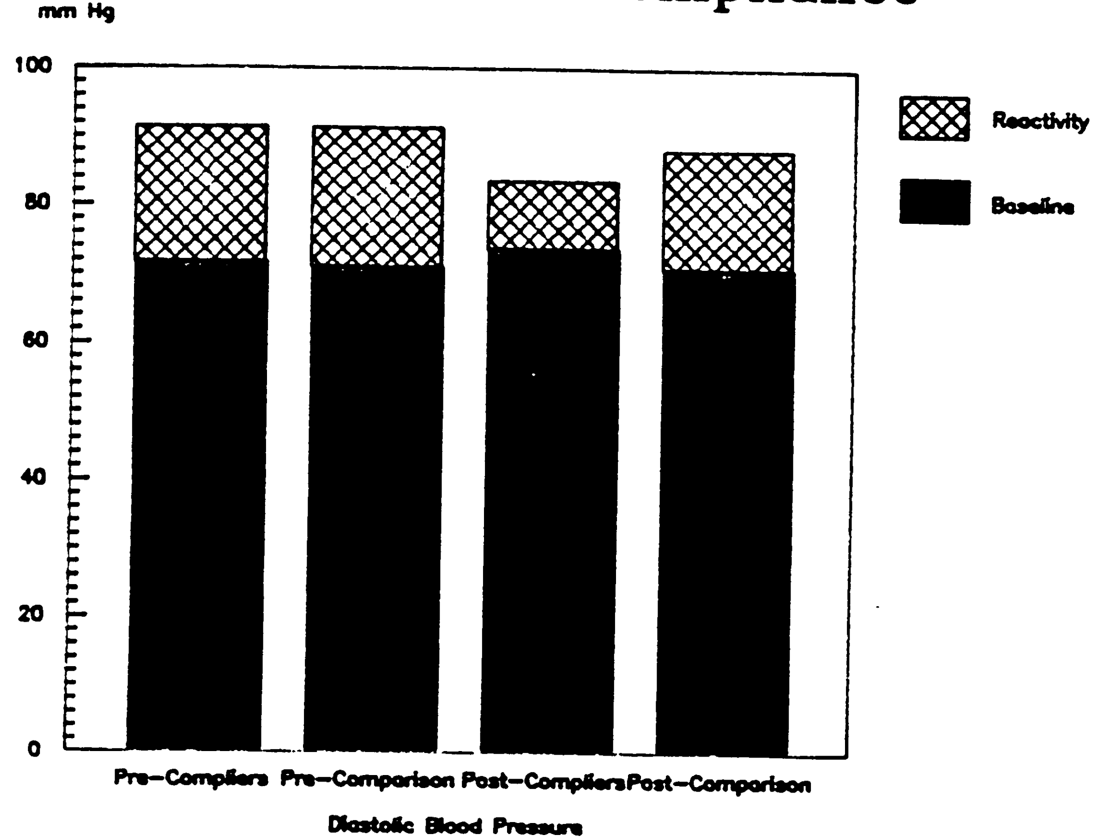

Figure 1

Table 2: Pre & Post-Intervention Baseline * and Reactivity + Measures for Subanalysis

	Compliers		Comparison	
SBP Measures	M	SD	M	SD
Pre-baseline	118.7	5.2	115.8	2.1
Pre-reactivity	11.2	4.7	13.8	1.4
Post-baseline	118.4	4.6	116.0	2.1
Post-reactivity	10.1	3.2	11.1	1.4
DBP Measures				
Pre-baseline	71.5	2.7	70.8	1.2
Pre-reactivity	20.1	3.4	20.7	2.0
Post-baseline	73.5	5.3	70.6	1.3
Post-reactivity	10.2**	4.2	17.7	1.4
HR Measures				
Pre-baseline	74.8	4.6	72.5	1.9
Pre-reactivity	10.0	4.1	9.4	1.6
Post-baseline	80.2	3.8	72.4	2.1
Post-reactivity	3.2	1.7	5.9	1.6

* Baseline = average of three resting measures
+ Reactivity = Peak - Baseline
** $p < .05$ (comparison across groups)
Note: BP measured in mmHg, HR in beats per minute.

Discussion

Results from the analysis based upon the randomized groups do not support the hypothesis that aerobic fitness moderates CVR to environmental stressors. This is consistent with the reported findings of Roskies and her colleagues (17) in the one study to date which manipulated the variable of aerobic fitness and directly measured CVR through HR and BP response. As some previous studies have noted (7,9,8,17), aerobic exercise had little to no affect on CVR to an environmental stressor (i.e. the cold pressor test) despite the increased fitness level observed in the intervention group. These results are in marked contrast however, to the promising findings of Rogers and his colleagues who found that reduction in mean arterial response to the cold pressor test decreases linearly with increasing fitness level (11).

Besides the obvious possibility that there may be no relationship between CVR and aerobic fitness, there were several methodological concerns that may have lowered the power of the present study. Modest test-retest reliability of the outcome measures and potentially low compliance to the exercise protocol may have introduced variance obscuring any relationship between aerobic fitness and CVR.

The fact that the cold pressor test exhibited only moderate test-retest reliability lowers the study's power to detect any influence aerobic fitness might have on CVR. Although there is a trend toward specific hemodynamic responsivity to the cold pressor test (i.e. increased DBP probably via an increase in peripheral resistance), the assumption of within individual consistency of physiological reactions to cold over time remains debatable (20). In addition, CVR to the cold pressor test can be biased by levels of perceived challenge, previous experience, and individual level of discomfort (20). Dembroski and MacDougall (14) showed that the magnitude of response to the cold pressor test can vary greatly for different methods of test presentation to the subjects. Any habituation effect was hoped to have been minimized by employing a screening cold pressor test. In addition, a strict protocol of administration was designed to minimize inter-test variation. However, such a procedure does not address individual perceptions, expectations and coping styles, which may have changed over time.

The issue of compliance is one of considerable importance when implementing a training study. Roskies et al. (17) included only those subjects who reached 90% participation in the exercise sessions. In this study, however, the primary analysis was based upon the "intention to treat" principle and thus included everyone who received the intervention regardless of compliance (except two subjects who dropped out of the study due to injury and illness). Unfortunately, subjects reported completing only

64% of the total number of sessions required and may have included some over-reporting of exercise sessions completed at home. Although the intervention group did experience a clinically and statistically significant increase in submaximal predicted METs, there was considerable variation in MET improvement within the group. This could, in part, explain the lack of a relationship between aerobic fitness (i.e. submaximal predicted METs) and the variables of exercise compliance and CVR.

To examine the possible role non-compliance may have had on the original analysis, a subgroup of known exercise compliers was compared to all other participants. This selected group of exercisers did indeed experience a reduction in DBP reactivity as was hypothesized in this study. A major issue when dealing with the findings of such a subanalysis is the operation of self-selection factors. Although this study manipulated the variable of aerobic fitness, those subjects who most readily complied may have characteristics which resembled those of subjects in other studies with higher fitness levels. For example, Rogers et al. (11) demonstrated that individuals with higher levels of aerobic fitness (i.e. marathoners versus medium-distance runners versus cardiac rehabilitation patients) exhibited greater reductions in mean arterial BP response to the cold pressor test. Due to factors which may be difficult to define, participants who tend to comply with exercise programs may possess an undefined attribute promoting CVR reduction. Possibly, those that really complied also had expectations which prompted their improvement. Although it is difficult to make definitive statements given the design of this post-hoc analysis, the results certainly suggest further research regarding the potential for aerobic fitness training to decrease DBP reactivity to the cold pressor test.

Returning to the original analysis, the significantly improved HR recovery of the intervention group was also consistent with the findings of prior studies. Both Cox et al. (7) and Sinyor et al. (9) demonstrated a similarly more rapid return to baseline post-stress. Because neither study utilized the cold pressor test or determined a stable baseline prior to the stressor, the present study adds new support for this perspective.

Results of this study do not support the hypothesis that increased levels of aerobic fitness decrease CVR to environmental stress when subjects randomized to exercise are compared to controls. However, the reliability of the outcome measures and questionable compliance to the aerobic training program may have undermined the power of this study to support such a hypothesis. A secondary analysis comparing known compliers to the exercise protocol with all the others did support the study's hypothesis. The latter findings suggest that future experiments utilizing aerobic training ensure strict compliance to exercise protocols.

In addition, a variety of stressors should be utilized to obtain a clearer picture of the impact aerobic fitness has on CVR to a broad range of tasks (i.e. both active as well as passive coping tasks).

Due to the fact that this study utilized healthy college students, it is also important to complete future research utilizing middle-aged and CHD populations. Rogers et al. (11) demonstrated an attenuated arterial BP response to the cold pressor test in cardiac rehabilitation exercisers as well as in younger, healthier exercisers. The possible reduction in myocardial demand resulting from this positive effect of exercise may have an even greater impact in older populations.

Results from this study do not conclusively support the hypothesis that aerobic fitness modifies CVR to environmental stress. However, the re-analysis of known exercise compliers lends support to the hypothesis that DBP reactivity to the cold pressor test may be modified by an aerobic training program. Thus, individuals adhering to an aerobic training program may benefit in terms of decreased CVR to at least some types of non-exercise stressors. Continued research in this area is necessary before the potential role of aerobic fitness in modifying CVR to stress can be clearly defined.

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CHAPTER IV

SUMMARY AND RESEARCH RECOMMENDATIONS

Summary

This study was conducted to determine if participation in an aerobic fitness training program reduces CVR (i.e. SBP,DBP,HR) to environmental stressors (i.e. the cold pressor test).

