The Impact of Aerobic Fitness on Cardiovascular, Biochemical, and Subjective Response to Psychosocial Stress

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ABSTRACT

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Aerobic fitness is associated with numerous adaptations which permit more efficient coping with physical stress. The experiments in this thesis examined whether aerobic fitness influences the response to psychosocial stress. In the first experiment, heart rate, biochemical measures and self-reported arousal and anxiety were monitored in 15 highly trained and 15 untrained males at various points before, during and following exposure to a series of psychosocial stressors. Heart rate and subjective measures increased indistinguishably in both groups during the stressors, but following their termination, recovery was faster in the trained. Biochemical measures revealed that trained subjects had higher baseline levels of plasma prolactin and attained peak levels of norepinephrine earlier than untrained subjects. These between-group differences in reactivity and recovery from psychosocial stress were interpreted as reflecting a more adaptive response pattern to psychosocial stress in aerobically trained individuals.

The second experiment further examined this question in a context where aerobic fitness level was experimentally manipulated. Thirty-eight males were assigned to either aerobic, anaerobic (weight-lifting) or wait-list control

groups. Experimental groups met 3-4 times per week in one hour sessions aimed at improving either cardiovascular endurance or muscular strength. Aerobic fitness level, response to psychosocial stress, and self-report measures were obtained prior to and following ten weeks of training. Examination of pre-treatment scores revealed a correlation between aerobic fitness level and more rapid heart rate recovery following stress. Although fitness measures confirmed the effectiveness of aerobic training, no group differences were found in heart rate and subjective response or recovery to psychosocial stress, following treatment. However, fitness improvement by subjects in the aerobic group was associated with more rapid heart rate recovery following psychosocial stress. Improvement in fitness was also associated with increased baseline norepinephrine and reduced cortisol levels. Self-report measures revealed an increase in self-mastery in the aerobic group alone.

These experiments replicate previous findings which indicate that aerobic fitness is associated with enhanced cardiovascular recovery from psychosocial stress. Subjective and biochemical findings in the first experiment suggested that training may be associated with more adaptive responding to psychosocial stress. The discrepant findings on these measures across the two experiments are discussed in light of possible selection factors which might predispose individuals to participate in such activities, initial levels of physical and psychological fitness, and the duration of aerobic training which may be required to elicit such effects.

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Introduction

The impact of psychosocial stress on health has attracted much interest in recent years. Various investigators have implicated such stress in the development of serious illness such as heart disease and cancer (Jenkins, 1976; Sklar & Anisman, 1980) as well as acute infectious disease (Gruchow, 1979). The impact of stress on psychopathology has long been noted (see Anisman & Zacharko, 1982). Accordingly, attempts have been made to reduce reactions to such stress or moderate its effects through various coping techniques, which have included both behavioral and cognitively oriented approaches (Wolpe, 1968; Meichenbaum, 1977). One technique which has recently been cited in the proposed management of anxiety or stress-related disorders is that of aerobic exercise (e.g. Eliot, 1979; Folkins & Amsterdam, 1977; Ledwidge, 1980). The following will evaluate the evidence for such a claim.

The parameters for aerobic exercise as well as its physiological effects will first be described. Psychological effects associated with such activity will then be reviewed, with emphasis on studies reporting effects on anxiety or stress-related measures. A subsequent section will describe autonomic and physiological correlates of laboratory psychosocial stress, and present evidence for viewing the response to such stress as an index of overall coping. Studies which have examined the effects of aerobic training on the response to psychosocial stress will follow.

Aerobic Exercise: Training Parameters and Physiological Effects

Aerobic or endurance exercise is characterized by sustained activity in large muscle groups, according to clearly defined parameters of duration, intensity and frequency. To qualify as an aerobic bout, the activity must be maintained for at least 15 minutes, with an intensity of effort ranging between 60 to 90% of maximum. Aerobic training implies adherence to these parameters, with a frequency of at least three times per week. Typical activities include brisk walking, jogging, running, swimming, cycling, etc., with aerobic effects usually apparent by six weeks of training (Astrand & Rodahl, 1977).

As the name implies, the energy required by working muscles for performance of such activities derives primarily from the oxidation of carbohydrates and fats (Shephard, 1972). Moreover, regular participation in such activities is associated with increased efficiency in the transport and utilization of oxygen by these muscles. The degree of this efficiency can be evaluated directly by measuring oxygen consumption, through a gas-exchange procedure, during physical work. Maximum efficiency, or oxygen consumption (VO_2max) at the point of exhaustion, is regarded as the ultimate measure of aerobic fitness (Astrand & Rodahl, 1977).

In addition to the above measure, other procedures exist to indirectly assess aerobic activity or fitness. Specifically, the delivery of oxygen to working muscles would appear to depend importantly on cardiac output; given the positive linear relationship between consumption of oxygen and heart rate, the latter is often used to gauge the degree of aerobic involvement, as well as fitness level (Astrand & Rodahl, 1977). For example, exercise intensity is often expressed as the amount of work required to elevate heart rate to a certain percentage (60 to 80) of maximal heart rate (MHR), the latter determined through a formula incorporating age and fitness level (Astrand & Rodahl, 1977). Accordingly, indirect assessment of aerobic fitness usually involves measuring heart rate response to physical work on a treadmill or bicycle ergometer. This method is more convenient and economical than direct measurement of oxygen consumption (Astrand & Rodahl, 1977).

It should be noted, however, that there is error associated with estimation of VO_2max through heart rate response, particularly under conditions of submaximal work (Astrand & Rodahl, 1977). This is due to the imperfect correlation which exists between VO_2max and heart rate response; this is not surprising, given the sensitivity of heart rate to other factors (e.g. prior psychological state, temperature), as well as the contribution of non-cardiac adaptations (i.e. increased oxygen utilization by muscle through increased enzyme activity; increased density of capillaries in muscle (Blomqvist & Saltin, 1983)), to VO_2max.

Various adaptations at physiological and biochemical levels are incurred through regular participation in aerobic activity. These adaptations, which presumably allow subsequent performance of such activities with less organismic strain, include alterations in resting measures. Most notable of these are lowered resting heart rate and blood pressure (Clausen, 1977), lower resting glucose and insulin (Leblanc et al, 1977), and increased testosterone levels (Young & Ismail, 1978). In response to standard workloads, training results in reduced working heart rate and faster recovery following work termination (Clausen, 1977), less accumulation and more rapid elimination of lactic acid (Winder, Hickson, Hagberg, Ehsani & McLane, 1979), and smaller increases in norepinephrine (Peronnet et al, 1981; Winder, Hagberg, Hickson, Ehsani, & McLane, 1978) and cortisol (White, Ismail & Bottoms, 1976). While aerobic adaptations are generally thought to require a minimum of 6 weeks of training (Astrand & Rodahl, 1977), there is evidence of changes in both physiological and biochemical measures with as little as two weeks of training (Hickson, Hagberg, Ehsani & Holloszi, 1981; Winder et al, 1978).

While physical training apparently increases the efficiency of the body in the face of acute exercise, it appears that it also incurs cross-adaptation to other physical stressors. Animal research suggests a protective effect of such training on the response to extreme heat or cold, as well as to environmental toxins (Ostman & Sjostrand, 1975; Zimkin, 1964). Paralleling this is human research indicating a blunting of the blood pressure and skin temperature responses to cold stress, in trained subjects as compared to untrained (Baum, Bruck & Schwenicke, 1976; Leblanc, Cote, DuLac, & Dulong-Turcot, 1978).

In the following, acute exercise refers to a single bout of aerobic activity, while chronic exercise, exercise training or conditioning implies a program of no less than six weeks, which adheres to the parameters outlined above. Subjects who are aerobically fit or unfit at time of study, will be referred to as trained and untrained, respectively. Studies reported here have typically used jogging or running as the main ingredients of fitness programs; acute effects have been elicited through exercise either on bicycle ergometers or treadmills.

Although the emphasis in this thesis is on <u>training effects</u> of exercise, it can be argued that the effects observed as a result of training may derive from the accumulation of acute effects. For this reason, acute effects of aerobic exercise will be included in the following review.

<u>Aerobic Exercise: Psychological Effects</u>

Growing interest in the psychological effects of aerobic exercise has heightened speculation that such activity may improve psychological well-being. This has been evident in both popular (e.g. Cooper, 1977) as well as scientific reviews (Folkins & Sime, 1981; Ledwidge, 1980). Unfortunately, the scarcity of well-controlled studies in this area leads one to the conclusion that the often-sweeping claims (e.g. Kostrubala, 1976) which are made regarding beneficial effects of exercise extend far beyond any solid empirical support. Nevertheless, a recent critical review of the relevant literature reveals consistently positive effects of acute and chronic exercise on psychological measures, particularly those related to affect and personality (Folkins & Sime, 1981). These will be summarized in the following.

There exist numerous reports of improved mood following acute (Lichtman & Poser, 1982; Markoff, Ryan & Young, 1982) and chronic exercise (Folkins, Lynch & Gardner, 1972; Folkins, 1976; Young, 1979). Self-concept has been shown to improve following exercise training across a wide range of populations: normal adults (Hanson & Nedde, 1974; Hilyer & Mitchell, 1979), geriatrics (Buccola & Stone, 1975), adolescents (McGowan, Jarman, & Pedersen, 1974), rehabilitation patients (Collingwood, 1972), obese teenagers (Collingwood & Willett, 1971), juvenile offenders (Hilyer et al, 1982) and alcoholics (Gary & Guthrie, 1972). Depression is apparently reduced as a result of exercise training, with this effect seen in both normal (Brown, Ramirez & Taub, 1978 (Expt 1); Folkins et al, 1972; Morgan, Roberts, Brand & Feinerman, 1970) and clinically depressed individuals (Brown, Ramirez & Taub, 1978 (Expt 2); Doyne, Chambless & Beutler, 1983; Greist, Klein, Faris, Gurman & Morgan, 1979; Kavanagh, Shepard, Tuck & Qureshi, 1977; McCann & Holmes, 1984).

Reductions on anxiety measures have also been reported to follow acute as well as chronic exercise. Given the focus of the present thesis, the following section will review these findings.

Aerobic Exercise: Effects on Anxiety

DeVries (1968) first reported effects of exercise on measures of neuromuscular activity, with reductions in resting muscle action potential following acute exercise; participation in a six-week fitness program yielded the same net reduction from pre to post-treatment, in comparison to inactive control subjects. It is noteworthy that this latter reduction was largely due to approximately half the subjects who reported extreme nervous tension prior to the program (DeVries, 1968). A subsequent study (DeVries & Adams, 1972) found that optimal parameters for the acute effect consisted of 15 minutes of light to moderate exercise (50 and 60% of MHR), with more intense exercise proving less effective. As well, exercise was found to be superior to the tranquilizer drug meprobamate on activity in resting musculature, with the effect persisting for at least one hour post-exercise (DeVries & Adams, 1972).

Morgan and his colleagues have systematically examined the effects of acute exercise on anxiety (Bahrke & Morgan, 1978; Morgan, Roberts & Feinerman, 1971; Morgan, 1973: Morgan & Horstman, 1976). The most recent study compared treadmill exercise at 70% MHR for 20 minutes, with non-cultic meditation, finding these equally effective in reducing anxiety as assessed both by a standard questionnaire (Spielberger State-Trait Anxiety Inventory (STAI)) as well as a physiological measure (finger temperature) of arousal. However, an unexpected effect was seen in a group of control subjects who sat quietly in a recliner, and who manifested similar changes. These authors speculate that distraction from anxiety-provoking cognitions, or simply taking "time-out", serves to diminish anxiety regardless of the technique used, although they add that the duration of the effect may be more sustained in the case of exercise (Bahrke & Morgan, 1978).

Discrepancies become evident in reviewing these studies. Specifically, mild to moderate exercise was reported to reduce anxiety in one study (DeVries & Adams, 1972), but was found ineffective in another (Morgan, Roberts & Feinerman, 1971). On the other hand, exercise at 70% as well as 80% MHR was reported to reduce anxiety scores in two investigations (Bahrke & Morgan, 1978; Morgan & Horstman, 1976), but was found, in another study, to be less effective than exercise at lower intensities (DeVries & Adamas, 1972). It is noteworthy that none of these studies report on the aerobic fitness level of the subjects used; given known differences in physiological response to exercise between trained and untrained subjects (e.g. Clausen, 1977), differences in subjective response to exercise would be expected as well. Differences between trained and untrained individuals on measures of emotional arousal following a bout of exercise have, in fact, been demonstrated (Zillman, Johnson, & Day, 1974). Thus, while acute exercise, of the duration used in these studies, generally results in reductions on measures of anxiety, it is conceivable that exercise intensity and fitness level interact to account for these different outcomes.

Other studies have examined the effects of exercise on anxiety while anxious or phobic subjects were in situations specifically designed to elicit anxiety. Female students viewed a film depicting industrial accidents while exercising on a stationary bicycle, and subsequently reported being less anxious during the film than did seated controls (Girodo & Pellegrini, 1976). Similar findings have been reported with test-anxiety (Driscoll, 1976), speech anxiety (Schwartz & Kaloupek, Note 1), agoraphobia (Orwin, 1973) and situational phobia (Orwin, 1974).

In addition to these, primarily acute effects, there are several reports of reduced anxiety following aerobic fitness training. Folkins, Lynch & Gardner (1972) found decreases in reported anxiety following a semester-long jogging course, with the degree of reduction correlating with improvement in aerobic fitness. It is noteworthy that, as with the early report by DeVries (1968), the least psychologically and/or physically fit benefited most from fitness training (Folkins et al, 1972). Reductions on the STAI have recently been shown to follow ten weeks of aerobic training (Blumenthal, Williams, Needels & Wallace 1982). Although both of these studies involved experimental-control comparisons, it should be noted that in neither case was there random assignment to treatment; experimental subjects chose the experimental treatment. Such a confound of self-selection seriously limits the conclusions which can be drawn from such studies (Campbell & Stanley, 1963).

Long has recently compared the effects of aerobic conditioning with stress-management in reducing anxiety in subjects seeking treatment for "chronic intermittent stress" (Long, in press-a). She found that a ten-week program of either treatment led to reductions in self-reported anxiety, and increases in self-mastery, in comparison to a waiting-list control group. These effects were found to persist at a 15-month follow-up even in the absence of continued participation in aerobic activity (Long, in press-b). It was on this basis that she proposed that the effects of exercise on anxiety were due not to physiological effects of aerobic exercise per se, but to a generalization of the increased self-mastery accompanying training, an effect which persisted beyond the treatment period (Long, in press-b). Interestingly, change on this particular construct has been implicated as being the key component which leads to psychotherapeutic change in a variety of conditions, including anxiety (Bandura, 1977).

In addition to the above suggestions that exercise may be exerting its effects on anxiety reduction through "time out" (Bahrke & Morgan, 1978) or mastery (Long, in press-b), it has also been proposed that exercise may alter physiological reactions to stress (e.g. Eliot, 1979; Folkins & Amsterdam, 1977). It is well-established that physiological response to stress is elicited in the face of physical threat (Cannon, 1932). Such responses are also evident in the face of mentally challenging or emotionally charged situations (see Mason, 1975). There is a growing body of literature which documents the response to such situations in laboratory settings (Frankenhauser, 1980). Moreover, there is increasing evidence that the profile of autonomic and physiological response to such "psychosocial" stress may provide a measure of overall coping with stress, and by extension, to psychological functioning (Cameron & Meichenbaum, 1982). The following section will review these studies.

Psychosocial Stress: Correlates of Reactivity

Heightened sympathetic activity, as reflected in heart rate and skin conductance levels, has been shown to accompany laboratory psychosocial stress (Frankenhauser, 1980; Lacey & Lacey, 1952), and is associated with active coping with stress (see Light & Obrist, 1980).

The ascending (i.e. associated with stressor onset) and recovery (i.e. associated with stressor termination) limbs of the response profile have been separately related to measures thought to reflect the ability to cope with, or the impact of, the stressor. For example, it has been shown that the autonomic response itself can be modified by altering the cognitive appraisal of the stressor (Lazarus & Alfert, 1964; Speisman, Lazarus, Mordkoff, & Davison, 1964). After reviewing supporting evidence from both animal and human research, Burchfield (1979) suggested that an adaptive response pattern to situations necessitating active coping consists of elevations in arousal or endocrine response prior to stress followed by decreases following stressor onset. For example, such a profile, as revealed through repeated sampling of self-reported arousal, has been found to correlate with effective performance of challenging athletic tasks (Fenz, 1975; Mahoney & Avener, 1977). Moreover, it is noteworthy that a heightened anticipatory response to stress has been found in individuals scoring low on trait anxiety inventories (Valins, 1967; van Doornen, Orlebeke, & Somsen, 1980).

Paralleling this literature on autonomic response are reports indicating that a pronounced catecholamine response to stress is associated with better psychological functioning. Catecholamines, which are released in response to psychosocial and physical stress (e.g. Dimsdale & Moss, 1980-a), are thought to provide sensitive indices of the emotional impact of psychosocial stress. Roessler, Burch and Mefferd (1967) provided one of the earliest reports relating higher catecholamine excretion with greater ego strength. High catecholamine excretion under stress has also been related to lower neuroticism and emotional stability (Forsman, 1980; Frankenhauser, Mellis, Rissler, Bjorkvall & Patkai, 1968) and is associated with better performance on mental tasks (Frankenhauser & Rissler, 1970; Frankenhauser & Anderson, 1974; Johansson, Frankenhauser & Magnusson, 1973).