Forty-four college age students were selected from a group of volunteers to participate in this study. Pre-intervention assessment was performed in three parts. Part I entailed all subjects completing an informed consent form and a health history form to provide information concerning possible physical limitations to participation in the study. Part II entailed a screening cold pressor test and exercise tolerance test. The cold pressor test was administered first. After a stable DBP baseline was achieved (i.e. DBP within 5 mm Hg for three consecutive readings), the subject immersed his or her hand in ice water for approximately one minute with HR and BP recorded at approximately 50 seconds into the task. The subject was then allowed to withdraw his or her hand from the water while HR and BP continued to be monitored at one minute intervals. Reactivity scores were calculated by subtracting average baseline levels from the peak level during the cold pressor test. Finally a graded exercise treadmill test was given to estimate the subjects' baseline exercise tolerance. Those with DBP reactivity $\leq$ 5 mm Hg and predicted METs > 16 were eliminated from the study.

Part III of the assessment consisted of a second, more standardized, cold pressor test for those who met the initial reactivity and fitness requirements. Of the 44 subjects who maintained DBP reactivity $\geq$ 5 mm Hg, 24 were randomized to the intervention group while 20 were assigned to the control group.

All subjects kept an exercise log of all physical activities during the 8-week intervention period. The intervention group was also asked to participate in an aerobic exercise session 4 days/wk for 8 weeks which consisted of walking or jogging at or near their THR for 30 minutes. Subjects in the control group were asked to maintain their usual level of physical activity throughout the duration of the study. After the 8-week training period, both groups were again administered the cold pressor test and treadmill test to determine if there were any reductions in the magnitude or duration of CVR post-intervention as well as changes in exercise capacity.

The Statistical Analysis System (SAS) was used to conduct the statistical analysis. Reliability estimates for 1-week and 8-week CVR to the cold pressor test showed the measures to be only moderately reliable with no clear evidence of a degradation effect over the 8 week interval.

Independent t-tests were used to analyze submaximal predicted MET levels pre and post-intervention to quantify and determine any changes in aerobic fitness. A series of independent t-tests was conducted on each of the dependent measures: SBP, DBP, and HR to determine any differences in baseline or reactivity to the cold pressor test between groups. ANCOVA's were used to compare change scores representing pre-intervention to post-intervention reductions in CVR to the cold pressor test in order to adjust for any pre-intervention differences in CVR. Recovery data (i.e. differences in CVR measures from baseline at each minute of recovery) was also analyzed using ANCOVAs to control for pre-intervention recovery differences.

Finally, correlational analyses were used to determine any relationships between pre-intervention METs and pre-intervention CVR in both groups combined and the relationship between change in METs and change in CVR in the intervention group. Correlation coefficients were also developed to determine any relationship between exercise compliance in the intervention group and change in METs as well as with change in CVR.

There were no significant baseline differences between groups in terms of pre-intervention METs. The intervention group experienced a clinically and statistically significant increase in submaximal predicted METs in comparison to the control group thereby demonstrating a training effect. No significant group differences were found on any BP and HR baseline or reactivity measures on the pre-intervention cold pressor test. In addition, no significant differences were observed in these same measures at baseline during the post-intervention cold pressor test. The ANCOVA procedures were all non-significant demonstrating that the post-intervention reactivity scores were unaffected by group assignment. The same analysis applied to the recovery data found no significant differences for SBP and DBP. However, HR returned to baseline more rapidly in the intervention group.

No significant relationships were found between pre-intervention METs and pre-intervention CVR. Also, no significant relationships were demonstrated in the intervention group between change in METs and change in CVR, exercise compliance and change in METs, as well as exercise compliance and change in CVR.

Due to the lack of a relationship between reported compliance to exercise and changes in exercise capacity, a re-analysis defining the intervention group as those 8 subjects who had a minimum compliance rate of 87% (or 26 on-site sessions attended) compared to all other 34 individuals in the study was completed. The same ANCOVA procedures revealed a significant group effect in the modification of DBP reactivity but not SBP or HR reactivity. Analysis of this group's recovery data revealed a significantly better DBP recovery at three minutes.

Research Implications

The overall results of this investigation which assumed a treatment effect for all experimental subjects suggest that aerobic fitness has no effect on CVR to the cold pressor test. However, a re-analysis suggests that individuals known to comply to an aerobic fitness training program may experience a reduction in DBP to the cold pressor test. It is known that aerobic fitness decreases CVR to physical stress resulting in the positive adaptations of a reduced HR and BP response. This research does not discount the possibility that aerobic fitness may also decrease CVR to environmental stressors (i.e. reduction in DBP to the cold pressor test).

Several researchers have found aerobic exercise to have little or no effect on CVR which would be consistent with the primary results of this study (Cox et al., 1979; Sinyor et al., 1983; Hull et al., 1984; Roskies et al., 1986; and Claytor et al., 1988). This study did attempt to change apparent methodological concerns in the few experimental designs previously completed: the cold pressor test was used as it is the only environmental stressor with a documented association to the development of CHD in humans (Keys et al., 1971), CVR was measured directly through the parameters of HR and BP, a general population was used, and an attempt was made to ensure that all subjects exhibited some level of CVR to the experimental stressor. These changes, however, did not appear to alter the negative findings of previous experimental studies.

Several additional methodological concerns may have limited the power of the present investigation to demonstrate a relationship between aerobic fitness and CVR. The moderate levels of test-retest reliability to the cold pressor test demonstrated in this study may have lowered its power to detect any influence aerobic fitness might have on CVR. The consistency of the physiological reactions to the cold pressor test can be biased by levels of perceived challenge, previous experience, and individual level of discomfort (Buell et al., 1986) as well as the method of presentation to the subjects (Dembroski & MacDougall, 1986). This study employed a screening cold pressor test and also established a strict protocol of administration; however, it did not control for individual variance in coping response styles or learning histories. Other possible mechanisms to increase the reliability of the cold pressor test would be to tape instructions to decrease differences in experimenter presentation over time; improved climate control of the testing environment; and control for diet, exercise, and drug intake prior to testing.

Another problematic issue which is regularly found in training studies was compliance of the subjects to the exercise regimen. All subjects were included in the data analysis (with the exception of two individuals who were dropped due to injury and illness) even though the overall self-reported compliance average was 64% or just under two-thirds attendance to the required sessions. Roskies et al. (1986) utilized only data from subjects with a 90% compliance rate. Thus, a subgroup of exercisers known to comply to at least 87% of the protocol requirements was analyzed to obtain a more accurate treatment group.

The findings from this second analysis supported the original hypothesis in terms of a reduction in DBP reactivity to the cold pressor test. However, the findings must be accepted with considerable caution. In such a subgroup analysis true randomization no longer exists, and the operation of self-selection may influence the results. Those 8 compliant subjects may have had psychophysiological characteristics similar to subjects in previous cross-sectional studies who exhibited higher levels of aerobic fitness.

Finally, a significantly improved DBP recovery in the intervention group was consistent with the findings of other studies (Cox et al., 1979; Sinyor et al.,1983). This study adds support to the findings of these other researchers who neither utilized the cold pressor test nor determined a stable baseline prior to stressor initiation. There is a need to analyze recovery as well as reactivity data to more thoroughly understand the relationship between aerobic fitness and CVR.

Recommendations for Future Research

The inconclusive findings demonstrated in this study signifies the need for further research into the area of aerobic fitness and its effect on CVR to environmental stress. In addition to the methodological concerns addressed in the present study, its findings highlight several other significant areas of interest.

First among these areas is the need for a standardized cold pressor test. In order to secure accurate estimates of CVR to environmental stress through this method, the reliability estimates for the cold pressor test must be improved. A strict protocol of administration which reduces individual variation to the greatest extent possible needs to be employed to minimize within subject variation in expectations and coping style.

The second issue which would hold importance in future studies which manipulate the variable of aerobic fitness is compliance to the exercise regimen. When adherence to the training protocol is low, the power of the study to demonstrate a relationship between aerobic fitness and CVR is greatly diminished. All subjects need to comply to maximize the impact of aerobic fitness on CVR reduction. In addition, an expectation of improvement factor may be present if subjects are led to believe that exercise reduces CVR. To prevent this, the control group could be given an alternate, and equally plausible, yet non-functional activity in which to engage.

Finally, subject selection factors should be considered in future research to enhance the power of the studies. The most obvious method to increase power would simply be to increase the total number of subjects. Subjects may be more likely to demonstrate changes in CVR and aerobic fitness if they are more reactive and less fit at the outset.

There are several issues requiring further research which were not highlighted in this investigation. A variety of stressors should be utilized to provide more insight into the psychophysiological mechanisms related to a reduction in CVR (i.e. both active as well as passive coping tasks). Also, the different types of stressors and the mechanisms which lead to reductions in CVR during the actual presence of a stressor versus during recovery from a stressor need to be further delineated. Another factor to be considered is the association between the Type A behavior pattern and CVR. Decreased responses to stress were demonstrated in fit Type As by Lake and her colleagues (1985), but these decreases were not seen in aerobically trained Type As by Roskies et al. (1986). It may be possible that the A/B dichotomy becomes less pronounced with increasing fitness levels; however, further research into this area is necessary. Using structured interview techniques and Type A surveys before and after an aerobic fitness training program could enlighten the researcher as to any changes which may occur in behavior patterns as well as CVR with aerobic fitness.