The profile of physiological recovery from psychosocial stress has also been related to psychological functioning, with several lines of evidence suggesting that faster recovery is associated with better psychological adjustment. For example, it was suggested some time ago that faster recovery of skin conductance levels following exposure to a stressor, reflects emotional stability and the absence of neuroticism (Darrow & Heath, 1932; Freeman, 1939). More recent work, using heart rate and skin conductance measures, has confirmed these findings with measures of anxiety and neuroticism (Katkin, 1966; Bull & Nethercott 1972; Bull & Gale, 1973). Research using clinically anxious or neurotic patients has revealed similar findings. Specifically, patients exhibiting phobic anxiety demonstrate both elevated electromyographic response to lab stressors as well as longer recovery profiles (Malmo, 1970; Malmo & Shagass, 1952). The latter study revealed that blood pressure in neurotic patients continued to rise throughout presentation of a stressor, whereas in normals, levels decreased or remained stable (Malmo & Shagass, 1952).

Rapid recovery of urine catecholamines following stress have also been associated with lower neuroticism (Johansson & Frankenhauser, 1973) and a state of relaxation (Johansson, 1976). Frankenhauser has proposed that stress could cause a wear and tear on the organism and interfere with mechanisms that "normally function to demobilize internal resources during post stress periods". According to this scheme, cumulative effects of life stress may alter recovery mechanisms, and lead to poor conservation of energies for dealing with subsequent experiences (Frankenhauser, 1980). A recent study, which supports this notion, found that speed of heart rate and blood pressure recovery following psychosocial stress could differentiate groups reporting high and low life-stress (Pardine & Napoli, 1983). Subjects reporting few stressful life events in the preceding months showed a faster recovery to baseline following performance of challenging mental tasks, than those reporting high stress (Pardine & Napoli, 1983).

Taken together, the above findings suggest that effective coping is reflected in both heightened anticipatory or early response to stress, and faster recovery of autonomic and endocrine measures following stress termination (Burchfield, 1979; Frankenhauser, 1980).

A question which arises is whether the adaptations which accompany aerobic fitness training alter the response to psychosocial stress. Such a demonstration might provide some insight into the mechanism of action of the reported effects of exercise on anxiety or stress-related conditions. Attempts have been made to test out the assumption of an altered emotional response related to aerobic fitness training. The following will review these studies.

Aerobic Exercise: Effects on Response to Psychosocial Stress

Several studies have examined the influence of aerobic training on autonomic response to psychosocial stress, through comparison of individuals differing in fitness level. In the first such published study, trained subjects showed lower blood pressure elevations and smaller decreases in skin temperature in response to films depicting sexual or medical (surgical) scenes, than untrained subjects, with these elevations being of shorter duration in trained subjects

(Cantor, Zillman & Day, 1978). While suggestive, this study suffers from numerous flaws. The only measure of fitness used to assign subjects to groups consisted of blood pressure response to an intense 30 second bout of exercise on a stationary bicycle; this does not, in any way, constitute a valid test of aerobic fitness (see Astrand & Rodahl, 1977). In fact, the effects seen may merely reflect differences between groups differing in cardiovascular responsivity rather than aerobic fitness *per se*. Moreover, the psychosocial stress consisted of a film stress, which can be considered a "passive" stressor (see Obrist, 1981). It is known that the cardiovascular system responds differently to stressors which elicit passive as opposed to active coping (Obrist, 1981). Thus, it may not be possible to generalize such findings to real-life stressors which necessitate active coping. Finally, measures were taken following termination of the film, and although presented as such, do not actually reflect response to the task.

A second study (Cox, Evans & Jamieson, 1979) correlated aerobic fitness level with heart rate response to laboratory psychosocial stress, which consisted of performing a difficult task while subjected to criticisms from an abusive experimenter. It was found that fitness level, while unrelated to the substantial heart rate elevations to the experimental situation, was associated with faster return of heart rate towards baseline, following stressor termination. This finding was later questioned by another group of investigators (Zimmerman & Fulton, 1982) who argued that the observed relationship between aerobic fitness and faster recovery merely reflected an artifact associated with the lower resting heart rate which accompanies training. These investigators attempted to replicate the Cox et al (1979) study, and showed that when corrected for baseline heart rate, no such effect was seen (Zimmerman & Fulton, 1982). However, the latter study differed in important ways from the Cox et al (1979) experiment. First, self-reported activity served as the only measure of aerobic training; self-report measures are known to correlate poorly with actual exercise test performance (Taylor et al, 1978). Moreover, resting heart rates in the Zimmerman and Fulton (1982) study were inexplicably high, and the nature of the stress manipulation did not succeed in elevating heart rate to levels seen in the Cox et al (1979) experiment. A rebuttal by the original investigators followed this report; these researchers reanalyzed their data, in part by separating subjects into trained and untrained groups, and confirmed the recovery effect (Jamieson, Evans & Cox, 1982). Another intact group comparison demonstrated a similar relationship between aerobic fitness and recovery of skin conductance following psychosocial stress (Keller & Seraganian, Expt 1, 1984).

While the above studies sampled younger, student populations, faster recovery has been related to fitness level in middle-aged subjects as well, with rapidity of skin conductance and heart rate recovery correlating with aerobic fitness level in male executives (Hollander & Seraganian, 1984).

Thus, studies which have examined the relationship between aerobic fitness level and response pattern to psychosocial stress have found that fitness is unrelated to the actual response to such stress, but is associated with a more rapid recovery following its termination.

In addition to the above correlational designs, there exists, to date, only one study which has manipulated aerobic fitness and examined the impact of such training on stress-response (Keller & Seraganian; Expt 2, 1984). A 10 week aerobic training program was shown to lead to more rapid autonomic recovery from psychosocial stress as compared to control groups receiving training in meditation or music appreciation (Keller & Seraganian, Expt 2, 1984).

The Present Investigation

The results of the above studies indicate that trained individuals show faster recovery of sympathetic activity following psychosocial stress, specifically on measures of heart rate and skin conductance. However, several problems are apparent in this literature.

First, the absence of subjective measures during exposure to psychosocial stress do not allow any statements as to whether trained subjects perceive such stress differently than untrained. Second, the stressors used were often not of sufficient duration, type, or difficulty to allow generalizations to reactions or coping outside the laboratory. Third, the absence of biochemical measures further limits the conclusions which can be drawn regarding the impact of aerobic fitness on the overall response profile. Fourth, these studies monitored variables at only two or three points during or following psychosocial stress, which may preclude the detection of subtle differences in response between the trained and untrained. Fifth, the measures of aerobic fitness used were, for the most part, of questionable validity or sensitivity. Finally, and most importantly, with the exception of the work by Keller and Seraganian (in press), these studies did not manipulate fitness level, which greatly limits any causal statements regarding the impact of aerobic fitness on response to psychosocial stress.

In consideration of the above, the experiments in this thesis were designed to further address the possibility that aerobic fitness influences the response to psychosocial stress. The first experiment compared response to laboratory psychosocial stress in groups of trained and untrained subjects. The second study examined whether manipulation of aerobic fitness would lead to an altered response to psychosocial stress. The latter experimental design, while acknowledged to provide a more definitive answer to this question, was preceded by a more economical correlational design (see Campbell & Stanley, 1963), which was intended to provide preliminary information in this regard.

Experiment 1

Physiological response to psychosocial stressors has been investigated in individuals differing in fitness level (Cantor et al, 1978; Cox et al, 1979; Hollander & Seraganian, 1984; Keller & Seraganian, 1984). These studies monitored heart rate and skin conductance measures during laboratory stress, and found aerobic fitness to be related to more rapid return to baseline levels following stressor termination. Although consistent with the hypothesis that aerobic fitness influences emotional reactivity, the findings have been limited to these two response modalities and thus provide little information on overall reactivity. A multimodal comparison of trained and untrained subjects in a psychosocial stress paradigm, appears warranted.

The present study compared reactivity to psychosocial stressors in trained and untrained individuals, selected on the basis of extreme scores on measures of aerobic fitness. Simultaneous monitoring of cardiovascular, biochemical and subjective indices was employed in order to obtain a clearer picture of how psychosocial stress influenced such measures in these groups. Heart rate, plasma epinephrine, norepinephrine, cortisol, prolactin, lactic acid, and self-reports of arousal and anxiety were sampled prior to, during, and following exposure to psychosocial stress. The stress package consisted of three consecutively performed tasks which were selected on the basis of their demonstrated ability to elevate autonomic measures. Mental arithmetic with white noise (e.g. Lawler, 1980), a general knowledge quiz (Schiffer et al, 1976), and the Stroop Color-Word Interference Task (Stroop, 1935: used by Cox et al, 1979; Frankenhauser & Johansson, 1976) comprised the psychosocial stress package. Catecholamine and cortisol measures were included on the basis of prior evidence that these provided sensitive indices of the impact of psychosocial stress on the individual (Frankenhauser, 1980; Mason, 1975). Additional biochemical measures included were prolactin, which has been shown to be released in a variety of stressful situations (Noel, Suh, Stone & Frantz, 1972), and lactic acid, which has been suggested to be related, possibly in causal fashion, to anxiety-provoking situations (Hall & Brown, 1979; Pitts & McLure, 1967). Lactic acid, which is a toxic byproduct of anaerobic metabolism, is particularly interesting in the context of the present study, given accepted differences in its metabolism by trained as compared to untrained individuals during physical work (e.g. Winder et al, 1979). It was hoped that by employing multiple sampling points in each of several measures, an integrated picture of how aerobic fitness level influences reactivity to psychosocial stress would be obtained.

Method

Subjects. Subjects were recruited through advertisements posted in the Montreal university community, as well as the Montreal YMCA (Downtown Branch). Advertisements solicited male English-speaking Caucasians between 20-30 years of age, for a project examining the "effects of physical and mental task performance on certain physiological and biochemical measures". Respondents were initially screened for either extensive or minimal participation in aerobic activities. Subjects who met these criteria were given a bicycle ergometer test to estimate their VO_2max. A score above 52 or under 40 ml/kg/min was used as the final screening criterion, and two groups (group trained and group untrained) at the extremes of the aerobic fitness continuum were thus formed. The final sample contained fifteen subjects per group. All subjects received $25.00 for their participation.

Apparatus and Stimuli. The experimental chamber consisted of an electrically-shielded enclosure (10 X 11 ft; Spectrashield) allowing both temperature and humidity control. A Beckman recorder (Model R-511A) was employed to monitor heart rate and self-report of subjective arousal. Heart rate was recorded using Beckman Dyna/trace electrodes filled with Beckman electrode electrolyte, with the signal processed through a Beckman (Type 9857) cardiotachometer coupler.

Subjective arousal level (SAL) was monitored by a nine-position dial beneath the subject's right hand, which lit one of a corresponding series of nine lights, mounted on a panel directly in front of the subject. Labels beneath the lights consisted of four settings on either side of a central reference point, and ranged from "extremely relaxed" to "extremely aroused". Output from the dial was fed into one channel of the dynograph. A 19 gauge butterfly needle (Abbott-4500) and Venoject vacutainers containing sodium heparin allowed all blood samples to be drawn with a single venopuncture. Aerobic fitness level was assessed with a Bodyguard Model 990 ergometer, with pedaling rate aided by a metronome (Franz Model LM-FB-5), and a Baumanometer sphygmomanometer for blood pressure readings.

All instructions and tasks were pre-taped on a Sony stereo taperecorder (Model TC-630) and delivered through Sony stereo headphones. A Sony videocamera/recorder (AVC- 3400) and television monitor were used to monitor the subject's performance. The three tasks employed in the psychosocial stress session were: mental arithmetic performed with exposure to white noise, a shortened version of "The Electrocardiogram Quiz" (Schiffer, Hartley, Schulman & Abelman, 1976) and the Stroop color-word task (Stroop, 1935) with additional conflicting color-words. The mental arithmetic task consisted of alternating serial subtraction and multiplication/addition problems delivered to the left ear while 90 db white noise (provided by a Grason-Stadler (Model 901B) white noise generator) delivered to the right. The quiz comprised 23 pretaped questions of varying difficulty, with each question followed several seconds later by the correct answer. For the third task, color-words were projected (by a Kodak Carousel-650 slide projector), on a screen, directly above the panel of lights. Slides were presented at the rate of one per second, in incongruous colors. For instance, the word "red" could appear in green letters. The task required that the subject report the color in which the word was printed. Pre-recorded color names were randomly and simultaneously delivered over the headphones.

Procedure

Subjects were tested individually over two sessions: aerobic fitness testing which was conducted during the afternoon, and the psychosocial stress session, which was held at 9 AM, from two to four days later.

Aerobic Fitness Test. Prior to arrival at the laboratory, subjects were instructed to avoid consumption of food, caffeine-containing beverages or cigarettes for two hours prior to the session. Upon arrival, the subject read and signed an informed consent form (Appendix A) describing both sessions, completed the Spielberger Trait Anxiety Inventory (Spielberger, Gorsuch & Lushene, 1970), as well as a questionnaire (Appendix B) to establish physical health, contraindications (e.g. medications, psychiatric illness), as well as extent of participation in aerobic exercise. After changing into running shoes, shorts, and a hospital gown, the subject's weight, pulse, and blood pressure (to screen for hypertension, over 135/90 mm Hg) were recorded. Electrodes were then placed on the back to allow continuous heart rate monitoring. Following a 1-min warm-up at no resistance, the subject pedaled at 50 rpm against progressively increasing workloads (300, 600, 900, 1200 and 1500 KpM/min). If heart rate exceeded 130 beats/min after 2 min of pedaling at a given workload, that particular workload remained in effect for an additional 4 min. If the heart rate was below 130 beats/min, the next progressive workload was imposed. Thus, the subject cycled for a total of six minutes at the final workload. Following a brief cool-down period, the electrodes were removed and the subject showered and left the laboratory.

Psychosocial Stress Session. Following an overnight fast, the subject arrived in the laboratory at 9:00 AM, had electrodes for monitoring heart rate placed on the back, and completed the Spielberger State Anxiety Inventory (Spielberger et al, 1970). The subject was then led into the experimental chamber, and was seated in an armchair which faced the screen and panel of lights. The blood sampling technique was then explained and the butterfly needle with attached catheter (heparinized between sample collections) inserted into the right forearm vein. Blood samples were drawn off into heparinized vacutainers and placed immediately on ice at eight predetermined times. Headphones were used for all subsequent communication to the subject. A curtain was drawn shielding the subject from the experimenters and the blood sampling apparatus. An opening in the curtain exposed the subject's right arm and hand, which rested on the arm of the chair and on the SAL dial respectively. The subject was observed throughout the session on a video monitor.

Figure 1 contains the experimental protocol for the psychosocial stress session. The session began with general instructions as well as an explanation of use of the SAL dial:

> In front of you is a panel of nine red lights which are turned on and off by the dial below your left hand. The center light is turned on now. Turning the dial to the right or left, turns on lights in either direction. Try it for a few seconds, finishing off by bringing it back to the center position (pause). Note the word "NOW" beneath this center light. Try to think of this center light as representing your level of arousal, tension, nervousness, or excitement right now. Use it as a reference point against which you will compare any changes during the session. You will be asked at various points to indicate your level of arousal. For example, if you feel somewhat aroused, you would turn on light number +1. Or, if you feel very relaxed, you would turn on light number -3. You will be asked at various times to indicate changes in level by turning the knob.

A 15-minute rest period followed, during which time the subject was instructed to close his eyes and try to relax. At the end of this rest period, the subject was instructed to indicate SAL and the first blood sample (A) was drawn. Throughout the session, blood samples, indicated in Figure 1 by capital letters, were drawn immediately following SAL reports.

EXPERIMENTAL PROTOCOL

	BASELINE	STRESS PERIOD				RECOVERY			
ACTIVITY	SITTING QUIETLY IN CHAIR	INSTRUCTIONS MENTAL ARITHMETIC (MA) QUIZ STROOP				SITTING QUIETLY IN CHAIR			
TOTAL TIME	15 MIN	17 MIN				15 MIN			
SAMPLE DESIGNATION	A	B	C	D	E	F'	F	G	H
ELAPSED TIME (MIN)	15	19	25	30	32	33	37	42	47
	END OF BASELINE	ONE MIN INTO MA	ONE MIN INTO QUIZ	ONE MIN INTO STROOP	THREE MIN INTO STROOP				

Figure 1. Protocol for psychosocial stress session

The stress period then began with the following instructions:

> You will now be performing three mental tasks. The first will be arithmetic problems involving subtraction, multiplication and addition. The second will be a general knowledge quiz. The third will be a color-word task. Although not difficult for most people, the exacting nature of these tasks requires that you employ your full powers of concentration in order to perform well. In front of you is a videocamera, and just above your seat is a microphone. These allow the experimenters to monitor you throughout the session. As well, the entire session is being videotaped, and your performance will be evaluated later by the experimenters. Your image will now be displayed on the monitor in front of you.

The subject's image was then briefly displayed on the monitor in front on him. Instructions for the arithmetic task followed:

> You will now be given instructions for the arithmetic task. During this task you will hear problems to solve through one ear, and some white noise through the other. Listen carefully as no problem will be repeated, and give your answers orally. There will be two types of problems presented. One type of problem will involve continuous subtraction. For example, you might be asked to subtract 4 continuously from 100. You would subtract 4 from 100, and give the answer 96, the subtract 4 from 96 and give the answer 92, and so on, until you are told to stop. Thus, the answers you would be giving would be 96, 92, 88, and so on. If you make a mistake, just continue subtracting from that mistake, and as long as the subsequent subtractions are right, you will only be penalized for that one mistake. You will be given a limited time to answer, and your score for this type of problem will be determined by the number of correct subtractions within that time. The second type of problem will consist of examples involving multiplication and addition. For example, you might be asked: What is 4 times 6 plus 1? You would first multiply 4 by 6, which is 24, then add 1, with your answer then being 25. Problems will be presented quickly, one right after the other. Once again, your responses will be videotaped for later scoring by the experimenters.

The mental arithmetic task, consisting of examples of continuous subtraction alternating with segments of multiplication/addition problems, followed (Appendix C). At the end of the first minute of the task, an indication of SAL was requested, and the second blood sample (B) drawn. Instructions were then given for the quiz, which consisted of 23 questions (Appendix D) which the subject was required to answer orally. Correct answers were given approximately seven seconds after each question. SAL was requested and the third (C) blood sample drawn at the end of the first minute of the quiz.

Upon completion of the quiz, the following instructions were given for the color-word task:

> You will now be performing the color-word task. Color-words will quickly be flashed on the screen, one at a time. Each color-word is printed in different colors. Your task is to say the color of the print, and not the word itself. For example, the word "red" now appears on the screen in green print. You would answer "green", the color of the print. As another example, in this next slide, you would answer "yellow". In addition, you will be hearing, at the same time, other color-names through the headphones. Try to ignore these and name only the color of the print. If you make a mistake during the task, do not go back to correct yourself, simply continue. Remember to try as hard as you can, and try not to quit.

Blood samples were drawn after the first minute (D) and at the end of the color-word task (E), approximately two minutes later.

The recovery period, during which the subject sat quietly, then followed. Blood samples were drawn at the 5 (F), 10 (G) and 15 (H) minute points of the recovery period. After the headphones, butterfly needle and electrodes were removed, the SSAI was readministered. The subject was then debriefed regarding the purpose of the experiment, and informed of the contrived aspects of the psychosocial stressors and accompanying instructions.

Measures

The scoring and analysis of the various measures are described below.

Estimated Maximal Oxygen Uptake. Heart rate and work load at the final two minutes on the ergometer were entered into a standardized nomogram (Astrand & Rodahl, 1977). After correcting for body weight, a final figure of estimated maximal oxygen consumption in ml/kg/min was determined.

Aerobic Points. The physical activity questionnaire was used to assess frequency, intensity and duration of participation in aerobic activities, on a weekly basis. Cooper's aerobic point system (Cooper, 1977) was employed to translate these data into a numerical form. A weekly value of 30 points has been suggested by Cooper to be the minimum required for the average man to maintain aerobic fitness.

Heart Rate (HR). The number of heart beats recorded over 1 min periods, were counted at points A through H. In addition to these nine points, HR was also scored for 1 min immediately following termination of the stress period. This point is represented as point F' in Figure 1 and Figure 2.

Subjective Arousal Level (SAL). The ratings taken from the nine-position dial which ranged from -4 ("extremely relaxed") to +4 ("extremely aroused") were converted for scoring purposes to a scale of 1 to 9, with a score of 1 equivalent to -4 and a score of 9 equivalent to +4.

Spielberger State/Trait Anxiety Inventories. The Trait inventory was administered at time of screening. The State inventory (SSAI) was administered prior to the psychosocial stress session, and immediately following the recovery period.

Performance. The number of correct responses on the arithmetic and quiz tasks, were separately evaluated. Scoring of the color-word task proved unreliable and is not reported.

Biochemical Analysis. At each sample point, blood was drawn into a heparinized tube for assay of all substances except lactic acid. After centrifugation, plasma was stored at -70°C for subsequent assays for epinephrine (E), norepinephrine (NE), cortisol and prolactin. Due to financial constraint, E and NE were assayed only for points A, B, D and E for ten randomly selected subjects in each group. These assays, performed in the Department of Exercise Physiology at the University of Montreal (Peronnet et al, 1981) followed the radioenzymatic method of Passon & Peuler (1973), modified by Peuler & Johnson (1975), using catecholamine radioenzymatic assay kits (Cat-A-Kit, Upjohn). Intra-assay variance was 7.5% for E, and 10.5% for NE.

Cortisol was assayed using assay kits (Amerlex Cortisol RIA kit, Amersham) which employ a competitive protein binding radioimmunoassay similar to that described by Murphy (1967). Intra-assay and interassay variance was less than 10%. Prolactin levels were assayed by radioimmunoasssay (Hwang, Guyda & Friesen, 1971). Variation coefficients yielded a precision of 4% and a reproducibility of 6%. Sensitivity was found to be 2.3 ng/ml. Lactic acid was analyzed according to the method described by Gutman & Wahlefeld (1974), and modified by Desharnais, Audet and Brisson (1979) for use on an automatic analyzer. At each sample point, immediately following the drawing of blood for the other measures, 2 ml of blood was drawn into a tube containing sodium fluoride and potassium oxalate. The tube was inverted several times, with 1 ml of blood deproteinized in 0.6N $HClO_4$ (perchloric acid) for analysis. After centrifugation, plasma was stored at -20°C for subsequent hormone assay. Cortisol, prolactin and lactic acid levels were determined at the Department of Health Sciences at the University of Quebec at Trois Rivieres.

Results

Table 1 contains the mean age, weight, resting systolic and diastolic blood pressure, estimated maximal oxygen consumption, and aerobic points/week for groups trained and untrained. T-tests indicated that the groups did not differ in age, weight, or blood pressure, but differed markedly in estimated maximal oxygen consumption. On the latter measure there was no overlap between groups: the lowest score in group trained was 53.7, and the highest score in group untrained was 39.6. Group trained also had a significantly greater number of aerobic points than did group untrained. Trained subjects had engaged in aerobic activities for an average of 5.5 years.

Performance scores during the stressor tasks did not differ in the two groups. Heart rate, subjective and biochemical measures were analyzed by repeated measures analysis of variance (ANOVA: Biomedical Data Programs, University of California, 1978). A t-test on heart rates at point A (see Figure 1) revealed that group trained (51 $\pm$ 1.9) had significantly lower ($t(28) = -4.36$, $p < 0.0001$) basal heart rate than group untrained (64.5 $\pm$ 2.4), replicating clearly established differences between such groups (Astrand & Rodahl, 1977). Heart rate data for each subject were therefore expressed as a difference score from baseline.

Figure 2 presents mean heart rate change scores for points B through H. All subjects showed marked elevations at the onset of the stress period. ANOVA of the stress period, points B through E, was significant for periods ($F(3,84)=$

Table 1

Means and Standard Errors of Selected Variables in Groups Trained and Untrained

	Trained	Untrained
Age	26.0 ± 0.8	25.7 ± 0.6
Weight (kg)	70.0 ± 1.3	76.1 ± 3.0
Systolic blood pressure (mm/Hg)	119.9 ± 2.9	114.3 ± 2.9
Diastolic blood pressure (mm/Hg)	68.5 ± 2.1	69.8 ± 2.5
Estimated maximal oxygen consumption	69.1 ± 2.7	32.8 ± 1.2 *
Aerobic points/wk	312.5 ± 31.8	20.1 ± 4.4 *

* $p < .0001$

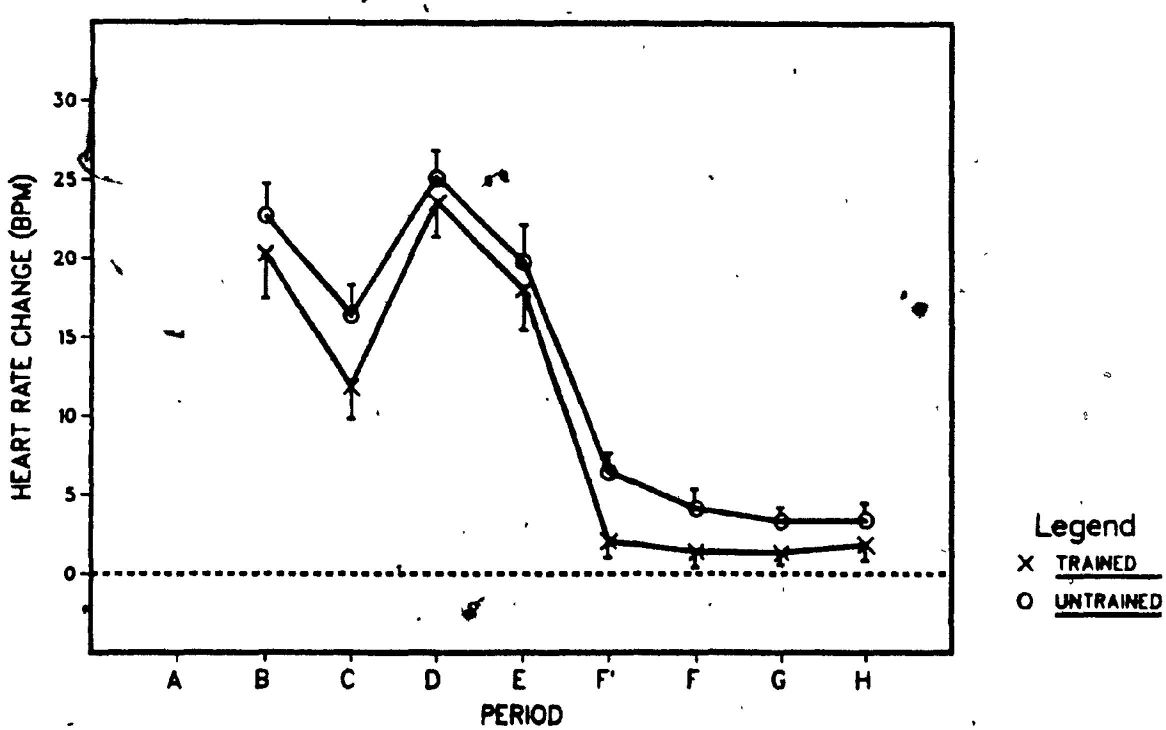

Figure 2. Mean (± standard error) heart rate change from baseline in beats/min for all periods for groups trained and untrained

20.45, $p < 0.01$), but not for groups ($F(1,28) = 0.83$, n.s.). ANOVA of the recovery period, points F' through H, was significant both for groups ($F(1,28) = 10.01$, $p < 0.005$) and periods ($F(3,84) = 3.44$, $p < 0.05$). The critical difference (cd), according to a Tukey test, revealed that group trained had significantly lower values than group untrained at points F', F and G (cd= 1.72, $p < 0.05$). By point H, the groups were indistinguishable.

Figure 3 depicts SAL and SSAI scores. ANOVA of SAL at all points was significant for periods ($F(7,196) = 148.92$, $p < 0.0001$). All subjects showed marked elevations in arousal during the stress period, followed by reductions during recovery. At point H, group trained subjects reported lower mean (2.1) scores than group untrained (2.8) ($t=-2.15$, $df=28$, $p < 0.05$). The inset in Figure 3 presents the SSAI scores which yielded a significant group x period interaction ($F(1,28) = 7.05$, $p=0.01$). Tukey tests (cd=2.89, $p < 0.05$), revealed that pre-scores were indistinguishable, but that group trained reported significantly lower post-scores. The groups did not differ on trait anxiety ($t(28) = -0.63$, n.s.).

Figure 4 present group means for E and NE for ten subjects in groups trained and untrained. ANOVAs revealed no group, but a significant period effect both for E ($F(3,54) = 7.32$, $p < 0.0005$) and NE ($F(3,54) = 3.26$, $p < .05$). Due to large within-group variability, log-transformation of individual scores was performed (Winer, 1971). No systematic differences across groups were evident from inspection of response profiles for E. However, inspeotion of individual

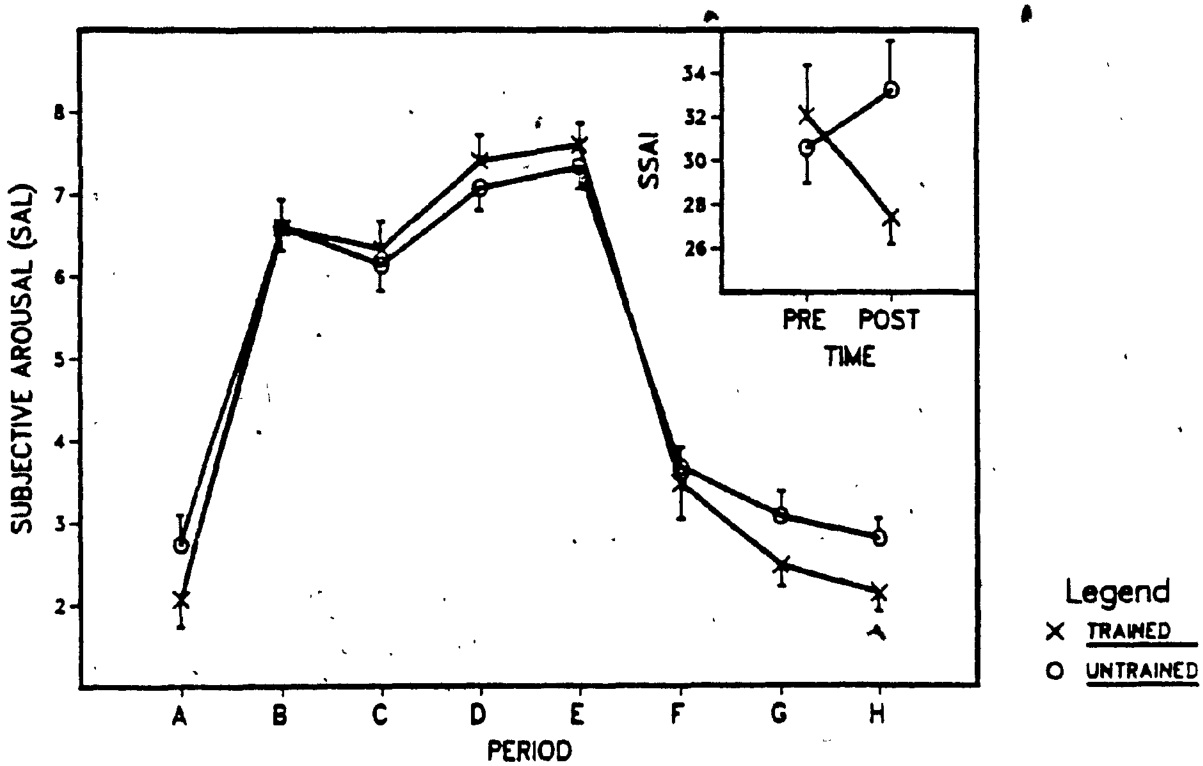

Figure 3. Mean (± standard error) subjective arousal level for all periods for groups trained and untrained. Inset: Mean (± standard error) Spielberger State Anxiety (SSAI) score prior to (pre) and following (post) the psychosocial stress session

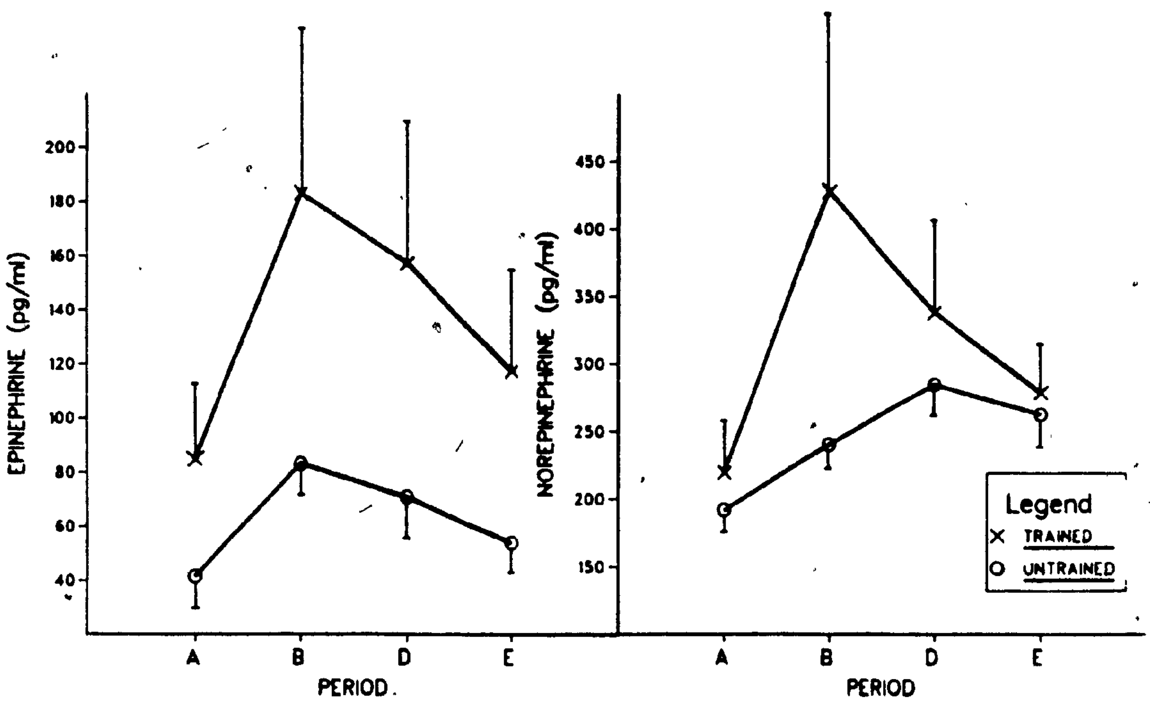

Figure 4. Mean (± standard error) epinephrine (pg/ml) and norepinephrine (pg/ml) levels for periods A, B, D, and E, for groups trained and untrained

scores for NE, presented in Figure 5 suggested that the peak response occured at different sample points in the two groups. Chi-square revealed that group membership was significantly ($X(1)= 7.2$, $p < 0.05$) related to the point at which the peak response occured, with members of group trained peaking significantly earlier than group untrained. Whereas eight out of ten subjects in group trained evidenced a peak response at point B, the same proportion in group untrained showed peak responses at points D or E. An ANOVA on these log-transformed data produced a group x period interaction which approached significance ($F(3,54)= 2.40$, $p=0.08$). It should be noted that assays were initially conducted for 2 highly trained and 2 highly untrained subjects. Differences in peaking of norepinephrine values was apparent with these subjects, and assays were then conducted on an additional 3 subjects per group, followed by an additional 5, with group differences evident with each set of assays.