Stemming from this tie between CVR and coping style is the ability to generalize fitness-related differences during stressful situations in more naturalistic settings (Sinyor et al., 1983). In order to achieve beneficial results in terms of decreasing CVR to aid in the prevention of CHD, it must be accomplished during everyday response to environmental stress.

Another area which requires further study deals with the effects of acute exercise on CVR. One recent finding which is promising reported a reduction in DBP responses across stressors by as much as 48% and 40% at one and three hours post-exercise respectively, with the strongest moderations in cold pressor test reactivity (Ebsen & Prkachin, 1988). Future research should administer varying intensities and durations of acute exercise to individuals, and measure their CVR to stress at several time intervals post-exercise (i.e. 1 hour, 3 hours, 12 hours, 24 hours). The effects of exercise withdrawal could then be monitored to determine the time period of optimal protection for the CV system from acute exercise. An exercise training study using a protocol similar to the one in this current study, could be performed with the inclusion of a detraining component to determine withdrawal effects on CVR of more prolonged exercise training.

Results from this study do not conclusively support the hypothesis that aerobic fitness modifies CVR to environmental stress. However, the re-analysis of known exercise compliers lends some support to the hypothesis that DBP reactivity to the cold pressor test may be modified by an aerobic training program. Future research must address the concerns noted above before the potential role of aerobic fitness in modifying CVR to stress can be clearly defined.

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APPENDIX A

METHODOLOGY

METHODOLOGY

Subject Selection

Subjects were selected from a group of volunteers enrolled in Personal Health classes in the Fall of 1988. Participation in this study allowed the student to earn up to 5 percentage points of extra credit in their Personal Health class. Extra credit was awarded on the completion of the 3-hour assessment package and compliance to the exercise training program. These points were averaged into the final grade at the end of the semester after the class grading curve had been established. The following point allotment schedule was utilized.

Completion of 2-hour pre-assessment only:	0.5 points
Completion of pre + post-assessment and	
80% compliance to exercise program:	3.0 points
90% compliance to exercise program:	4.0 points
100% compliance to exercise program:	5.0 points

As an example, an individual with an 85% average (preliminary letter grade of B) might receive an additional five points to reach an average of 90% (final letter grade of A-). Alternatively, an individual with a 76% average (Preliminary letter grade of C) might earn an additional 3.6 points to reach a 79.6% average (final letter grade of B-). This extra point system was similar in magnitude and procedure to that utilized by the Psychology Department in their Introductory Psychology classes.

To participate in the study, subjects were required to be:

1. 17-23 years of age.
2. Normotensive (i.e. < 140/90 mm Hg).
3. Free of significant orthopedic problems.
4. No history of diabetes, Raynaud's Syndrome, or cardiovascular disease.

A power analysis was calculated to estimate sample size. Given an alpha level of .05, a beta level of .20, and an estimated p and q of .33 and .13 respectively, a sample size of approximately 22 subjects in each group was needed. Thus, to achieve a power of 80% at the estimated intervention effect, the overall number of subjects needed was 44.

Procedures

Assessment was performed in three parts. Part I entailed all subjects completing an informed consent form and a health history form in a group testing format. The health history form provided information concerning possible physical limitations to participation in the study.

Part II entailed an individual session in the Behavioral Physiology Laboratory. Measurement of HR and BP were taken each minute by an automated BP monitor (Model SD-700A, Industrial &

Biomedical Sensors Corporation). The BP cuff was placed on the right arm and positioned just superior to the ante cubital fossa. Each subject was seated quietly while HR and BP were determined each minute. When DBP had not changed more than 5 mm Hg over a period of three consecutive minutes, then a stable baseline was established. These three readings were averaged and considered the baseline level to which readings during the stressor were compared.

The subjects were then administered the cold pressor test as the stressor to determine cardiovascular reactivity at the outset of the study. The subject immersed his or her left hand in ice water (0-3 degrees C) for one minute with HR and BP being recorded approximately 50 seconds into the task. Then the subject was allowed to withdraw his or her hand from the water and sit quietly while HR and BP continued to be monitored at one minute intervals. The elapsed time for this recovery was recorded. Reactivity scores were calculated by subtracting baseline levels from peak levels. Finally, a treadmill test was given to estimate the subjects' baseline exercise tolerance and determine target heart rate range for exercise. A submaximal fixed HR of 150 bpm was used to determine predicted MET values for comparisons in this study. Those with DBP reactivity $\leq$ 5 mm Hg and an exercise tolerance > 16 METs (predicted) were eliminated from the study.

The third part of the assessment consisted of a more stringent CPT for those who met the initial reactivity and fitness requirements. The same protocol was followed with several modifications: instructions were read to the subjects for standardization purposes, the subjects received no time feedback from the experimenter, and the recovery readings were monitored until subjects DBP was within 5 mm Hg of the initial reading or a minimum of three readings.

Subjects were instructed to keep an exercise log of all physical activities regardless of group assignment, and the intervention group was also asked to participate in an exercise session 4 d/wk for 8 weeks. Nine exercise sessions were offered each week to accommodate various scheduling difficulties. Each group session lasted 40 minutes and consisted of walking, jogging, or running for approximately 30 minutes at or near their target heart rate (THR) range. The THR range was calculated by estimating maximum heart rate and calculating the THR range of 75-85% heart rate reserve using the Karvonen method. Subjects in the control group were asked to maintain their usual level of physical activity throughout the duration of the study.

After the 8-week training period, both groups were again administered the cold pressor test to determine if there were any reductions in the magnitude or duration of CVR. Subjects were debriefed regarding their study participation following the post-intervention assessment.

Research Design

A randomized control group pretest-posttest design was used in this study. The subjects were randomly assigned to either an experimental or control group.

Statistical Analyses

Reliability Estimate. To estimate the consistency of measurement techniques which were used to assess the subjects' test values, reliability estimates were calculated by comparing baseline SBP, DBP, and HR from the screening to pre-intervention assessments (1 week test-retest reliability) and using the data from the control group from pre to post-intervention assessments (8 week test-retest).

External Validity Parameters. The subjects of this study were volunteers who were randomly assigned to an experimental or control group. The sampling procedure utilized allowed the researcher to generalize to a college-aged population.

Internal Validity Parameters. Variance was minimized in this study by: (a) having a control group; (b) calibrating the equipment prior to all testing; and (c) having the post-testing identical to the pretesting procedures. In addition, all psychophysiological assessments were performed by the same researcher and assistant to minimize changes in psychophysiological functioning associated with novel interpersonal relationships.

Data Analyses. Statistical analyses included a series of t-tests for each of the dependent measures: SBP, DBP, and HR. Independent t-tests were calculated on the pretest variables to determine homogeneity of variance. The main analysis compared change scores representing pre-intervention to post-intervention reductions in CVR to the cold pressor test. This procedure utilized analysis of covariance to adjust for any pre-intervention baseline differences. Finally, a re-analysis of the data using 8 individuals from the intervention group known to comply with the exercise protocol by direct observation (i.e. a minimum of 26 on-site sessions attended or 87% compliance) were compared to the remaining 34 individuals. Significance was set a priori at an alpha level of .05. All data was analyzed using the Statistical Analysis System (SAS). The summary results for all these measures may be found in Appendix B.

Statistical analyses revealed no significant differences between groups in terms of age, sex, and entry submaximal predicted MET levels. Analysis comparing the change in submaximal predicted MET levels after the 8 week training program found significantly greater increases for the intervention group.

No significant differences were observed at the outset of the study on any BP and HR baseline or reactivity measures. Also, there were no differences between HR and BP baselines at the post-intervention cold pressor test.

Analysis comparing the post-intervention reactivity levels found the scores to be unaffected by group assignment.

A recovery analysis was generated on all three CVR parameters for each minute of recovery. The findings for SBP and DBP were non-significant. Only the first minute recovery HR was found to be significantly better in the intervention group with a more rapid return to baseline or below.

There was no relationship between baseline submaximal predicted METs and pre-intervention CVR for either group. There was also a lack of relationship between change in METs and change in CVR in the intervention group. In addition, there was no relationship between compliance to the aerobic fitness training program and submaximal METs or compliance and change in CVR.

Utilizing data from a subgroup of known compliers, ANCOVA revealed a significant group effect in the modification of DBP reactivity but not SBP or HR reactivity. However, all the post-intervention CVR means for the exercise compliers were lower than those of the comparison group and exhibited greater declines.

Conclusions

Based upon the overall results of this study, the researcher concludes that aerobic fitness does not reduce CVR to the cold pressor test. However, the results from an analysis of known aerobic training compliers supported the hypothesis that aerobic exercise moderates DBP reactivity to environmental stress.

APPENDIX B

STATISTICAL ANALYSES

Table of Subject Characteristics

	Control	Exercise
Number	20	22
Age(Mean)	20	20
Sex	6 male	7 male
	14 female	15 female
Pre-intervention submaximal METs*	6.8 ± 1.9	7.3 ± 1.4

* mean ± S.D.