Figure 6 presents group means for cortisol, prolactin, and lactic acid for 13 subjects (through technical mishap, some samples were lost) in group trained and 15 subjects in group untrained. ANOVA revealed a trend for group trained to have higher cortisol values ($F(1,26)= 3.14$, $p \simeq 0.09$) than group untrained. Cortisol values differed significantly across periods ($F(7,182)= 4.89$, $p < 0.0001$). Tukey tests indicated that although scores from baseline to the stress period did not differ, significant reductions occured from

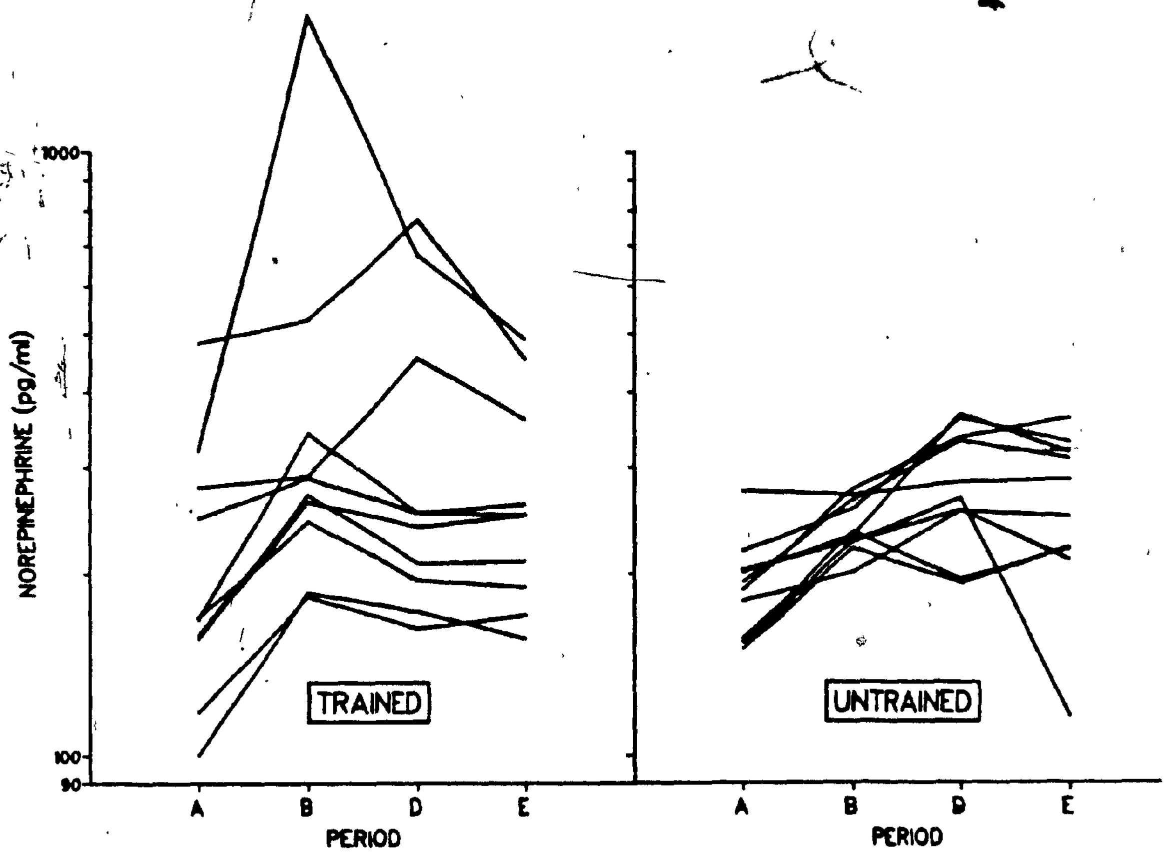

Figure 5. Individual profiles of norepinephrine values (log-transformed) for periods A, B, D, and E, for groups trained and untrained

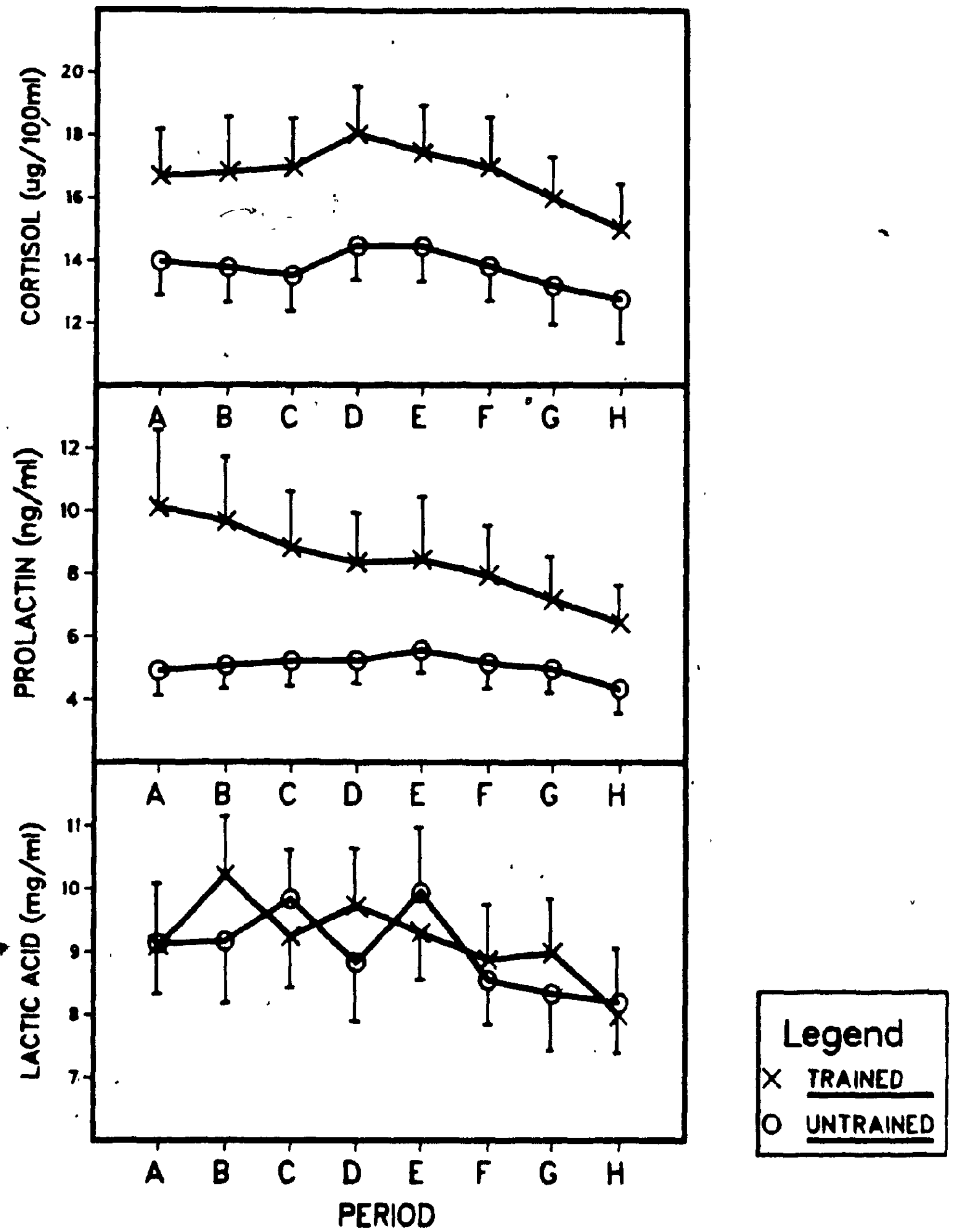

Figure 6. Mean (± standard error) values for cortisol, prolactin and lactic acid for groups trained and untrained. Upper panel: Cortisol (ug/100 ml); Middle panel: Prolactin (ng/ml); Lower panel: Lactic acid (mg/ml)

the stress period to points G and H of recovery (cd= 0.99, $p < 0.05$). ANOVA of prolactin scores, presented in the middle panel of Figure 6, was significant for periods ($F(7,182) = 4.26$, $p < 0.0005$) and for the group x period interaction ($F(7,182) = 3.18$, $p < 0.005$). Tukey tests showed that group trained had significantly higher values than group untrained at points A and B (cd= 3.86, $p < 0.05$). From points C to H, the groups were indistinguishable. ANOVA of lactic acid scores, presented in the lower panel of Figure 6, was significant for periods ($F(7,82) = 3.37$, $p < 0.005$). Tukey test (cd= 0.81, $p < 0.05$) revealed no significant elevation from baseline to the stress period, but a significant reduction throughout the recovery period, so that point H was significantly reduced relative to points A-E.

Discussion

Trained and untrained individuals showed different response profiles to psychosocial stress. During the stressors, both groups increased indistinguishably in heart rate; once the stressors had ended, the trained returned to baseline more rapidly. Likewise, at baseline and during the stressors, self-report measures did not reveal any group differences, but at the end of the session, trained subjects reported lower anxiety scores. During the psychosocial stressors, the peak norepinephrine response occurred earlier in trained subjects. Resting biochemical measures indicated significantly higher prolactin levels, and a trend towards higher levels of cortisol.

The difference in heart rate recovery seen here replicates previous reports (Cox, 1979; Hollander & Seraganian, 1984; Keller & Seraganian, 1984), which have found aerobic fitness to be associated with more rapid physiological recovery from psychosocial stress. The Spielberger State findings as well as the lower subjective arousal level in trained subjects at minute 15 of the recovery period, represent the first demonstration of an altered subjective response to an acute psychosocial stressor in trained versus untrained individuals. Pre to post scores were unchanged for untrained subjects whereas scores for trained subjects declined significantly. This correspondence in recovery rates between subjective and heart rate indices reinforces the role of aerobic fitness in accelerating recovery from psychosocial stress.

The absence of performance differences between the groups militates against the possibility that the tasks were less difficult for the trained subjects. The reduction in state anxiety seen in trained subjects at the end of the session, could reflect enhanced perception of the deceleration of heart rate following a stressful situation. This interpretation is consistent with reports of enhanced perception of physiological arousal in the aerobically trained (Hollandsworth, 1979; Jones & Hollandsworth, 1981; Nucci, Note 6).

Greater arousal preceding exposure to a stressor has been proposed to reflect more effective coping (Burchfield, 1979; Mahoney & Avener, 1977). Furthermore, Burchfield (1979) has suggested that an adaptive response to stress appears to involve "decreased arousal response after stressor onset". In the case of catecholamine levels, specifically, large increases in response to a stressor, followed by rapid elimination, are thought to be indicative of emotional stability and psychological well-being (Forsman, 1980; Roessler, 1967). In the present experiment, most of the trained subjects had attained their peak norepinephrine level by the first stress point, and were returning towards baseline levels at a point in time when levels in the untrained subjects were continuing to rise. In an analagous fashion, prolactin levels in trained subjects were significantly elevated over untrained at baseline and the first stress point, but then decreased to levels comparable to untrained subjects by the second stress point. Additionally, there was a trend for levels of cortisol to be higher in trained subjects. Thus, the tendency for trained subjects to exhibit either higher baseline levels, or greater increases immediately following stress onset could be consistent with a more adaptive response to emotional stress. It should be noted that this effect could only have been manifest with repeated blood sampling such as that used here; such multiple sampling appears critical, particularly given the lability of these measures (Dimsdale & Moss, 1980-b).

Finally, lactic acid levels, although giving some indication of declining during recovery, showed no group differences and minimal reactivity to the stressors. Despite clearly established differences in lactic acid metabolism between the trained and untrained in response to physical stressors (Winder et al, 1979), the present data do not indicate that such metabolic adaptations play a role in modifying how the trained react to psychosocial stressors. More generally, these findings are consistent with prior criticisms (Ackerman & Sachar, 1974) of models which have ascribed a central role to lactic acid in the etiology and control of anxiety reactions (Pitts & McClure, 1967).

Regarding the biochemical measures in general, the possibility exists that the values reported as "baseline" here, do not represent a true baseline, but rather may reflect anticipation of the tasks. This possibility is afforded some support by significantly lower scores following the stress period, for both cortisol and lactic acid. However, it is unclear why such an anticipatory reaction would be manifest at a biochemical level while heart rate and subjective indices gave little indication of arousal.

Two predictions follow from the present findings of fitness-related differences in laboratory stress-response. Since responding to laboratory situations is regarded to be an index of responding in "real-life", it would be expected that aerobic fitness would be associated with an altered response to stress outside the laboratory. Although no studies have directly addressed this possibility, recent evidence suggests that fitness level is associated with a reduction in the intensity with which daily stresses are experienced (Cha; Note 2; Golden, Sinyor & Seraganian, Note 3; Killip, Note 4). In the first two of these studies, subjects were tested for aerobic fitness level and completed a questionnaire aimed at assessing the frequency and perception of "daily hassles", which are defined as the routine, annoying and frustrating events in daily life (DeLongis, Coyne, Dakof, Folkman & Lazarus, 1982). Although subjects differing in fitness level were found to report the same absolute number of hassles, the intensity with which these were experienced were less in trained subjects (Golden et al, Note 2; Cha, Note 3).

The second prediction would be that one proposed endpoint of stress, namely physical illness (Rabkin & Struening, 1976), would be reduced through aerobic fitness training. This has, in fact, recently been reported by Roth and Holmes (in press), where life stress was found to have little impact on physical health in trained subjects but the same stress exerted the predicted deleterious effect on untrained subjects. This finding is consistent with previous work indicating that regular exercise may moderate the stress-illness relationship (Kobasa, Maddi & Puccetti, 1982; Bryntwick, Note 5).

To summarize, the present data suggest that aerobic fitness level is associated with an altered response pattern to psychosocial stress, with a high level of fitness associated with more adaptive responding. However, while the group differences observed here may have resulted directly from aerobic fitness training, alternative explanations present themselves in interpreting these findings.

One possibility is that the results observed may have been due to differences between trained and untrained subjects on variables other than aerobic training; these differences may have existed prior to training. For example, it is conceivable that such vigorous activities might be preferentially sought by individuals possessing certain characteristics, with these individuals differing in important ways from those who would not select such activities. These characteristics, which may have served as confounding independent variables in the first experiment, may be psychological (e.g. personality variables) and/or physiological in nature. For example, aerobic fitness level is known to be strongly influenced by constitutional, possibly genetic factors, in addition to being altered through aerobic training (Lester et al, 1968; Wolthuis et al, 1977). Different levels of such factors may be unequally distributed across groups who differ in aerobic fitness levels, and this imbalance may have contributed to the observed group differences.

It is also conceivable that aspects of the testing itself resulted in a differential response to psychosocial stress in these two groups of subjects. For example, although subjects were not specifically informed about the experimental hypothesis, it is possible that the aim of the study was apparent to them, with this contributing to the observed group effects. In a related vein, the very act of screening for fitness level may have exerted different effects on subjects in the two groups. Although information regarding scores or relative performance on the fitness test was withheld from all subjects until the conclusion of the study, most of the trained subjects were aware of the nature of the ergometer test (some had performed this test previously), as well as the significance of the large increases in work loads which characterized their fitness tests. Thus, it is likely that these subjects knew that they had "performed well"; in a similar way, it is possible that untrained subjects were aware of their relatively "poorer" performance. It is conceivable that such awareness of the nature of the study, coupled with knowledge of one's performance in the screening session, would lead to differential effects in psychosocial stress-response in groups of subjects differing in fitness level, or perhaps accentuate the possible pre-existing differences mentioned above.

Another possibility is that the observed differences in response pattern may be due, not specifically to improved aerobic conditioning, but may be the result of regular participation in any recreational activity, be it physical or nonphysical. Possible non-specific factors shared by such activities which might lead to effects on stress-response would be social contact with other participants, distraction or "time-out" from daily stress, or the sense of accomplishment or mastery which accompanies successful performance of such activities. Such non-specific effects of exercise have been previously suggested to underlie its effects on stress-related measures (Bahrke & Morgan, 1978; Long, in press-b).

Thus, the results of the present experiment, while suggestive, cannot address the question of whether aerobic fitness *per se* was responsible for the effects observed. This could only be addressed in a within-subject, longitudinal design where aerobic fitness is experimentally manipulated, with response to psychosocial stress examined prior to and following training. Comparison of such training with the effects of participation in another, non-aerobic activity, would add information regarding the specificity of aerobic fitness in this regard. The above strategy was adopted in the following experiment.

Experiment 2

In the first experiment, the response pattern to psychosocial stress was seen to differ in trained and untrained individuals, with trained individuals exhibiting a more adaptive pattern to stress. While suggestive, the correlational design used could not address the question of whether aerobic fitness *per se* was responsible for the effects observed. Possible confounds include pre-existing group differences, differential effects of testing, or non-specific effects (i.e. social interaction, distraction, mastery) of aerobic fitness training.

This second experiment examined whether the effects observed in the previous study reflected the unique contribution of aerobic conditioning, rather than merely reflecting pre-existing and possibly pre-disposing differences which may differentiate trained individuals from untrained. This was accomplished by manipulating aerobic fitness through training, and examining accompanying changes in stress-response. Additionally, subjects receiving aerobic training were compared to a group receiving anaerobic training, which emphasizes muscular strength rather than cardiovascular endurance as the endpoint of conditioning. It was hoped that such a comparison, by controlling for non-specific factors as described above, would allow for the examination of the specific contribution of the improvement in aerobic power to stress-response. Finally, a waiting-list group was included as a control for extraneous variables (e.g. testing, maturation) inherent in both experimental conditions (Campbell & Stanley, 1963).

In addition to testing for response to psychosocial stress in the laboratory, a self-report measure aimed at assessing response to stress in daily life was included in this experiment. It was felt that this would provide informative data regarding the possible generalization of fitness training to stress-response outside the laboratory. Such measures are particularly important in the present context, given the criticism that laboratory paradigms are limited in their prediction of stress-response outside the laboratory (see Laux & Vossel, 1982). Recent evidence suggests that aerobic fitness is associated with reduced severity of reported daily stress (Cha, Note 3; Golden, Sinyor & Seraganian, Note 2). The measure used in these latter studies was a questionnaire developed by Richard Lazarus, which is named the "Daily Hassles Scale" (Delongis et al, 1982; Kanner et al, 1981). The frequency of hassles, in this context, represent the number of irritating frustrating, and distressing minor events which individuals encounter in daily life; a rating of the perceived severity of each hassle provides additional information regarding the impact of such events on the individual. This measure was used in the following experiment to evaluate possible fitness-related changes in the perceived impact of daily stress. It is noteworthy that the measure of daily hassles have been found to correlate more closely with psychosomatic symptoms and health status than have traditional measures of major life events (Kanner et al, 1981; Delongis et al, 1982).

In addition, a scale aimed at measuring self-mastery (Pearlin & Schooler, 1978) was included to examine possible changes on this dimension as a result of treatment. This particular construct is regarded as a "core resource" which aids the individual in handling adverse environmental events (Bandura, 1977). High levels on this measure have been shown to correlate with reduction in the impact of life strain on perceived stress-response (Pearlin & Schooler, 1978). Measures related to this construct (self-confidence, self-concept) have been consistently reported to be influenced by aerobic training (Hanson & Nedde, 1974; Hilyer & Mitchell, 1979). It was hoped that this measure would provide some information regarding a possible mechanism of action (e.g. mastery) which has been postulated to underlie the effects of exercise on stress-response (Long, in press-b).

In the following experiment, subjects were assigned to aerobic, anaerobic or wait-list control, with response to psychosocial stress examined prior to and following a ten week treatment period. Additional self-report measures evaluating stress-response and mastery were included to provide information relevant to functioning outside the laboratory. The protocol in this experiment differed slightly from that used in the first experiment. Given the limited reactivity of lactic acid in the previous experiment, no assays were conducted for this measure. Trait anxiety was not measured for similar reasons. An additional sample point, two minutes into the recovery period, was added for the other biochemical measures, particularly given the rapid recovery of catecholamines seen in pilot work in the first experiment. Finally, aerobic fitness level was determined through a treadmill rather than bicycle protocol, given the apparently greater reliability as well as sensitivity of this procedure in predicting oxygen consumption from submaximal tests (Astrand & Rodahl, 1977). In particular, treadmill testing is not limited by a selective effect of fatigue, weakness or pain of the quadriceps muscles, which is inherent in ergometer testing, and which would tend to underestimate the true level of aerobic conditioning (Cooper, 1977).

Method

Subjects. Subjects were recruited through advertisements in the Montreal university community and local newspapers, which solicited males between 20 and 30 years of age with English as a first language, to participate in a project examining the "relationships between physical and psychological health". Respondents were initially screened for minimal participation in aerobic activities. Subjects who met these criteria were further screened for fitness level through bicycle ergometer testing to estimate their VO_2max. A score below 40 ml/kg/min was used as the final screening criterion. The thirty eight males who were retained in the final sample were assigned to either an aerobic (jogging; N=15) training group, an anaerobic (weightlifting; N=15) conditioning control, or a waiting-list control group (N=8). The latter group was told that the groups were full, but that they would be provided with the results of the study upon its conclusion, along with one of these programs or the guidelines for program performance. Subjects were told that they would be required to perform various physical and psychological tasks before and after the ten-week program, and that they would receive $50.00 for their participation.

Apparatus and Stimuli. Bicycle ergometer testing, as described in Experiment 1, was used for screening subjects. All stimuli for the psychosocial stress session were pretaped on a Sony Betamax (Model SLO-323) videorecorder. ECG electrodes (Quinton) were used for heart rate recording.

Treadmill testing was conducted using a Quinton treadmill (Model 18-49C) with heart rate monitored via a Quinton ECG Monitor (Model 622A-MS). Lange skinfold calipers and a Hartz standard sphygmomanometer were employed to measure fat thickness and blood pressure, respectively. The arithmetic, quiz and Stroop tasks used for pre-testing were identical to those used in Experiment 1. In order to avoid any recall effects on the quiz, an alternate set of questions were used for post-testing (Appendix E).

Procedure

Screening. Subjects were initially screened for fitness level through a physical fitness questionnaire followed by bicycle ergometer testing, in a protocol identical to the aerobic fitness session in Experiment 1. Due to time constraints, only 29 subjects could be screened through ergometer testing. For the remaining subjects, information supplied by the activity questionnaire served to confer eligibility. The consent form used in this experiment was identical to that used in Experiment 1, with a description of the treadmill procedure substituted for the description of bicycle ergometer testing.

Pre-testing. The protocol for the psychosocial stress session was identical to that used in Experiment 1, except for an additional blood sample drawn at minute 2 of recovery. Subjects were individually tested in 2 hour blocks, from either 9-11 AM, 12-2 PM, or 3-5 PM. Subjects in the various groups were randomly assigned for testing time at pre-test.

Following the psychosocial stress session, the subject was given juice and allowed to rest for 15 minutes. Following this rest period, the subject changed into shorts and running shoes, had percent body fat (10 point procedure (Allen et al, 1956) recorded and treadmill testing was begun. Treadmill testing was conducted by technicians trained in cardiopulmonary rescucitation. Subjects performed a modified Balke (Balke & Ware, 1959) protocol for estimating maximal oxygen uptake through heart rate response to submaximal work. This protocol requires subjects to walk on a moving belt with elevation (and at later stages of the test, speed) progressively increased until a target heart rate is reached. Length of time, and corresponding increase in workload which is required to elevate heart rate, in this case to 85% of maximum, serves as a measure of aerobic fitness. Subjects initially walked at 0% elevation for 1 minute, with a treadmill speed of 3.3 mph. At the end of this minute, elevation was increased to 2%, and thereafter in increments of 1% every minute, until the target heart rate was reached. If target rate was not reached by the end of minute 25, the speed was then increased (elevation remained at 25% subsequent to this point) at the rate of 0.2 mph each minute, until target rate was reached.

The latter was calculated through the following recommended formula (American College of Sports Medicine (ACSM), 1980):

$$.85(MAX - RHR) + RHR$$

MAX, which refers to maximum heart rate, is computed by subtracting the subject's age from 220. RHR refers to resting heart rate; baseline heart rate during the psychosocial stress session was used for this calculation.

Testing was conducted over a two week period prior to start of treatment.

At the first training session for the experimental groups (or at the laboratory during the same period for controls), subjects completed a package of questionnaires consisting of Lazarus' Daily Hassles and Uplifts Scales, Hopkins' Symptom Checklist, and a rating scale for evaluating self-esteem (including factor scores for self-denigration and self-mastery) (Pearlin & Schooler, 1978). Given the question of interest, only the results from the Daily Hassles and self-esteem scales are reported here.

Assignment to groups. Random assignment to experimental groups was obviated by the limited availability of training facilities, which forced the scheduling of treatment sessions at different times. Thus, the following procedure was employed. Subjects who passed the screening were asked whether they would be available for one of two time periods (7:30-8:30 AM, 5:30-6:30 PM) without being informed of which type of training was scheduled for either of these times. In most cases, subjects indicated availability for one or the other time, and were assigned to the corresponding treatment program. Subjects who indicated that they were available for either time were alternately assigned to either condition. Control subjects comprised those subjects who were unavailable at either time, as well as subjects who were available but responded to advertisements after experimental groups were full.

Treatment

Fitness Instructors. The two instructors who led training sessions were experienced in the relevant exercise modality. Although not blind to the experimental hypotheses, these leaders were instructed to discuss only training-related issues with the subjects. In order to ensure equality of treatment (in all aspects but the particular modality (i.e. aerobic/anaerobic), training sessions for both treatments were regularly attended and monitored by the author.

Aerobic Training. Aerobic fitness classes were held from 7:30 to 8:30 AM on four weekday mornings at the Montreal YMCA (Downtown branch), with subjects required to attend at least three of these classes weekly. Following completion of forms at the first training session, the fitness instructor was introduced and provided a description on the potential beneits and risks associated with participation in aerobic activities. During the remaining sessions, the instructor followed a recommended protocol (ACSM, 1980) aimed at improving cardiovascular fitness. The exercise sessions consisted of 1 hr of progressively more vigorous activity, beginning with approximately 15 min of stretching and warm-up exercises, progressing through to light calisthenics, followed by approximately 30 min of jogging (on a 1/8 mile circular track), with calisthenics and various games (e.g.

team relay) interspersed in order to maintain the interest of subjects as well as their heart rates within the aerobic range. Subjects had been taught to measure their own heart rate (at the carotid artery), and recorded baseline rates prior to the session, as well as exercise and recovery rates during and following the jogging segment, for each class. These were recorded on individual index cards by the subjects and also provided a check for attendance. The session concluded following a cool-down period of approximately 15 min during which subjects performed various stretching exercise. Throughout the session, the instructor monitored all subjects in order to ensure that exercises were being performed safely and effectively.

Anaerobic Training. Anaerobic classes were held from 5:30 to 6:30 PM on three weekdays at a university gymnasium (weight-room). Subjects were required to attend all sessions, and were allowed access to the facilities at all other times. As with the aerobic group, following completion of questionnaires at the first session, the instructor explained the benefits and risks associated with anaerobic training. Classes began and ended with similar warm-up and stretching exercises as in the aerobic group, differing only in the 30 min intervening. During this period, subjects successively performed 12 different exercises, combining weight training (using Universal Gym apparatus) with high intensity, short duration bicycle ergometer work. Exercises included wrist curls, bench press, shoulder shrugs, leg raises, hamstring curls, shoulder press, and leg press. During the first session, the resistance required to achieve muscular failure after 15 repetitions was determined for each subject at each exercise station. For the next two weeks, subjects performed two sets of each exercise at this resistance. From week three until program termination, the resistance for each exercise was progressively increased to maintain the maximum number of repetitions at 8. Subjects worked in pairs, and completed a progress sheet which provided a log of their improvement over sessions.

Control Group. Questionnaires were administered individually to control subjects during the week in which experimental subjects began their training programs.

Post-testing. Subjects were tested in the psychosocial stress session at the same time of day as their pre-test. Testing was staggered over two weeks beginning in the eleventh week, with subjects specifically instructed not to participate in a fitness session the day before testing. Assignment of subjects to day of testing was quasi-random, with some constraints due to scheduling difficulties. Following post-testing, the experimental subjects met jointly to complete the questionnaire package, view video-tapes of aerobic and anaerobic training sessions, and receive payment for their participation.

Measures

Scoring and analysis of the various measures monitored during psychosocial stress was identical to that in Experiment 1. Scoring of additional measures are described below.

Aerobic fitness. This was the time required to attain 85% of maximum heart rate on the treadmill. The correlation found between this measure (TIME) and the screening ergometer test (r= .74) paralleled that reported in the literature (Astrand & Rodahl, 1977). Available norms indicate that TIME for those in very poor, poor, fair, good and excellent condition are as follows: below 11 min, between 11 and 13 min, between 13 and 16 min, between 16 and 19 min, and above 19 min, respectively (Cooper, 1977).

Percent Body Fat. A standard formula (Allen et al, 1956) which incorporates the 10 skinfold measurements, as well as height and weight of the subject, was used to calculate these data.

Daily Hassles. This scale yields scores for absolute frequency of hassles as well as the ratio of average severity per hassle (the total frequency score divided by the total severity score).

Self-esteem: This scale yielded scores for self-esteem, self-denigration and self-mastery.

Results

Data Analysis. The following strategy was used in analyzing the data. Firstly, product-moment correlations between pre-treatment aerobic fitness scores and pre-treatment psychosocial stress measures were computed for the entire sample, in order to assess whether differing levels of aerobic fitness were associated with differences in response to, or recovery from, psychosocial stress. Secondly, the effectiveness of the quasi-random assignment was examined by comparing the three groups on all pre-treatment scores, using one-way analyses of variance (ANOVA). Thirdly, effectiveness of treatment was assessed through changes in physiological measures associated with aerobic fitness. Fourth, three-way repeated-measures (group X session X period) ANOVAs were conducted on psychosocial stress measures, in order to examine whether treatment was associated with an altered response to psychosocial stress (Biochemical measures were analysed in a two-way (session X period) in the aerobic group alone). Finally, correlational analyses between changes in aerobic fitness and changes in psychosocial stress response were conducted in the aerobic group alone, in order to further examine the question of interest.

Subject Attrition. One subject in the aerobic group and two in the anaerobic group failed to attend at least 50% of classes, and were eliminated from all but the pre-treatment correlational analyses. Remaining subjects attended between 80-100% of all classes.

Pre-treatment Correlations

Correlations between treadmill time (TIME) and all baseline measures revealed significant correlations between aerobic fitness and resting heart rate (HR) ($r= -.42$, $p < .01$), resting diastolic blood pressure (DBP) ($r= -.42$, $p < .01$), and percent body fat (PBF) ($r= -.42$, $p < .05$). Correlations between TIME and response to psychosocial stress yielded only a tendency for heart rate at minute 5 of recovery (change from baseline) to be negatively correlated with TIME ($r= -.27$, $p=.05$, one-tailed). This relationship is depicted in the scatterplot in Figure 7.

Pre-treatment: Equivalence of Groups

Table 2 presents pre- and post-test means and standard errors for selected variables. One way ANOVAs conducted on pre-test values of these variables revealed no pre-treatment group differences, with the exception of self-mastery; pre-treatment scores on this measure were significantly ($F(2,31)= 3.3$, $p < .05$) lower in group aerobic relative to the other groups.