Table of Comparison of Auscultation to the Automated

Blood Pressure Monitor

Measure	r	p	cd*
SBP	.99	.56	.02
DBP	.92	.08	.15

Note: Comparison of ambulatory blood pressure monitor to auscultation using mercury manometer and 5th phase DBP.
* cd = coefficient of determination

Table of Reliability Estimates
(Pearson Correlation Coefficients)

	r	p
One Week Screening-Pre +		
SBP Reactivity	.61	.0001
DBP Reactivity	.61	.0001
HR Reactivity	.47	.0004
Eight Week Pre-Post * ++		
SBP Reactivity	.68	.001
DBP Reactivity	.51	.0207
HR Reactivity	.64	.0025

+ n=42

++ n=20

* Calculated using control group only

Table of Independent t-Test Results for Pre-intervention

Baseline Measures *

Measure	M	SD	t
SBP Baseline			
Control	113.5	12.0	-1.46
Exercise	119.0	12.6	
DBP Baseline			
Control	70.2	7.8	-0.64
Exercise	71.6	6.7	
HR Baseline			
Control	70.5	9.5	-1.36
Exercise	75.2	12.5	

* Baseline = average of three resting measures
Note: All t-tests are non-significant at an alpha level of .05.

Table of Independent t-Test Results for Pre-Intervention Reactivity Measures *

Measure	M	SD	t
SBP Reactivity			
Control	13.0	8.2	-0.21
Exercise	13.6	10.5	
DBP Reactivity			
Control	20.3	11.3	-0.13
Exercise	20.8	11.8	
HR Reactivity			
Control	7.1	9.1	-1.56
Exercise	11.8	10.0	

* Reactivity = Peak - Baseline
Note: All t-tests are non-significant at an alpha level of .05.

Table of Independent t-Test Results for Post-Intervention Baseline Measures *

Measure	M	SD	t
SBP Baseline			
Control	113.8	11.8	-1.41
Exercise	119.0	12.0	
DBP Baseline			
Control	70.8	7.6	-0.21
Exercise	71.4	10.8	
HR Baseline			
Control	71.8	14.3	-1.03
Exercise	75.8	10.4	

* Baseline = average of three resting measures
Note: All t-tests are non-significant at an alpha level of .05.

Table of Independent t-Test Results for Post-Intervention Reactivity Measures *

Measure	M	SD	t
SBP Reactivity			
Control	10.7	7.2	-0.16
Exercise	11.1	9.3	
DBP Reactivity			
Control	16.0	8.1	-1.56
Exercise	16.6	10.8	
HR Reactivity			
Control	4.8	10.0	-0.40
Exercise	5.9	7.6	

* Reactivity = Peak - Baseline

Table of Independent t-Test Results for Pre & Post-Intervention Submaximal Predicted METs

Measure	M	SD	t
Baseline METs			
Control	7.3	1.4	1.00
Exercise	6.8	1.9	
Post METs			
Control	7.9	1.4	-1.30
Exercise	8.5	1.6	
Change in METs			
Control	0.6	0.9	-3.10 *
Exercise	1.7	1.4	

* $p < .05$

Table of Dependent t-Test Results for Pre to Post-Intervention Differences**

Measure	M	SEM	t
Baseline SBP Difference			
Control	0.30	0.56	0.53
Exercise	-0.08	0.70	-0.11
Baseline DBP Difference			
Control	0.65	1.65	0.39
Exercise	-0.18	1.66	-0.11
Baseline HR Difference			
Control	1.25	3.23	0.39
Exercise	0.56	2.23	0.25
Peak SBP Difference			
Control	-2.00	1.61	-1.24
Exercise	-2.59	1.53	-1.70
Peak DBP Difference			
Control	-3.70	2.18	-1.69
Exercise	-4.41	2.66	-1.66
Peak HR Difference			
Control	-1.05	3.04	-0.35
Exercise	-5.27	2.13	-2.47*

* $p < .05$
** Difference = Post - Pre
Peak Difference = Peak post - Peak pre

Summary ANCOVA Table for Post SBP Reactivity

Source	Type III SS	df	F	p>F
Group	0	1	0	.99
SBP Reactivity	1436	1	41.67	.0001*

* $p < .05$

Summary ANCOVA Table for Post DBP Reactivity

Source	Type III SS	df	F	p>F
Group	1.53	1	0.02	.88
SBP Reactivity	1080.47	1	16.07	.0003*

* $p < .05$

Summary ANCOVA Table for Post HR Reactivity

Source	Type III SS	df	F	p>F
Group	26.49	1	0.57	.45
HR Reactivity	1277.98	1	27.36	.0001*

* $p < .05$

Summary ANCOVA Table for Post SBP Recovery
(One Minute)

Source	Type III SS	df	F	p>F
Group	10.39	1	.26	.6131
Pre SBP Recovery	1073.22	1	26.86	.0001 *

* P < .05

Summary ANCOVA Table for Post DBP Recovery
(One Minute)

Source	Type III SS	df	F	p>F
Group	15.60	1	.37	.5441
Pre DBP Recovery	153.19	1	3.68	.0625

* p < .05

Summary ANCOVA Table for Post HR Recovery
(One Minute)

Source	Type III SS	df	F	p>F
Group	344.98	1	8.70	.0054*
Pre HR Recovery	131.78	1	3.32	.0761

*p < .05

Summary ANCOVA Table for Post SBP Recovery
Compliers v. Comparison
(One Minute)

Source	Type III SS	df	F	p>F
Group	1.52	1	0.04	.8340
Pre SBP Recovery	405.05	1	11.83	.0014*
Post SBP Reactivity	28.10	1	0.82	.3707

*p < .05

Summary ANCOVA Table for Post SBP Recovery
Compliers v. Comparison
(Two Minute)

Source	Type III SS	df	F	p>F
Group	11.17	1	0.28	.5972
Pre SBP Recovery	0.06	1	0.00	.9683
Post SBP Reactivity	675.27	1	17.17	.0002*

*p < .05

Summary ANCOVA Table for Post SBP Recovery
Compliers v. Comparison
(Three Minute)

Source	Type III SS	df	F	p>F
Group	21.11	1	0.62	.4377
Pre SBP Recovery	579.61	1	16.90	.0002
Post SBP Reactivity	12.58	1	0.37	.5485*

* p <.05

Summary ANCOVA Table for Post DBP Recovery
Compliers v. Comparison
(One Minute)

Source	Type III SS	df	F	p>F
Group	136.67	1	3.06	.0883
Pre DBP Recovery	4.52	1	0.01	.7523
Post DBP Reactivity	185.32	1	4.15	.0487*

* p <.05

Summary ANCOVA Table for Post DBP Recovery
Compliers v. Comparison
(Two Minute)

Source	Type III SS	df	F	p>F
Group	220.42	1	2.78	.1039
Pre DBP Recovery	22.64	1	0.29	.5965
Post DBP Reactivity	74.04	1	0.93	.3404

* $p < .05$

Summary ANCOVA Table for Post DBP Recovery
Compliers v. Comparison
(Three Minute)

Source	Type III SS	df	F	p>F
Group	286.14	1	5.02	.0312*
Pre DBP Recovery	54.44	1	0.95	.3350
Post DBP Reactivity	475.73	1	8.34	.0064*

* p <.05

Summary ANCOVA Table for Post HR Recovery
Compliers v. Comparison
(One Minute)

Source	Type III SS	df	F	p>F
Group	.003	1	0.00	.9937
Pre HR Recovery	63.74	1	1.29	.2638
Post HR Reactivity	286.19	1	5.78	.0212*

* $p < .05$

Summary ANCOVA Table for Post HR Recovery
Compliers v. Comparison
(Two Minute)

Source	Type III SS	df	F	p>F
Group	20.44	1	0.53	.4691
Pre HR Recovery	0.55	1	0.01	.9048
Post HR Reactivity	389.49	1	10.45	.0025 *

* $p < .05$

Summary ANCOVA Table for Post HR Recovery
Compliers v. Comparison
(Three Minute)

Source	Type III SS	df	F	p>F
Group	15.60	1	0.35	.5560
Pre HR Recovery	23.25	1	0.53	.4727
Post HR Reactivity	602.02	1	13.62	.0007 *

* p <.05

Table of Relationship of METs to Reactivity
(Pearson Correlation Coefficients)

Measure	r
Baseline METs to Pre-intervention SBP Reactivity	
Control	.15
Exercise	-.22
Both groups	.14
Baseline METs to Pre-intervention DBP Reactivity	
Control	.45 *
Exercise	.09
Both groups	-.31 *
Baseline METs to Pre-intervention HR Reactivity	
Control	.01
Exercise	-.26
Both groups	-.50 *
Change in METs - Change in SBP Reactivity	
Control	-.36
Exercise	-.03
Change in METs - Change in DBP Reactivity	
Control	.44
Exercise	.11
Change in METs - Change in HR Reactivity	
Control	.06
Exercise	-.27

* $p < .05$.

Table of Relationship of Compliance to METs & Reactivity *
(Pearson Correlation Coefficients)

Measure	r **
Compliance	
Change in METs	-.01
Change in SBP Reactivity	.27
Change in DBP Reactivity	-.17
Change in HR Reactivity	-.22

* Change in Reactivity = Post Reactivity - Pre Reactivity
** Measures from exercise group only
n=22

Pre- and Post-intervention Reactivity Means *

Measure	M	SEM
Pre-intervention		
SBP		
Exercise	11.2	4.7
Comparison	13.8	1.4
DBP		
Exercise	20.1	3.4
Comparison	20.7	2.0
HR		
Exercise	10.0	4.1
Comparison	9.4	1.6
Post-intervention		
SBP		
Exercise	10.1	3.2
Comparison	11.1	1.4
DBP		
Exercise	10.2	4.2
Comparison	17.7	1.4
HR		
Exercise	3.2	1.7
Comparison	5.9	1.6

Note: Reactivity = Peak - baseline.
Note: Exercise group = Known Compliers
Comparison Group = All Others

Post-intervention Recovery Means *

Measure	M	SD
SBP Recovery		
One Minute:		
Control	5.8	5.9
Exercise	5.2	9.7
Two Minute:		
Control	-0.7	4.4
Exercise	-2.4	9.1
Three Minute:		
Control	-2.7	6.5
Exercise	-2.8	8.0
DBP Recovery		
One Minute:		
Control	0.4	7.1
Exercise	1.2	6.2
Two Minute:		
Control	-1.4	6.7
Exercise	-0.5	5.6
Three Minute:		
Control	-0.6	4.2
Exercise	-1.0	6.4
HR Recovery		
One Minute:		
Control	-1.1**	7.0
Exercise	-6.9	5.9
Two Minute:		
Control	-2.0	3.9
Exercise	-3.5	3.5
Three Minute:		
Control	-2.2	6.2
Exercise	-3.5	4.2

* Recovery = Recovery minute - baseline
** $p \leq .05$

APPENDIX C

INFORMED CONSENT

BEHAVIORAL PHYSIOLOGY LABORATORY

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 testing program conducted by the personnel of the Behavioral Physiology Laboratory of the Division of Health and Physical Education at Virginia Tech.

Title and Purpose of Study: The relationship between aerobic fitness and cardiovascular reactivity to stress. The purpose of this experiment is to determine if increasing the level of aerobic fitness modifies the body's physiological response to stress.

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

I. One hour of responding to a series of questionnaires asking you to describe your typical manner of coping with stress and a brief health questionnaire.

II. One 45 minute laboratory session consisting of a submaximal treadmill exercise test as well as a brief test of cardiovascular reactivity. This will include attaching a blood pressure cuff to your arm and several ECG leads to your chest. The first part of the session will include walking on the treadmill for a period of 10-14 minutes while heart rate and blood pressure are monitored. The next part of the session will consist of measuring your blood pressure and heart rate while your left hand is emersed in cold water for three minutes.

III. One hour of participation in the Behavioral Physiology Laboratory. This will entail a second cardiovascular reactivity session consisting of a three minute emersion of your left hand in a cold water bath and performance of a visual-motor task.

IV. You may be asked to participate in an aerobic fitness program requiring you to engage in group exercise sessions for up to four times per week for eight weeks. Exercise will consist of walking, jogging, or running for approximately 30 minutes at or near a target heart rate calculated from the results of the fitness test. Each session will last approximately 40 minutes and will be conducted in a group format on campus. Each subject will also be asked to keep a record of their exercise related activities. Regardless of the level of aerobic training you are assigned to during the course of this study, all participants will be afforded the opportunity to participate in an introductory exercise training course at the end of the study.

V. A reevaluation consisting of the procedures outlined in II and III above.

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

1. Local discomfort involving the left hand during emersion in cold water.

2. Risk of orthopedic injury related to participation in an aerobic training program including but not limited to strains, sprains, delayed muscle soreness, and even the possibility of death.

Certain personal benefits may be expected from participation in this experiment. These include:

1. Knowledge gained about personal coping style and fitness level.

2. Physical benefits of participation in an aerobic fitness training program such as a decrease in resting heart rate and blood pressure, increase in oxygen consumption, and decreased weight.

3. Participation in this study will allow the student to earn up to 5 percentage points of extra credit in their Personal Health class.

Extra credit which will be awarded based on completion of the 3-hour pre-assessment package, compliance to the exercise training program, and 2-hour post-intervention assessment as follows:

Completion of questionnaire assessment only:	1.0 point
Completion of questionnaires, treadmill and CVR pre-intervention assessments:	2.0 points
Completion of both pre + post-intervention assessments and	
80% compliance to exercise program:	3.0 points
90% compliance to exercise program:	4.0 points
100% compliance to exercise program:	5.0 points

These points will be averaged into the final grade at the end of the semester after the class grading curve has been established.

For example: an 85% might = B; plus 5 points = 90% = A-
an 76% might = C; plus 3.6 points = 79.6%. B-

Appropriate alternative procedures that might be advantageous to you include:

1. Participation in other introductory training programs possibly available through public or private health facilities.

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 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 inquiries concerning the procedures used in this experiment.

Scientific inquiry is indispensable to the advancement of knowledge. Your participation in this experiment provides the investigator the opportunity to conduct meaningful scientific observations designed to make significant educational contribution.

If you would like 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.

Date ________________ Time ______________ a.m./p.m.

Participant Signature ________________________

Witness ________________________
HPL Personnel

Project Director Christina Berglund Telephone 961-4900; 951-7906

HPER Human Subjects Chairman Dr. Baffi Telephone 961-6561

Dr. Charles Waring, Chairman, Institutional Review Board for Research Involving Human Subjects. Phone 961-5283.

APPENDIX D

SUBJECT DATA SHEETS

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? ______________
____

Has anyone in your family ever 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/day
Sleep		______	hours/night

Exercise Habits

During the past 2 months have you engaged in physical exercise? ( )Yes ( )No
If yes, please list any activities in which you participated during an average week in the past month below (including any competitive, recreational, or leisure activities). Also include frequency and duration (or number of laps, miles, sets, games, etc.) of the activity. BE SPECIFIC!!!!

Activity	Frequency (times/week)	Duration

Do you have any orthopedic problems which may restrict your ability to participate in a walk/jog/run program? ( )Yes ( )No

If so, please explain? ______________________________

____

Schedule

Please check the most convenient days and times for availability to participate in exercise sessions:

	8-12am	12-1pm	1-5pm	5-6pm
MONDAY	____	____	____	____
TUESDAY	____	____	____	____
WEDNESDAY	____	____	____	____
THURSDAY	____	____	____	____
FRIDAY	____	____	____	____

Are you willing to participate in an exercise program 4 days/week for 8 weeks? ( )Yes ( )No

*** Your commitment to this study will have an impact on the results; please consider this carefully when answering the above question!

PWC 170 MODIFIED BALKE TREADMILL TEST

Subject________________________________ ID#________________ Sex:_____

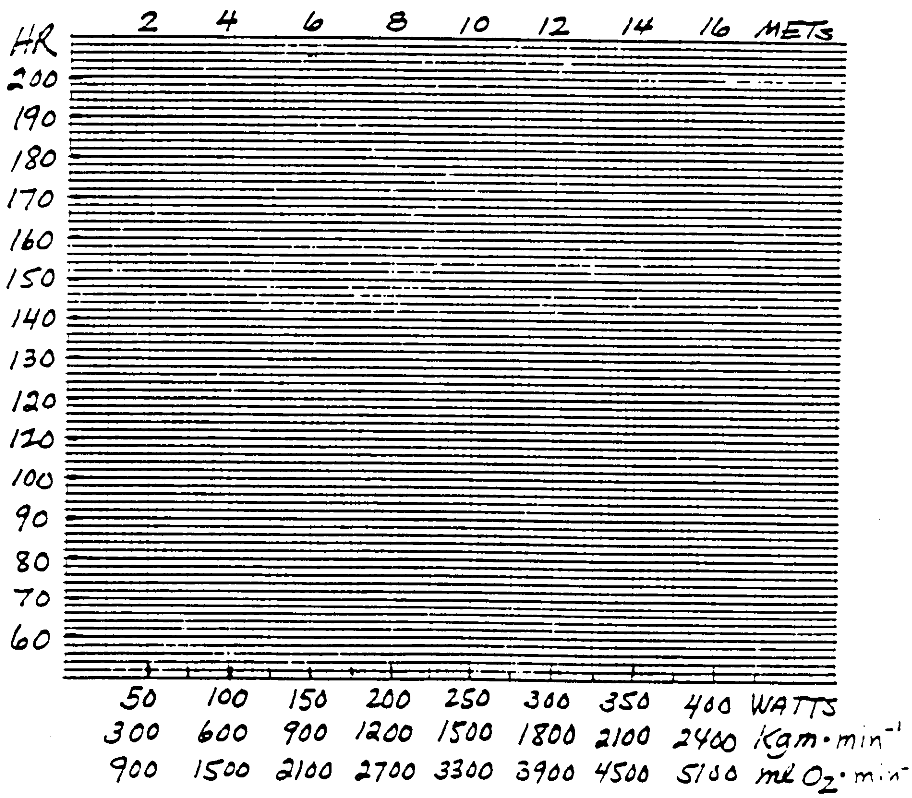
Age__________ Weight____________ Test Administrator___________

Resting Heart Rate________ Resting Blood Pressure_______________

STAGE	DURATION	TIME	SPEED	GRADE	HEART RATE	BLOOD PRESSURE	RPE
I	2:00	1-2	3.4	2.5	______	___/___	____
II	2:00	3-4	"	5.0	______	___/___	____
III	2:00	5-6	"	7.5	______	___/___	____
IV	2:00	7-8	"	10.0	______	___/___	____
V	2:00	9-10	"	12.5	______	___/___	____
VI	2:00	11-12	"	15.0	______	___/___	____
VII	2:00	13-14	"	17.5	______	___/___	____
VIII	2:00	15-16	"	20.0	______	___/___	____
IX	2:00	17-18	"	22.5	______	___/___	____
X	2:00	19-20	"	25.0	______	___/___	____
Recovery							
		2 min.			______	___/___	
		4 min.			______	___/___	
		6 min.			______	___/___	

Treadmill Energy Cost

% Grade	3.4 mph METS
0	3.6
2.5	4.8
5.0	5.9
7.5	7.1
10.0	8.3
12.5	9.5
15.0	10.6
17.5	11.8
20.0	13.0
22.5	14.2
25.0	15.3



MET CAPACITY:_________ml/min ÷ kg = ml/kg.min ÷ 3.5 = _________METs

EXERCISE LOG

DAY	ACTIVITY	DURATION (#miles, laps, etc. & time)	INTENSITY (% max.HR or HR)
Monday			
10/10			
Tuesday			
10/11			
Wednesday			
10/12			
Thursday			
10/13			
Friday			
10/14			
Saturday			
10/15			
Sunday			
10/16			

APPENDIX E

COLD PRESSOR TEST PROTOCOL

Cardiovascular Reactivity Protocol - Screening

1. Seat subject toward left side of chair.

2. Measure arm circumference and record. Use appropriate cuff size.

3. Palpate brachial artery. Utilize correct cuff placement. Make sure cuff is snug.

4. Instruct subject to relax arm in comfortable position. Do not move!

5. Instruct subject regarding intercom/video system.

6. Instruct subject that several resting measurements will be made followed by further instructions via intercom.

7. Instruct regarding ice bath for 1 minute. Ice bath will be uncomfortable, but there will be nothing unexpected. Secure verbal estimate of coping (scale of 1-7).