Pre-post Changes on Physiological Measures of Aerobic Fitness

Figure 8 depicts pre and post levels of TIME and resting heart rate for all groups. Two way ANOVA revealed significant group x session interactions for both TIME ($F(2,32) = 10.24$, $p < .005$) and resting HR ($F(2,32) = 9.49$, $p < .001$). Scheffe's multiple comparison test ($p < .05$) revealed the source of the interaction in both of these variables as being due to increases in TIME and decreases in

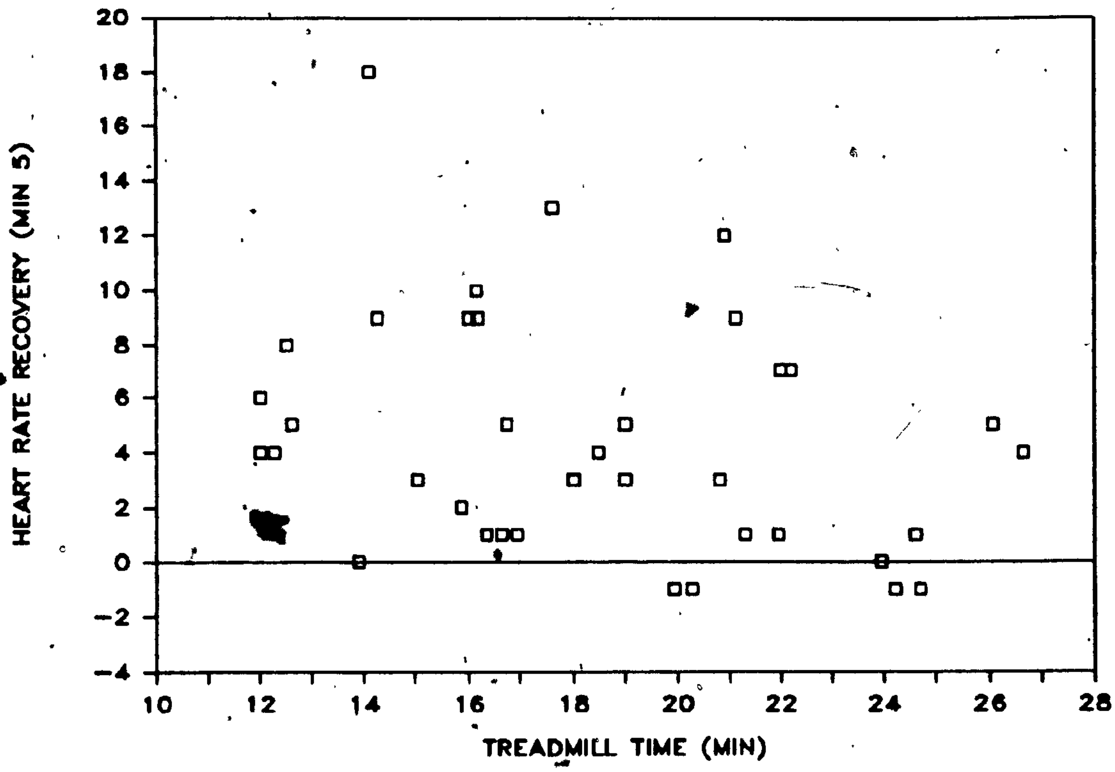

Figure 7. Scatterplot depicting the relationship between treadmill time and heart rate recovery (change from baseline) at minute 5 of the recovery period, for all subjects, prior to treatment

Table 2

Means and Standard Errors of Selected Variables in All Groups Prior to (Pre) and Following (Post) Treatment

Physical/Physiological Measures

		AER	ANA	CTL
Age		23.7 ± 0.8	23.7 ± 0.9	22.0 ± 1.2
Weight (kg)	Pre	76.7 ± 3.5	74.9 ± 2.2	80.2 ± 2.5
	Post	76.7 ± 3.6	76.0 ± 2.3	81.3 ± 3.2
Systolic blood pressure (mm/Hg)	Pre	118.6 ± 2.6	123.1 ± 3.0	113.0 ± 4.1
	Post	119.0 ± 2.8	122.6 ± 4.6	120.3 ± 4.1
Diastolic blood pressure (mm/Hg)	Pre	73.3 ± 2.4	72.8 ± 2.9	68.5 ± 1.9
	Post	73.9 ± 1.6	71.4 ± 2.8	75.5 ± 2.9
Percent Body Fat	Pre	11.6 ± 1.7	12.7 ± 1.3	14.4 ± 1.6
	Post	11.6 ± 1.5	12.9 ± 1.4	14.5 ± 1.8
Treadmill Time (min)	Pre	17.3 ± 1.2	19.5 ± 0.9	19.5 ± 1.6
	Post	21.2 ± 0.9	19.9 ± 1.0	18.9 ± 1.9
Resting HR	Pre	72.0 ± 3.1	64.7 ± 3.2	66.1 ± 4.9
	Post	59.0 ± 2.5	66.3 ± 4.4	65.1 ± 3.9

Self-report Measures

		AER	ANA	CTL
Daily Hassles (Frequency)	Pre	25.64 ± 3.2	36.08 ± 5.5	31.43 ± 5.6
	Post	23.30 ± 2.6	26.46 ± 5.4	24.00 ± 4.7
Daily Hassles (Severity)	Pre	1.51 ± 0.06	1.38 ± 0.05	1.55 ± 0.12
	Post	1.51 ± 0.07	1.29 ± 0.07	1.50 ± 0.14
Self-esteem	Pre	28.2 ± 1.1	29.1 ± 1.2	27.1 ± 2.7
	Post	30.1 ± 0.9	30.1 ± 0.8	27.3 ± 3.0
Self-denigration	Pre	13.9 ± 1.4	10.5 ± 1.2	13.1 ± 3.1
	Post	12.4 ± 1.3	9.0 ± 1.0	13.5 ± 2.4
Self-mastery	Pre	35.4 ± 1.9	40.7 ± 1.0	41.1 ± 2.8
	Post	40.4 ± 1.7	38.8 ± 1.5	38.1 ± 1.7

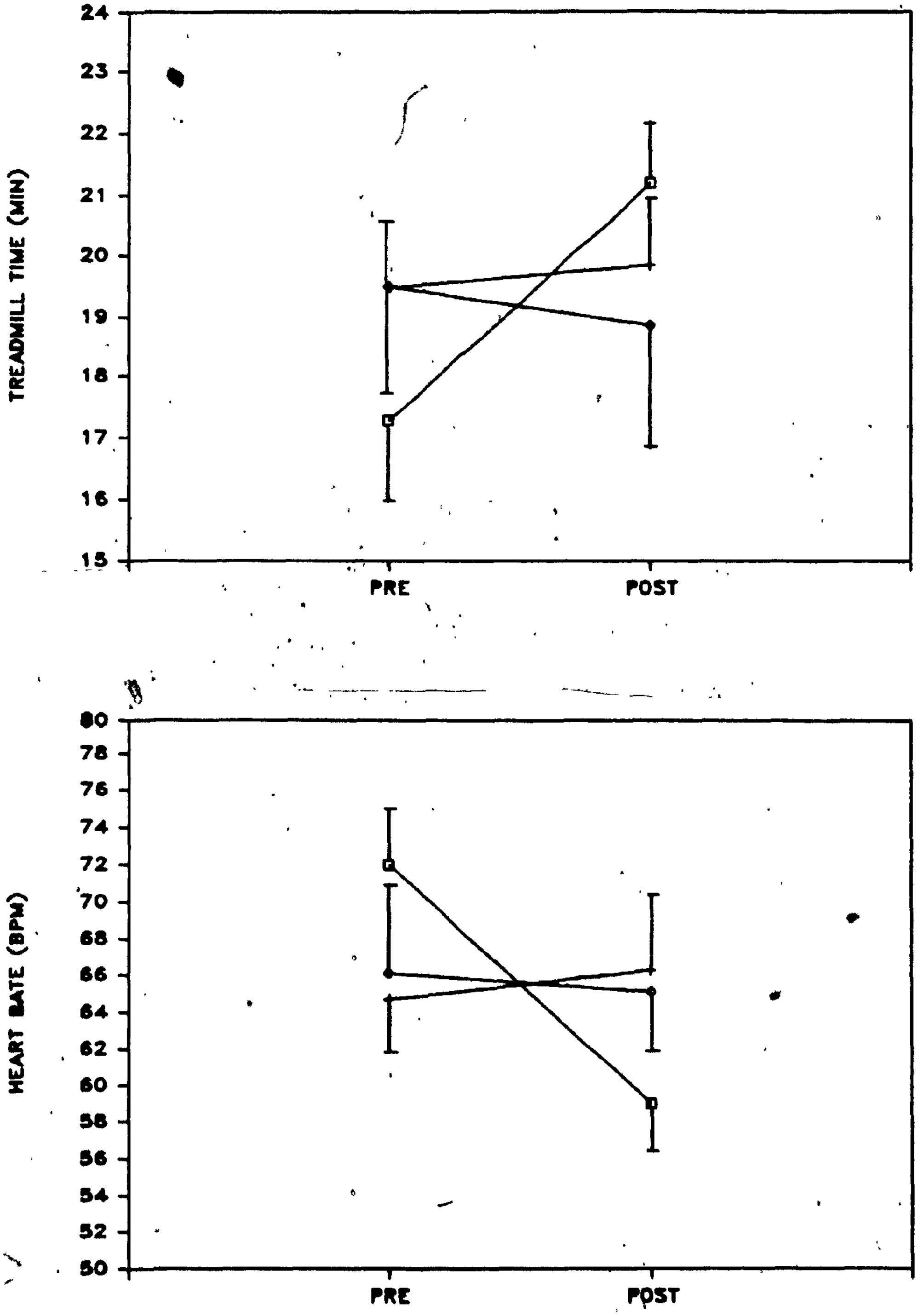

Figure 8. Mean (± standard error) scores on measures of aerobic fitness in aerobic (□), anaerobic (+) and control (◇) groups, prior to (pre) and following (post) treatment. Upper panel: Time (min) to attain 85% of maximal heart rate on the treadmill; Lower panel: Resting heart rate (bpm)

resting HR in group aerobic from pre to post-testing, with groups anaerobic and control showing no changes. However, no group differences were found for TIME or resting HR, at either pre or post-testing.

Pre-post Changes in Psychosocial Stress Response

Heart Rate. Figure 9 depicts mean heart rate change from baseline across all periods of the psychosocial stress session, prior to and following treatment, in all groups. A three-way ANOVA (group x session X period) revealed significant session ($F(1,32) = 6.47$, $p < .05$), period ($F(8,256) = 113.7$, $p < .0001$) and session x period effects ($F(8,256) = 2.56$, $p < .05$). No group x session x period interaction was seen on this measure.

Subjective Arousal Level. Figures 10 depicts SAL scores across all periods of the psychosocial stress period on pre- and post-testing, in all groups. A three way ANOVA (groups x session x period) revealed only a significant period effect ($F(8,256) = 158.4$, $p < 0001$).

Spielberger State Anxiety Inventory. Figures 11 depicts SSAI scores prior to and following the psychosocial stress session, and on pre- and post-testing, in all groups. A three-way ANOVA revealed only a significant period effect ($F(1,32) = 4.76$, $p < 05$).

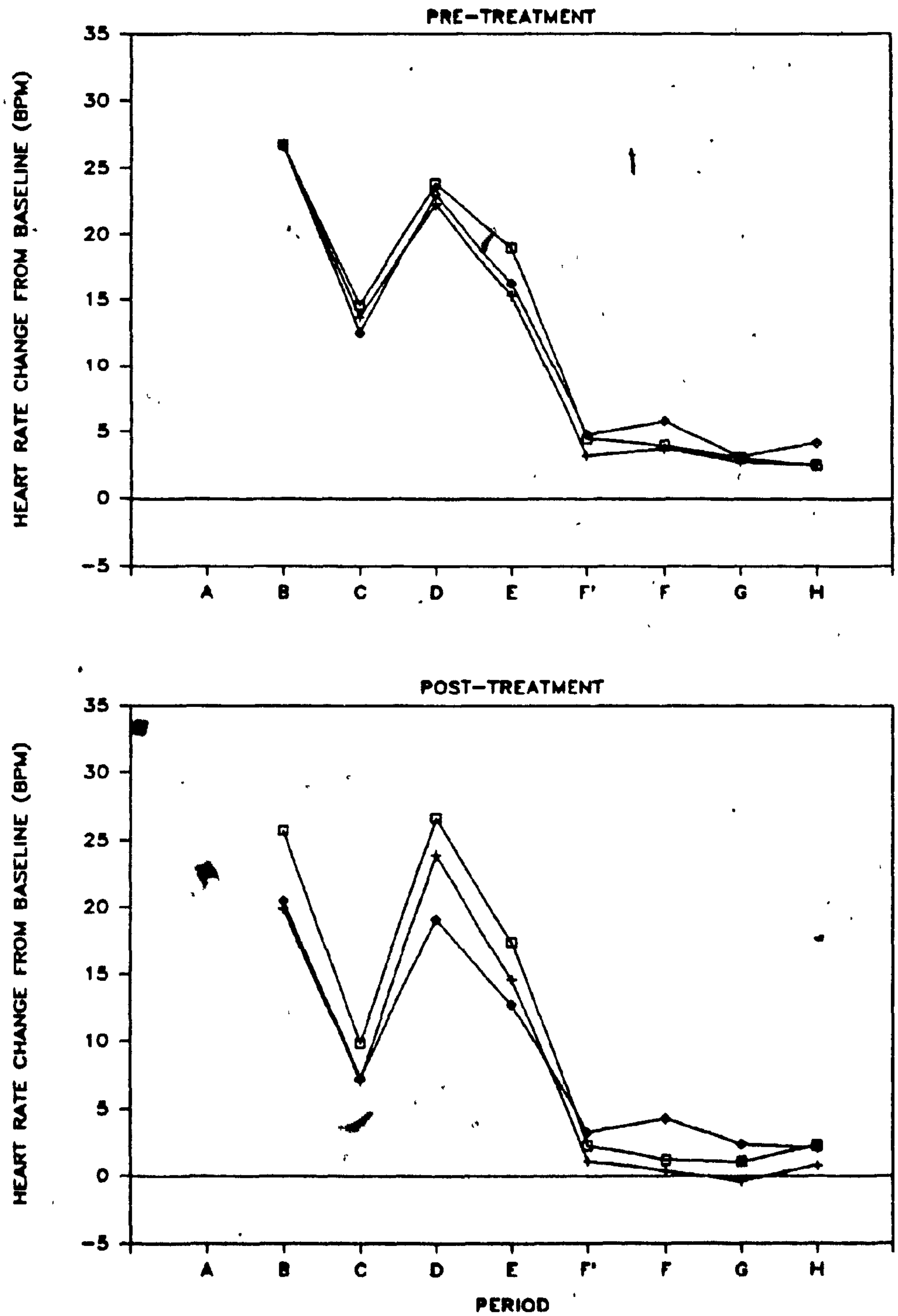

Figure 9. Mean heart rate change from baseline in beats/min for all periods in aerobic (□), anaerobic (+), and control (◇) groups, prior to and following treatment. Upper panel: Pre-treatment; Lower panel: Post-treatment

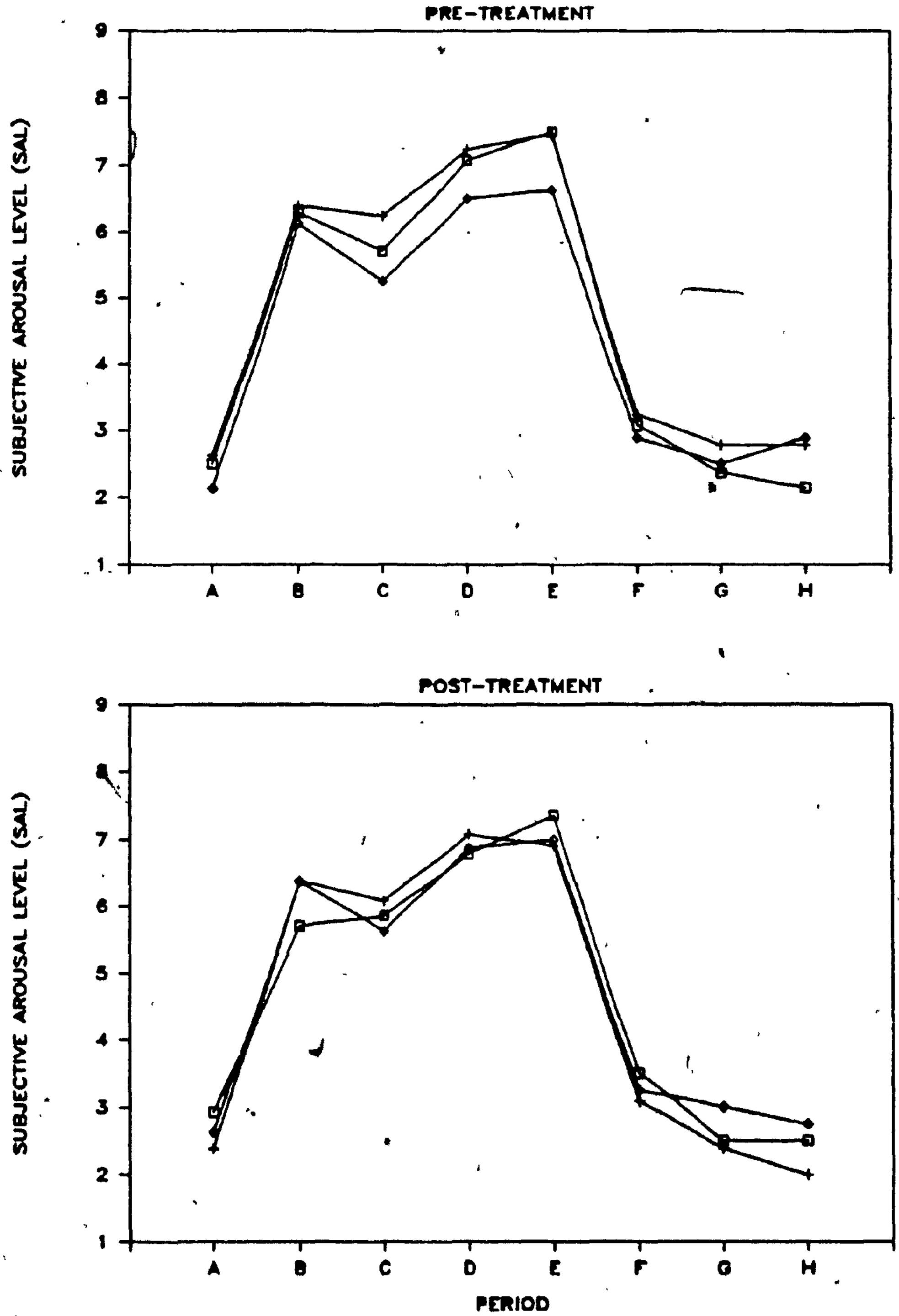

Figure 10. Mean subjective arousal level for all periods in aerobic (□), anaerobic (+), and control (◇) groups, prior to and following the treatment period. Upper panel: Pre-treatment; Lower panel: Post-treatment