8. Inquire if any questions about procedure.

9. Instruct subject to remain still throughout testing. Turn on BP monitor. Flip switch down toward test, then up toward cycle.

10. Leave room, close door.

11. If resting SBP greater than 130, return to room and reset cutoff to 180 mm Hg from 150 mm Hg.

12. Continue baseline readings until DBP is within 5 mm Hg on 3 consecutive readings.

13. At the end of the third baseline reading, immediately instruct subject to place left hand in ice bath up to and including wrist. Instruct subject that he will be asked to keep hand in ice bath for 60 seconds and not to remove before told to do so.

14. Instruct subject of time remaining each 15 seconds.

15. Instruct subject to remove hand from ice bath after next BP reading. Instruct subject to place hand on towel and remain stationary.

16. Continue to monitor BP until DBP within 5 mm Hg of average baseline.

17. Discontinue monitoring, return to subject, remove cuff and debrief.

18. Save data in both hard copy and disk formats.

Cardiovascular Reactivity Protocol - Pre-Intervention

1. Seat subject toward left side of chair. Insure towel is dry.

2. Use appropriate cuff size.

3. Palpate brachial artery. Utilize correct cuff placement. Make sure cuff is snug.

4. Read baseline 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're at ease and resting. So what we want you to do for the next few minutes is just sit back quietly and relax. Remember not to speak and to sit quietly with your arms in the proper position because movement interferes with the recording of physiological reactions. We will not be starting until you have had a chance to settle in and become comfortable.

When I give you the signal, I want you to place your left hand in the container of ice water to a point about two inches above your wrist and hold it there. I would like you to keep it there for one minute. I will tell you when this is finished and when to remove your hand.

Remember, when I say to, place your hand in the ice water, and remain still. When I say to stop, gently take your hand out and leave it on the towel. This will complete the procedure. There will be nothing unexpected.

5. Secure verbal estimate of coping (scale of 1-7).

6. Inquire if any questions about procedure.

7. Turn on BP monitor. Flip switch down toward test, then up toward cycle.

8. Leave room, close door.

9. If resting SBP greater than 130, return to room and reset cutoff to 180 mm Hg from 150 mm Hg.

10. Continue baseline readings until DBP is within 5 mm Hg on 3 consecutive readings.

11. At end of third baseline reading, immediately instruct subject: Please place your hand in the water now.

12. After 60 seconds, instruct subject:

    Please withdraw your hand from the water, place hand on the towel and remain stationary.

13. Continue to monitor BP for a minimum of 3 readings and until DBP within 5 mm Hg of average baseline.

14. Discontinue monitoring, return to subject, remove cuff and instruct subject:

    OK, now I would like you to fill out the questionnaire about what you thought about during this task.

15. Save data in both hard copy and disk format.

APPENDIX F

RAW DATA TABLES

Raw Data Key

SSBP 1-3 = Screening SBP Baselines

SSBP 4 = Screening Peak SBP

SSBP 5-7 = Screening SBP Recoveries

SDBP 1-3 = Screening DBP Baselines

SDBP 4 = Screening Peak DBP

SDBP 5-7 = Screening DBP Recoveries

SHR 1-3 = Screening HR Baselines

SHR 4 = Screening Peak HR

SHR 5-7 = Screening HR Recoveries

METS = Maximal Predicted METs (Pre -Intervention)

PSBP 1-3 = Pre-Intervention SBP Baselines

PSBP 4 = Pre-Intervention Peak SBP

PSBP 5-7 = Pre-Intervention SBP Recoveries

PDBP 1-3 = Pre-Intervention DBP Baselines

PDBP 4 = Pre-Intervention Peak DBP

PDBP 5-7 = Pre-Intervention DBP Recoveries

PHR 1-3 = Pre-Intervention HR Baselines

PHR 4 = Pre-Intervention Peak HR

PHR 5-7 = Pre-Intervention HR Recoveries

TSBP 1-3 = Post-Intervention SBP Baselines

TSBP 4 = Post-Intervention Peak SBP

TSBP 5-7 = Post-Intervention SBP Recoveries

TDBP 1-3 = Post-Intervention DBP Baselines

TDBP 4 = Post-Intervention Peak DBP

TDBP 5-7 = Post-Intervention DBP Recoveries

THR 1-3 = Post-Intervention HR Baselines

THR 4 = Post-Intervention Peak HR

THR 5-7 = Post-Intervention HR Recoveries

POSTMETS = Maximal predicted METs (Post-Intervention)

COMP = Percent Compliance

METS 2 = Submaximal Predicted METs (Pre-Intervention)

POSTMETS2= Submaximal Predicted METs (Post-Intervention)

RAW DATA

CVR AND AEROBIC FITNESS MEASURES

-- GROUP=1 --

OBS	ID	SEX	SSBP1	SSBP2	SSBP3	SSBP4	SSBP5	SSBP6	SSBP7	SDBP1	SDBP2	SDBP3	SDBP4	SDBP5	SDBP6	SDBP7	SHR1	SHR2	SHR3	SHR4	SHR5	SHR6	SHR7	METS
1	6	F	120	114	119	122	121	112	110	71	70	70	85	72	70	69	77	76	80	77	84	76	79	13.1
2	7	M	126	127	121	136	131	123	.	72	76	75	79	78	73	.	80	61	68	69	82	63	.	14.3
3	8	F	118	117	117	124	121	117	120	68	70	65	79	56	64	70	73	69	73	74	95	67	66	14.9
4	13	F	95	96	97	116	124	100	105	73	71	73	108	89	85	86	90	89	83	91	70	80	81	11.2
5	15	M	143	144	141	147	135	135	.	76	73	76	90	77	79	.	85	90	94	103	80	85	.	10.9
6	22	M	122	114	116	125	129	124	.	59	69	65	86	73	68	.	71	74	73	75	59	70	.	15.3
7	25	M	122	127	119	141	135	121	120	72	68	72	108	64	76	73	70	75	72	69	65	71	67	14.0
8	27	F	114	102	113	133	119	112	110	83	77	78	107	88	83	77	84	76	75	83	63	72	70	11.8

OBS	PSBP1	PSBP2	PSBP3	PSBP4	PSBP5	PSBP6	PSBP7	PDBP1	PDBP2	PDBP3	PDBP4	PDBP5	PDBP6	PDBP7	PHR1	PHR2	PHR3	PHR4	PHR5	PHR6	PHR7	TSBP1	TSBP2	TSBP3
1	119	113	108	123	117	109	112	79	81	74	84	73	72	77	86	83	86	86	79	81	87	116	113	116
2	121	122	120	133	127	123	119	69	68	69	109	75	66	69	57	58	60	69	69	57	54	117	113	115
3	113	112	113	137	124	118	116	77	78	79	105	76	71	73	84	77	82	78	69	72	67	115	118	113
4	96	103	97	126	152	107	102	65	68	69	98	91	84	81	59	55	54	74	57	56	58	99	99	103
5	134	149	142	146	146	132	131	69	71	66	82	69	67	59	77	73	72	91	65	68	69	134	139	137
6	117	119	116	131	129	119	124	71	68	70	94	70	68	61	45	55	48	61	44	47	47	124	119	124
7	135	124	138	153	162	142	135	57	54	59	107	66	61	50	74	80	67	86	70	74	70	131	124	125
8	110	115	113	138	144	126	119	82	83	84	99	93	85	70	69	68	73	95	48	53	63	102	109	109

OBS	TSBP4	TSBP5	TSBP6	TSBP7	TDBP1	TDBP2	TDBP3	TDBP4	TDBP5	TDBP6	TDBP7	THR1	THR2	THR3	THR4	THR5	THR6	THR7	POSTMETS	COMP	METS2	POSTMET2	GROUP
1	120	115	108	111	68	63	67	84	65	67	67	77	83	80	75	79	80	75	12.1	.	7.4	7.6	2
2	127	125	117	117	64	65	65	86	75	69	75	51	54	55	60	48	49	52	12.7	.	9.8	8.3	2
3	141	126	116	120	74	70	72	83	63	74	64	72	75	73	72	71	73	70	12.4	.	9.0	9.0	2
4	116	118	96	98	71	70	72	93	79	80	68	65	63	64	83	66	58	62	11.7	.	7.5	8.3	2
5	149	139	135	132	60	60	60	87	63	55	61	70	69	69	70	68	64	64	11.8	.	7.1	8.4	2
6	129	120	118	109	64	61	59	85	61	67	65	55	55	55	58	55	53	57	14.6	.	8.8	9.5	2
7	139	139	126	128	74	70	74	107	82	79	74	53	59	51	64	52	55	54	15.0	.	9.2	10.6	2
8	129	118	109	101	70	79	78	93	85	79	76	72	80	73	93	61	63	63	15.6	.	8.0	10.0	2

RAW DATA

CVR AND AEROBIC FITNESS MEASURES

GROUP=1

OBS	ID	SEX	SSBP1	SSBP2	SSBP3	SSBP4	SSBP5	SSBP6	SSBP7	SDBP1	SDBP2	SDBP3	SDBP4	SDBP5	SDBP6	SDBP7	SHR1	SHR2	SHR3	SHR4	SHR5	SHR6	SHR7	METS
9	29	F	103	102	103	119	111	99	102	78	73	78	99	71	73	73	74	70	73	76	60	80	72	8.6
10	34	F	117	111	115	127	107	106	.	68	69	70	79	74	70	.	78	81	87	66	71	73	.	10.6
11	36	F	123	106	107	120	106	110	.	82	83	84	97	81	83	.	84	84	81	84	73	81	.	11.2
12	38	F	91	104	92	120	106	103	104	60	64	64	89	71	70	60	77	82	82	77	78	80	77	10.9
13	39	M	130	133	134	140	133	131	.	88	84	85	93	84	82	.	83	78	81	81	77	85	.	13.0
14	43	F	110	114	112	129	116	118	119	77	82	79	95	73	76	79	96	95	93	94	86	93	93	10.5
15	46	F	107	113	90	125	126	109	111	66	66	64	86	74	64	68	78	76	79	80	73	83	77	9.8
16	49	F	110	112	112	108	113	.	.	65	66	62	70	64	.	.	64	64	66	78	69	.	.	11.4

OBS	PSBP1	PSBP2	PSBP3	PSBP4	PSBP5	PSBP6	PSBP7	PDBP1	PDBP2	PDBP3	PDBP4	PDBP5	PDBP6	PDBP7	PHR1	PHR2	PHR3	PHR4	PHR5	PHR6	PHR7	TSBP1	TSBP2	TSBP3
9	95	94	97	118	109	99	99	66	67	67	98	76	71	69	72	79	80	79	66	81	77	109	113	106
10	118	117	113	124	116	111	114	69	73	73	91	67	69	72	68	73	73	77	70	72	74	122	120	107
11	113	112	108	117	120	110	104	76	72	72	89	81	71	75	64	68	72	65	61	65	64	95	108	101
12	104	101	104	121	115	106	100	67	69	63	92	79	75	73	76	77	78	88	76	81	82	107	102	99
13	125	126	122	124	121	120	122	85	89	86	96	83	86	89	53	56	71	70	67	75	73	140	137	135
14	109	102	102	125	103	102	103	79	80	81	98	83	87	84	66	66	68	71	69	65	71	107	102	103
15	118	119	113	121	125	115	122	67	64	64	72	68	67	67	75	74	78	75	70	70	71	123	120	121
16	119	120	113	124	125	115	112	65	68	68	84	74	59	71	84	82	65	67	65	69	63	111	107	103

OBS	TSBP4	TSBP5	TSBP6	TSBP7	TDBP1	TDBP2	TDBP3	TDBP4	TDBP5	TDBP6	TDBP7	THR1	THR2	THR3	THR4	THR5	THR6	THR7	POSTMETS	COMP	METS2	POSTMET2	GROUPX
9	120	112	105	102	75	70	73	93	76	74	77	76	73	76	70	68	73	72	11.0	.	5.6	7.1	2
10	123	119	114	111	76	76	72	81	76	73	73	91	96	97	98	100	93	93	10.2	.	5.9	5.9	2
11	117	110	114	109	76	79	74	84	76	74	79	63	70	68	70	67	70	64	11.4	.	8.3	8.3	2
12	118	111	106	105	73	71	76	80	65	73	72	77	81	85	74	80	78	75	10.8	.	7.1	7.2	2
13	141	138	134	135	88	89	89	89	85	83	82	105	105	107	106	105	103	100	10.2	.	7.1	5.9	2
14	117	102	101	101	78	74	75	86	67	71	71	75	77	77	78	67	73	81	11.3	.	5.9	7.1	2
15	118	123	122	120	73	70	74	83	72	69	70	79	82	90	76	76	77	86	11.1	.	5.6	7.1	2
16	113	114	108	96	67	65	68	81	54	45	64	81	73	78	76	86	75	79	13.6	.	6.5	7.1	2

RAW DATA

CVR AND AEROBIC FITNESS MEASURES

---------- GROUP=1 ----------

OBS	ID	SEX	SSBP1	SSBP2	SSBP3	SSBP4	SSBP5	SSBP6	SSBP7	SDBP1	SDBP2	SDBP3	SDBP4	SDBP5	SDBP6	SDBP7	SHR1	SHR2	SHR3	SHR4	SHR5	SHR6	SHR7	METS
17	53	F	131	128	131	147	139	126	129	82	79	81	95	74	77	67	77	76	81	80	71	72	75	9.4
18	62	M	115	109	115	115	112	110	.	77	76	76	83	67	71	.	64	66	66	65	60	64	.	11.6
19	100	F	104	104	109	118	108	97	103	68	66	69	69	59	67	68	88	93	90	92	85	82	99	9.1
20	500	F	106	95	100	109	106	104	.	55	57	60	71	64	59	.	63	56	53	59	51	53	.	11.8

OBS	PSBP1	PSBP2	PSBP3	PSBP4	PSBP5	PSBP6	PSBP7	PDBP1	PDBP2	PDBP3	PDBP4	PDBP5	PDBP6	PDBP7	PHR1	PHR2	PHR3	PHR4	PHR5	PHR6	PHR7	TSBP1	TSBP2
17	94	93	96	108	98	95	98	68	66	71	82	69	69	69	81	80	77	100	75	81	75	96	94
18	126	125	123	134	125	124	122	71	69	69	82	76	73	71	59	72	60	68	55	60	57	125	122
19	108	106	113	117	111	110	111	59	60	61	76	58	52	55	76	89	81	91	78	93	81	114	117
20	104	105	102	109	108	103	100	61	60	56	72	55	62	57	63	74	59	62	50	59	64	109	103

OBS	TSBP3	TSBP4	TSBP5	TSBP6	TSBP7	TDBP1	TDBP2	TDBP3	TDBP4	TDBP5	TDBP6	TDBP7	THR1	THR2	THR3	THR4	THR5	THR6	THR7	POSTMETS	COMP	METS2	POSTMET2	GROUPX
17	100	112	104	96	95	72	67	67	90	67	66	68	62	65	68	97	85	70	73	10.2	.	4.8	5.4	2
18	119	129	131	122	117	84	85	81	94	89	84	85	58	61	57	63	58	57	58	14.0	.	8.8	9.0	2
19	100	114	108	106	104	56	61	61	76	52	54	55	78	78	81	95	79	83	73	10.4	.	6.0	7.1	2
20	106	117	120	109	111	63	61	61	81	72	52	59	48	48	47	54	43	49	47	15.5	.	8.0	9.5	2

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CVR AND AEROBIC FITNESS MEASURES

-- GROUP=2 --

OBS	ID	SEX	SSBP1	SSBP2	SSBP3	SSBP4	SSBP5	SSBP6	SSBP7	SDBP1	SDBP2	SDBP3	SDBP4	SDBP5	SDBP6	SDBP7	SHR1	SHR2	SHR3	SHR4	SHR5	SHR6	SHR7	METS
21	3	F	102	100	102	123	109	98	97	75	78	76	88	78	72	74	87	83	81	81	77	81	83	11.8
22	4	F	111	113	105	141	152	111	107	69	74	70	91	83	78	83	78	76	76	106	51	60	75	6.6
23	9	M	121	121	112	126	124	112	115	63	64	66	86	67	63	60	74	73	86	81	74	74	67	13.6
24	16	F	108	112	107	114	110	101	104	69	64	67	78	62	61	62	66	70	68	91	72	70	68	11.6
25	18	M	128	123	127	137	124	126	.	62	57	57	83	62	64	.	93	87	93	100	87	88	.	12.4
26	20	M	135	140	143	143	144	141	128	77	82	77	92	78	77	80	89	92	92	94	91	89	79	10.3
27	26	M	100	114	109	137	147	111	.	72	72	69	110	66	73	.	79	87	79	100	77	77	.	11.2
28	28	F	110	105	107	122	119	110	111	67	69	69	97	76	62	59	70	63	66	79	61	67	67	11.2

OBS	PSBP1	PSBP2	PSBP3	PSBP4	PSBP5	PSBP6	PSBP7	PDBP1	PDBP2	PDBP3	PDB.P4	PDBP5	PDBP6	PDBP7	PHR1	PHR2	PHR3	PHR4	PHR5	PHR6	PHR7	TSBP1	TSBP2
21	110	114	106	125	114	103	103	80	81	83	86	77	77	76	86	84	87	85	76	81	81	128	114
22	111	118	121	152	153	112	107	78	73	76	125	101	87	87	64	75	78	101	59	63	68	117	113
23	115	112	113	131	126	125	121	64	65	66	84	68	65	64	75	73	67	77	78	74	69	109	115
24	108	115	109	115	115	105	102	63	62	65	77	57	64	65	88	81	71	96	74	63	70	102	108
25	124	124	131	135	132	141	131	63	62	63	92	64	65	74	79	82	62	89	65	69	75	125	132
26	146	137	144	157	154	150	141	78	82	77	102	81	88	88	105	89	86	109	99	100	83	142	143
27	116	123	124	149	154	127	130	78	73	77	113	78	84	76	61	59	60	83	53	59	59	116	115
28	113	101	108	121	119	107	103	66	65	63	96	66	66	59	59	62	55	75	52	57	60	101	109