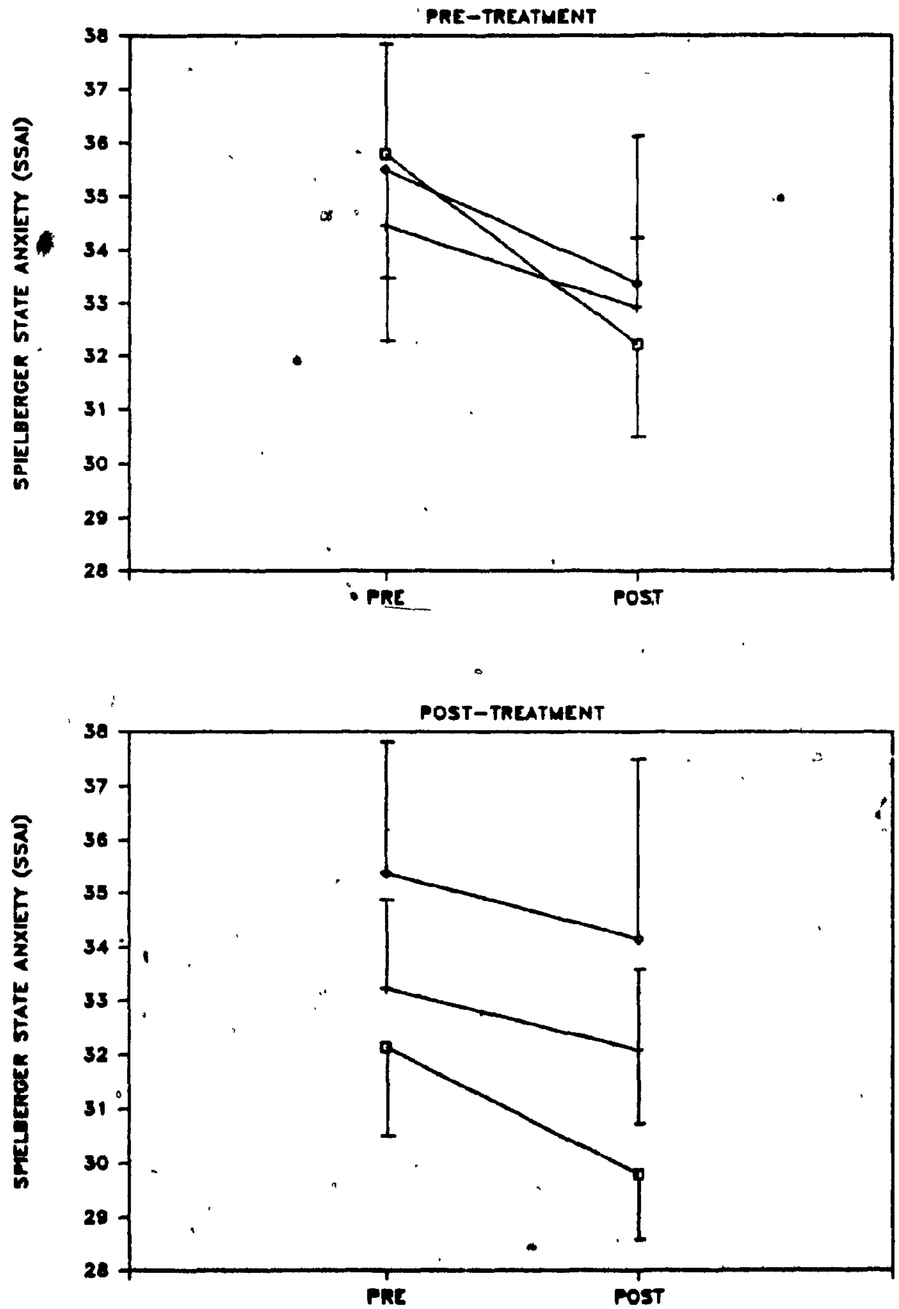

Figure 11. Mean (± standard error) Spielberger State Anxiety score prior to (pre) and following (post) the psychosocial stress session in aerobic (□), anaerobic (+), and control (◇) groups, prior to and following the treatment period. Upper panel: Pre-treatment; Lower panel: Post-treatment

Performance on Tasks. Groups did not differ on task performance on pre-testing, nor on post-testing. Performance improved in all groups from pre- to post-testing.

Biochemical Measures. Six subjects from group aerobic were selected, on the basis of improvement in aerobic fitness, for catecholamine analysis and 10 for cortisol and prolactin analyses. Mean levels of epinephrine and norepinephrine across selected periods of the psychosocial stress session, at pre- and post-treatment, are presented in Figure 12. Two way ANOVA revealed only significant period effects for both E ($F(6,24) = 4.91$, $p < .005$), and NE ($F(6,24) = 3.81$, $p < .01$). Mean cortisol and prolactin levels at both test sessions are presented in Figure 13. ANOVA revealed no period, treatment, or period by treatment interaction for either cortisol or prolactin.

Self-report measures. ANOVA revealed no effect of treatment on number or perceived severity of hassles, although these were reduced in all groups from pre to post-treatment. ANOVA of self-esteem scale revealed only a group X session interaction for self-mastery ($F(2,30) = 6.96$, $p < .005$), attributable to subjects in group aerobic significantly increasing on this measure, relative to the anaerobic and control conditions.

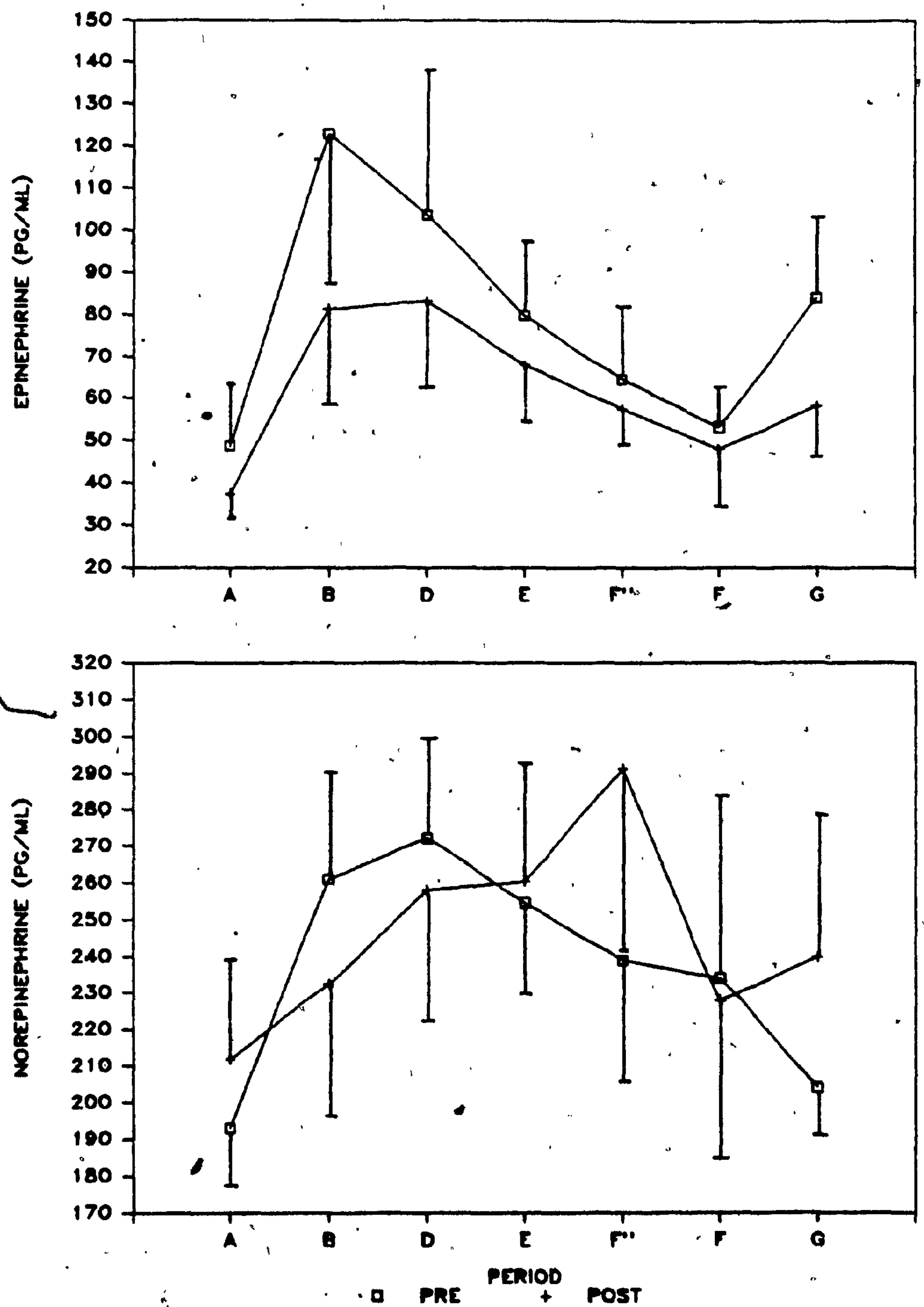

Figure 12. Mean (± standard error) epinephrine and norepinephrine (pg/ml) levels for 6 selected subjects in group aerobic, prior (pre) to and following (post) the treatment period. Upper panel: Epinephrine; Lower panel: Norepinephrine

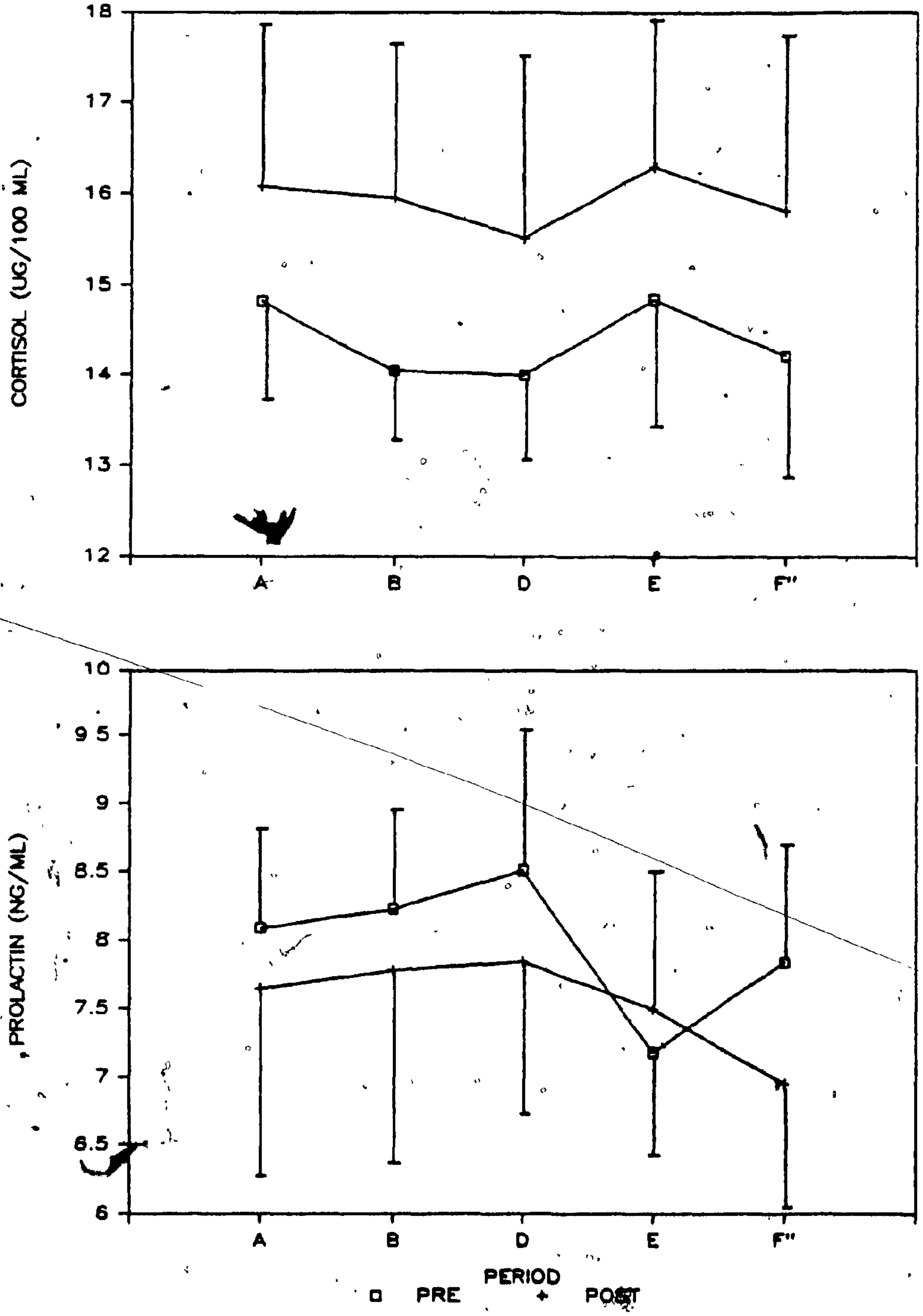

Figure 13. Mean (± standard error) cortisol and prolactin levels for 10 selected subjects in group aerobic, prior to (pre) and following (post) the treatment period. Upper panel: Cortisol (ug/100 ml); Lower panel: Prolactin (ng/ml)

Pre-post Correlational Analyses

Change in TIME with change on baseline measures. These correlations were conducted for group aerobic only, given the relatively minimal changes in aerobic fitness in the other groups. Correlation coefficients are presented in Table 3. Increases in TIME were associated with reductions in resting HR and cortisol (COR) levels, and increases in resting NE. Scatterplots depicting the latter two correlations are presented in Figure 14.

Change in TIME with change in psychosocial stress response. Pre-post treatment change scores were computed from stress response scores corrected (change from) for baseline. Correlations conducted in group aerobic, presented in Table 4, revealed only an association between TIME and heart rate at minute 5 of the recovery period ($r=-0.47$, $p<.05$, one-tailed), with increases in TIME associated with reduced heart rate, supporting the finding seen in Experiment 1. This relationship is depicted graphically in the scatterplot seen in Figure 15. Analyses conducted on biochemical measures revealed that NE scores were negatively correlated with TIME, with significance seen at point D and E of the stress period, and at point G of the recovery period. As well, increase in TIME was associated with increased reactivity of cortisol with stress onset (point B). Visual inspection of the apparently significant relationship between improvement in TIME and higher prolactin levels at point E revealed what appeared to be a spurious relationship resulting from outlying points.

Table 3

Correlations Between Change in Treadmill Time
and Changes in Baseline Measures of
Selected Variables in Group Aerobic

HR	WT	SBP	DBP	PBF	SAL	SSAI
-0.60*	-0.36	-0.28	-0.27	-0.01	-0.11	-0.12
N=14	N=14	N=14	N=14	N=14	N=14	N=14

E	NE	COR	PRO
-0.41	+0.91**	-0.68*	-0.49
N=6	N=6	N=10	N=10

*$p < .02$

**$p < .01$

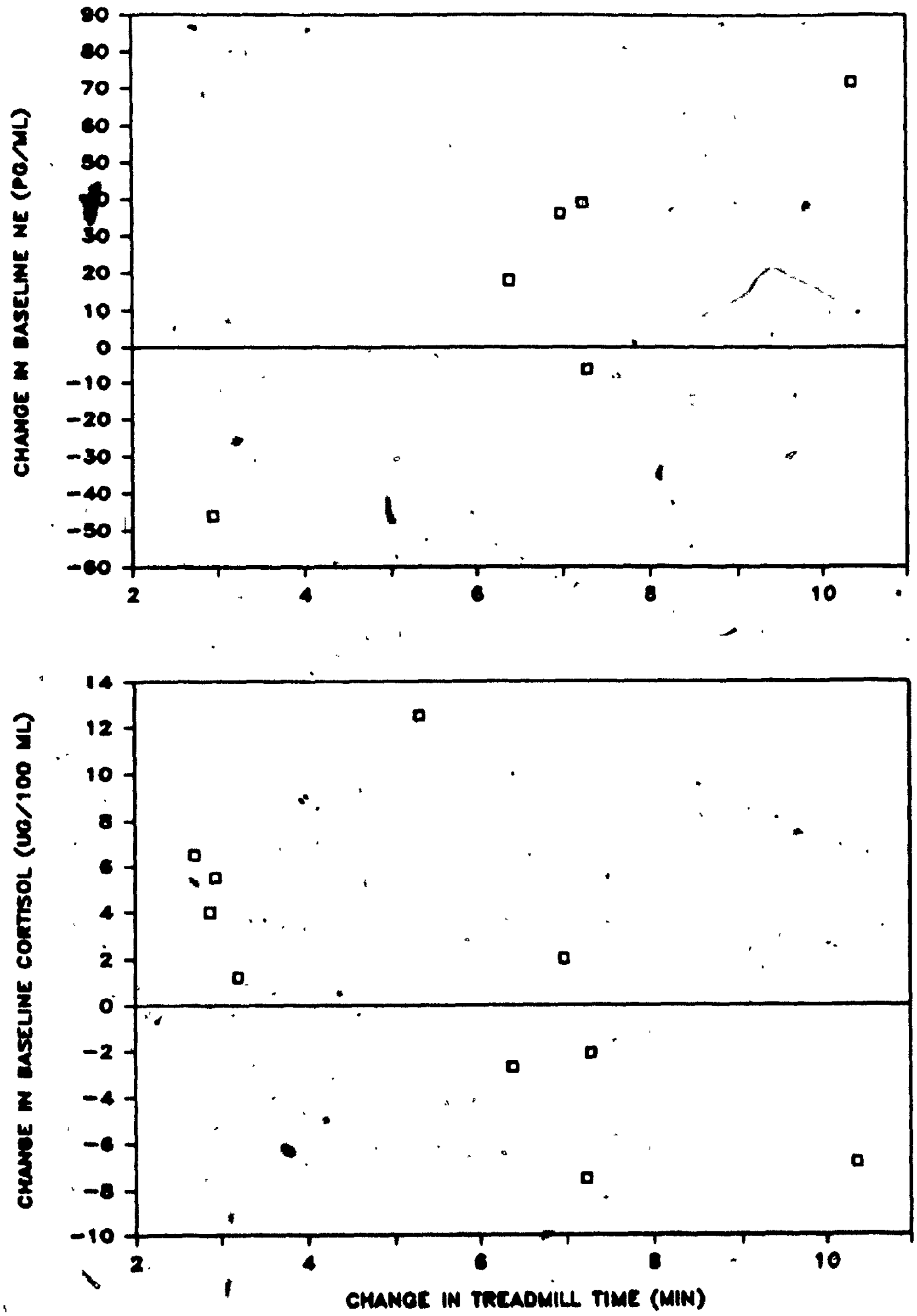

Figure 14. Scatterplots depicting the relationship between change in treadmill time from pre to post treatment with changes in baseline norepinephrine and cortisol levels for selected subjects in group aerobic. Upper panel: Norepinephrine (pg/ml; n=6); Lower panel: Cortisol (ug/100 ml; n=10)