OBS	TSBP3	TSBP4	TSBP5	TSBP6	TSBP7	TDBP1	TDBP2	TDBP3	TDBP4	TDBP5	TDBP6	TDBP7	THR1	THR2	THR3	THR4	THR5	THR6	THR7	POSTMETS	COMP	METS2	POSTMET2	GROUPX
21	115	120	114	111	112	75	77	77	95	79	80	82	62	93	69	70	66	69	71	10.4	73	3.8	7.4	2
22	108	149	150	117	112	75	72	70	111	80	71	67	75	78	78	91	68	76	76	10.8	80	4.8	7.1	2
23	115	121	110	118	119	56	59	56	75	58	71	70	76	75	76	78	75	76	80	15.2	0	8.9	10.6	2
24	103	111	110	100	103	53	52	54	59	54	59	57	83	80	79	86	84	79	79	10.7	90	8.4	7.1	1
25	128	138	136	138	.	58	61	58	78	57	59	.	91	84	85	97	91	84	.	13.4	100	8.3	8.9	2
26	133	152	135	138	137	71	68	67	86	69	70	59	72	75	74	89	69	69	77	13.2	50	4.8	8.3	2
27	117	130	138	117	118	64	66	69	98	77	66	62	54	56	51	77	46	53	52	15.6	60	7.2	10.6	2
28	111	121	108	102	105	62	57	57	83	57	49	52	62	66	65	73	54	64	61	14.7	.	7.1	9.5	2

RAW DATA

CVR AND AEROBIC FITNESS MEASURES

GROUP=2

OBS	ID	SEX	SSBP1	SSBP2	SSBP3	SSBP4	SSBP5	SSBP6	SSBP7	SDBP1	SDBP2	SDBP3	SDBP4	SDBP5	SDBP6	SDBP7	SHR1	SHR2	SHR3	SHR4	SHR5	SHR6	SHR7	METS
29	33	F	114	114	113	121	113	113	.	79	79	76	86	73	75	.	90	89	88	98	79	83	.	6.6
30	37	F	111	107	110	120	116	109	.	62	58	60	87	62	65	.	65	63	67	71	64	67	.	12.3
31	40	F	102	100	98	105	101	.	.	67	71	70	79	71	.	.	72	75	77	73	70	.	.	13.4
32	41	F	.	.	.	123	115	116	.	.	.	82	92	76	85	.	.	.	.	82	71	80	.	9.6
33	42	F	109	110	115	119	118	117	.	68	69	71	72	70	71	.	89	91	100	96	88	94	.	7.4
34	45	F	110	111	113	141	132	116	114	83	80	81	110	91	80	78	76	77	78	94	69	76	77	12.3
35	47	F	109	109	116	133	108	107	.	74	73	72	96	78	74	.	87	86	94	103	87	90	.	9.3
36	50	M	132	119	115	143	150	130	123	90	89	85	91	91	80	83	87	84	87	93	75	90	85	9.0

OBS	PSBP1	PSBP2	PSBP3	PSBP4	PSBP5	PSBP6	PSBP7	PDBP1	PDBP2	PDBP3	PDBP4	PDBP5	PDBP6	PDBP7	PHR1	PHR2	PHR3	PHR4	PHR5	PHR6	PHR7	TSBP1	TSBP2
29	128	128	127	130	125	119	117	74	73	74	83	75	77	76	101	99	99	101	93	95	91	108	113
30	103	105	102	118	109	98	100	61	62	62	87	58	63	63	69	69	71	69	66	67	71	108	101
31	97	89	103	104	108	97	98	66	63	63	75	71	70	71	75	70	80	72	76	73	72	101	96
32	116	114	118	131	123	115	117	81	84	79	101	81	81	80	59	63	68	82	62	61	67	119	112
33	135	133	126	134	131	129	130	75	74	78	84	76	76	67	101	106	104	110	102	104	101	124	120
34	117	115	114	147	124	116	114	75	75	73	107	72	74	77	80	76	72	86	63	71	69	119	124
35	119	119	117	138	121	115	112	65	67	67	87	74	68	66	90	92	94	104	84	93	89	109	111
36	136	130	126	144	162	137	133	83	81	78	98	88	78	72	70	62	56	82	47	47	53	131	128

OBS	TSBP3	TSBP4	TSBP5	TSBP6	TSBP7	TDBP1	TDBP2	TDBP3	TDBP4	TDBP5	TDBP6	TDBP7	THR1	THR2	THR3	THR4	THR5	THR6	THR7	POSTMETS	COMP	METS2	POSTMET2	GROUPX
29	112	121	108	106	108	76	78	78	92	79	77	82	91	93	97	96	92	88	96	9.7	23	3.8	4.8	2
30	103	114	106	106	96	54	55	54	71	53	58	60	72	73	74	73	67	71	72	15.0	90	8.3	9.5	1
31	96	108	96	97	98	73	69	72	82	70	73	74	77	66	70	66	62	62	62	12.8	50	7.1	8.0	2
32	117	127	121	117	117	76	73	126	80	74	79	80	88	78	84	88	69	81	89	15.2	93	6.0	9.4	1
33	123	129	124	119	125	70	72	71	78	77	70	65	102	87	99	94	92	88	83	16.8	93	5.6	8.3	1
34	117	138	124	118	112	86	88	88	111	94	83	94	83	84	85	89	68	76	79	13.2	97	8.4	8.6	1
35	116	132	118	112	113	69	68	71	100	77	65	71	68	76	78	90	69	72	75	12.0	100	4.3	5.9	2
36	124	155	144	131	135	79	84	84	100	89	81	79	66	73	72	68	54	66	64	16.6	73	4.8	9.5	2

RAW DATA

CVR AND AEROBIC FITNESS MEASURES

-- GROUP=2 --

OBS	ID	SEX	SSBP1	SSBP2	SSBP3	SSBP4	SSBP5	SSBP6	SSBP7	SDBP1	SDBP2	SDBP3	SDBP4	SDBP5	SDBP6	SDBP7	SHR1	SHR2	SHR3	SHR4	SHR5	SHR6	SHR7	METS
37	54	F	99	96	99	109	108	104	103	79	77	82	87	81	74	74	75	75	78	84	62	78	73	10.6
38	55	M	129	130	130	130	128	129	.	71	76	72	83	73	64	.	71	66	73	71	62	67	.	12.5
39	57	F	108	104	105	127	113	106	.	67	75	74	85	61	73	.	89	84	87	103	75	78	.	13.2
40	59	M	133	131	133	149	130	132	138	78	77	78	82	71	83	73	78	80	79	78	71	77	70	16.0
41	63	M	128	137	139	168	145	141	.	57	52	53	63	56	54	.	69	76	77	67	70	73	.	15.0
42	400	F	106	113	113	124	129	112	.	63	58	58	70	68	58	.	78	81	83	95	75	74	.	12.0

OBS	PSBP1	PSBP2	PSBP3	PSBP4	PSBP5	PSBP6	PSBP7	PDBP1	PDBP2	PDBP3	PDBP4	PDBP5	PDBP6	PDBP7	PHR1	PHR2	PHR3	PHR4	PHR5	PHR6	PHR7	TSBP1	TSBP2	TSBP3
37	103	108	110	118	118	113	107	73	74	76	80	75	72	79	64	69	80	91	66	73	70	109	110	104
38	137	132	130	130	136	126	135	73	75	74	91	72	76	70	72	72	72	74	72	73	70	134	134	133
39	94	104	101	127	110	106	102	77	81	76	112	89	84	83	66	71	66	99	57	66	66	104	101	107
40	145	141	134	137	146	134	130	61	65	65	74	65	66	69	65	68	64	62	66	66	67	139	133	135
41	130	124	128	145	148	125	134	76	72	72	104	68	69	68	67	67	65	75	62	63	64	154	145	151
42	121	125	129	130	139	118	114	70	68	63	75	78	63	69	74	73	74	91	57	64	63	120	108	114

OBS	TSBP4	TSBP5	TSBP6	TSBP7	TDBP1	TDBP2	TDBP3	TDBP4	TDBP5	TDBP6	TDBP7	THR1	THR2	THR3	THR4	THR5	THR6	THR7	POSTMETS	COMP	METS2	POSTMET2	GROUPX
37	116	113	106	103	79	79	82	98	83	82	83	73	78	78	85	63	74	70	11.5	80	6.8	8.3	2
38	136	139	128	136	67	66	66	77	64	63	61	88	82	84	88	86	84	85	14.8	87	9.0	9.5	1
39	129	115	107	107	84	88	87	112	81	85	86	75	89	81	94	73	79	73	10.4	100	5.8	7.1	1
40	144	142	132	133	77	79	79	82	80	75	74	57	63	55	55	51	53	54	18.2	100	9.8	11.8	1
41	152	156	150	145	74	75	77	83	69	69	66	69	70	74	84	67	74	69	16.2	30	9.5	9.5	2
42	118	125	94	97	71	68	69	85	78	76	68	62	60	67	66	49	51	54	12.8	33	7.1	8.3	2

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