Table 4

Correlations Between Change in Treadmill Time and Change in Selected Variables (All Change from Baseline) During Stress and Recovery Points in Group Aerobic

	STRESS				RECOVERY				
	B	C	D	E	F'	F''	F	G	H
HR	-.11	-.22	-.03	-.20	-.28	-.25	-.47**	-.24	-.32
SAL	.02	.16	.20	.22	--	.06	.14	.42	.27
E	.28	--	.50	.50	--	.32	.22	.46	--
NE	-.36	--	-.71*	-.90*	--	-.55	.08	-.71*	--
COR	.66*	--	-.08	-.05	--	--	--	--	--
PRO	.06	--	.27	.65*	--	.46	--	--	--

*$p < .05$

**$p < .05$ (one-tailed)

-- One or both pairs of variable(s) not sampled at this point

HR & SAL (N=14), E & NE (N=6), COR & PRO (N=10)

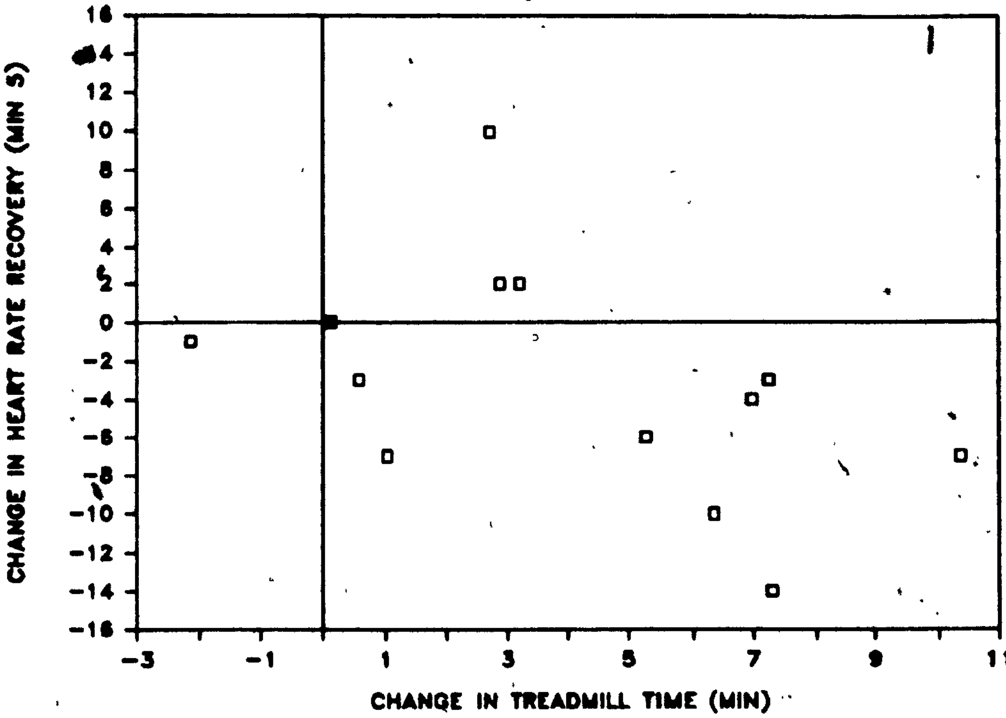

Figure 15. Scatterplot depicting the relationship between change in treadmill time from pre to post treatment, and change in heart rate recovery (change from baseline) at minute 5 of the recovery period, for subjects in group aerobic

Discussion

In a group of subjects who underwent aerobic training, in comparison to groups which received anaerobic or no training, aerobic fitness training failed to alter response to psychosocial stress. In spite of marked improvement in aerobic fitness from pre to post-testing in the aerobic group relative to these comparison groups, no group differences in physiological or psychological response to psychosocial stress were apparent at post-testing.

Looking at the aerobic group alone, however, it was found that degree of improvement in fitness was positively correlated with more rapid heart rate recovery in aerobic subjects from pre- to post-treatment. This relationship between aerobic fitness and heart rate recovery was also evident in the entire sample prior to treatment. Taken together, these findings are consistent with the results of the first experiment of this thesis, as well as previous reports (Cox et al, 1979; Keller & Seraganian, 1984). The failure to observe any relationship between aerobic fitness and the actual heart rate response to psychosocial stress is also consistent with these studies.

Improvement in aerobic fitness was also associated with higher baseline norepinephrine and lower baseline cortisol levels, as well as higher cortisol levels soon after stressor onset. It is unclear whether the baseline changes reflect purely physiological adaptations associated with aerobic training, or, given that these "resting" measures were taken during the psychosocial stress session, whether they in fact reflect an altered response to psychosocial stress. In either case, the significance of such altered baselines is unclear. However, the norepinephrine finding is consistent with a reduction in sympathetic nervous system responsivity which apparently accompanies training. For example, there is evidence of reduced adrenergic receptor density accompanying aerobic fitness training (Butler, O'brien, O'Malley & Kelly, 1982), which is thought to be an adaptation to regular exposure to high levels of catecholamines which are released during exercise (Peronnet et al, 1981). Thus, more norepinephrine would be required to elicit the same end-organ effects (e.g. heart rate and blood pressure). Interestingly, this reduced sympathetic nervous system responsivity has been demonstrated in subjects regularly engaged in eliciting the relaxation response (Hoffman et al, 1982).

Regarding the observed relationship between fitness improvement and greater cortisol levels with stressor onset, this finding is consistent with literature relating strong hormonal (albeit sympathetic-adrenal) release with improved psychological functioning (Forsman, 1980; Roessler, 1967). It should be mentioned, however, that such a finding may also be an artifact associated with the reductions in baseline on this measure; it is likely that the apparently reduced norepinephrine reactivity, evidenced in negative correlations between improvement in fitness and reduced increases from baseline, represents such an artifactual effect attributable to the changes in baseline on this measure.

Self-report measures revealed that self-mastery significantly improved in subjects receiving aerobic training as compared to subjects in the other groups; however, these subjects had lower pre-treatment scores on this measure than the other two groups, so that it is unclear whether the observed effect was due to treatment or simply regression towards the mean (Campbell & Stanley, 1963). Nevertheless, these results are consistent with numerous reports suggesting that aerobic training positively influences such measures (Hanson & Neede, 1974; Hilyer & Mitchell, 1979; Long, in press-a,b). Finally, no relationship was observed between improvement in aerobic fitness and subjective measures of arousal or anxiety during the session, or self-reported frequency or severity of daily hassles.

With the exception of the self-mastery finding, all of the significant results described above represent correlations between fitness improvement and various measures, in the aerobic group alone. No differences were found on heart rate and subjective response or recovery during psychosocial stress from pre to post-treatment. Thus, in spite of the clear effectiveness of aerobic treatment as manifested by changes on resting heart rate and treadmill time in the aerobic group, no differences were found between this group and the comparison conditions.

The failure to detect any group differences following treatment may be due to at least two possibilities. One potential problem is related to the initial fitness level of subjects in this experiment. Prior to treatment, all subjects may have had higher aerobic fitness levels than untrained subjects in the first experiment. Although a comparison of treadmill scores in this experiment with bicycle ergometer scores in the first experiment presents some difficulty, an estimate yielded a mean score for estimated VO2max of 39 in the present experiment, versus 32 in the previous experiment. One possible reason for this is that although subjects were initially recruited on the basis of comparability of fitness scores to untrained in the first experiment, up to a two month period elapsed between screening and pre-testing for some subjects. This may have allowed subjects to engage in physical activity (these were summer months) although they were explicitely instructed not to change their habitual level of activity. In fact, the screening procedure itself may have served as a stimulus for engaging in physical activity. This was confirmed by several subjects at pre-testing. Thus, it is possible that some of the expected effects could not manifest themselves, given the higher level of conditioning. This may have limited the extent of possible aerobic improvement; the effects of training programs of the duration used in the present experiment, are known to be particularly apparent in those who are most unfit from the outset (DeVries, 1968; Folkins et al, 1972; Hilyer & Mitchell, 1979; Morgan et al, 1970).

Second, although the training program was of sufficient duration to allow physical training effects to occur, it is conceivable that psychological adaptations follow a different time course. A ten-week training period was selected on the basis of prior literature indicating substantial physiological changes with programs of such duration (Astrand & Rodahl, 1977; Winder et al, 1978); as well, this training period is typically used in studies in this area (Long, in press-a; Hilyer & Mitchell, 1979). Perhaps a longer training program is required for changes in stress-response which may accompany aerobic training to become evident. It should be recalled that the subjects in the first experiment had been engaged in aerobic activities for an average of 5.5 years.

To summarize, while the present experiment partially confirmed the impact of aerobic training in enhancing recovery of heart rate following psychosocial stress, it failed to demonstrate group effects on heart rate, subjective and biochemical measures, effects which were expected on the basis of the findings in the first experiment. This failure may have been due to the fact that these latter findings represented differences which existed in these groups prior to training, as previously mentioned. However, the possibility exists that such effects as observed in the first experiment are attributable to aerobic training, but that the present experiment did not provide an adequate test of this possibility. The latter may have been due to subjects not being sufficiently untrained prior to treatment, and/or the treatment program not being of sufficient duration to elicit these effects.

General Discussion

The first experiment of this thesis examined the relationship between aerobic fitness level and response to laboratory psychosocial stress, through comparisons between trained and untrained subjects. Trained subjects showed faster heart rate recovery and lower self-reported arousal and anxiety following termination of stress, as well as an earlier peaking of norepinephrine and higher prolactin levels prior to stress. The finding of faster heart rate recovery replicates the work of others (Jamieson, Evans & Cox, 1982; Keller & Seraganian, 1984) but the subjective and biochemical findings represent the first demonstration of such differences between the trained and untrained. Earlier response to and faster recovery from psychosocial stress have been suggested to reflect improved psychological functioning (see Burchfield, 1979; Frankenhauser, 1980). Thus, these findings are consistent with the hypothesis that aerobic fitness is associated with a more adaptive response pattern to psychosocial stress.

The second experiment was designed to further address this question through the manipulation of aerobic fitness level, the inclusion of comparison groups, and the addition of self-report measures to provide data regarding stress-response outside laboratory situations. Analyses conducted on all subjects prior to training confirmed the expected relationship between initial aerobic fitness level and more rapid heart rate recovery following psychosocial stress. Although post-treatment scores revealed that subjects in the aerobic group became more aerobically fit as evidenced by reductions in resting heart rate and improved endurance on treadmill testing, no group differences were seen in heart rate or subjective recovery from psychosocial stress. Analyses conducted within the aerobic group alone revealed that fitness improvement was associated with faster heart rate recovery following stress. Preliminary biochemical measures, conducted on aerobic subjects alone, revealed that training was associated with an increase in resting levels of norepinephrine and a decrease in resting cortisol levels. Improvement in aerobic fitness was also associated with higher cortisol levels upon stress onset. Psychological measures revealed increases in self-mastery with aerobic training.

The second experiment replicated the correlation between initial aerobic fitness level and heart rate recovery following stress, and also demonstrated that fitness improvement for subjects in the aerobic group was correlated with faster recovery on this measure of sympathetic arousal. As an index of psychological functioning, such faster recovery has been shown to correlate with measures indicating more efficient psychological functioning (Bull & Gale, 1973; Johansson & Frankenhauser, 1973) as well as reflecting the degree of the individual's recent life stresses (Pardine & Napoli, 1983). The clinical implications of such recovery are less clear, although it would appear that such faster recovery would be adaptive in that it would restore homeostasis following such situations (Frankenhäuser, 1980); as well, this faster recovery may reduce the risk of further experiencing negative emotions (Zillman, Johnson & Day, 1974).

The second experiment failed to confirm the effect of aerobic fitness on subjective recovery observed in the first experiment, as well as the norepinephrine and prolactin effects. There are at least two possible reasons for this.

The most apparent possibility for the discrepancy between these studies is that the differences seen in the first experiment may have reflected self-selection of subjects into the two groups. That is, as is possible in any such correlational study, the subjects may have been different even before embarking on fitness training, with these differences possibly associated with participation or lack of participation in aerobic activities. Although correlational studies such as this can be regarded to provide preliminary information regarding a causal hypothesis (Campbell & Stanley, 1963), such problems with extrapolating from such studies has been described elsewhere (Folkins & Sime, 1981; Hammett, 1967).

The second possibility is that aerobic fitness is in fact associated with such adaptive responses, but that for several reasons, the second study did not permit the demonstration of these differences. The following will examine these possible reasons.

It seems first necessary to note that the validity of the second experiment as an experimental test of the effects observed in the first experiment, would appear to depend on certain premises. The first is that prior to group assignment and treatment, all subjects had aerobic fitness levels comparable to the untrained subjects in the first experiment. The second premise is that aerobic treatment would elevate the fitness level of these subjects to levels approaching those of trained subjects in the first experiment. Given the short duration of treatment, the latter was regarded as unrealistic from the outset; nevertheless, based on the assumption that the impact of aerobic fitness on stress-response represents a continuum effect, it was hoped that improvement in fitness would lead to changes in the direction predicted by the results observed in the first experiment. This would allow some examination of the question of interest.

Regarding the first premise, it appears that prior to treatment in Experiment 2, subjects in all groups were in better aerobic condition than untrained subjects in the first experiment. Furthermore, pre-treatment scores on several measures revealed that the subjects in the second experiment were not similar to untrained subjects in the first experiment. In particular, on heart rate recovery following stress, all subjects had recovered to a mean heart rate which fell between those seen in the two groups in the first experiment. Baseline cortisol and prolactin levels prior to treatment were also approximately halfway between levels in the trained and untrained in the first experiment. Subjective arousal level, on the other hand, resembled more that of trained subjects in the first experiment, with reductions seen post-session; it is unclear whether this is specifically related to aerobic fitness or other differences between untrained subjects in the first experiment and subjects in the second (e.g. expectation regarding treatment). Pre-treatment anxiety scores also differed from those in the first experiment; resting levels were higher in the entire sample in Experiment 2 as compared to mean levels across both groups in Experiment 1 (35 vs 31).

Overall, given this state of affairs, there may have been little room for aerobic training to alter fitness level or stress-response. Given that the more untrained subjects appear to derive the maximum psychological benefit from aerobic training (DeVries, 1968; Folkins et al, 1972), the present experiment may have been biased against observing such effects.

The second problem surrounds the extent to which fitness training altered fitness level. The improvement was in the order of 15%, which is similar to that seen in programs of similar duration (e.g. Long, in press-a). However, the effect of aerobic fitness on response to psychosocial stress may require a greater improvement in fitness, perhaps beyond a critical VO_2max. Alternatively, it may take some time for improved fitness of any degree to exert an impact on response to psychosocial stress. The psychological changes associated with fitness improvement may lag behind physiological changes, and a certain period of time may be required for these changes to be integrated. It should be noted that trained subjects in the first experiment had been exercising for an average of over five years. Finally, the variability in training intensity which was evident at aerobic training sessions may have prevented more marked group differences; notwithstanding the efforts of the instructor to motivate subjects to exert themselves, and in spite of the fact that almost all subjects in this group improved on aerobic fitness, some subjects participated more vigourously than others.

While it is difficult to conclusively indicate whether the apparent effects of aerobic fitness seen in the first experiment reflects merely correlation or causation, it appears that the initial fitness of subjects and the extent to which it was altered, present important confounds in interpreting the results of the second experiment.

Regarding the failure to observe any large differences in subjective report, either within the session or on the hassles questionnaire, it is possible that subjects may have to be sufficiently distressed prior to treatment, for effects to be seen. Previous studies suggest this to be the case (DeVries, 1968; Folkins et al, 1972). In the present experiments, subjects were not screened for high distress or life stress. Future studies would do well to focus on these individuals.

Finally, these experiments can also be considered to explore the possible underlying mechanisms through which aerobic fitness training may exert its psychological effects. The findings of the first experiment, coupled with the suggested importance of stress response to overall psychological functioning (Cameron & Meichenbaum, 1982), point to the possibility that aerobic fitness may minimize the impact of stress on the individual. This would appear to bear positively on such affective dimensions as anxiety or depression, which have been reported to be influenced by fitness training (Long, in press-a; McCann & Holmes, 1984). Moreover, the second study of this [redacted] revealed improved mastery as the only self-report measure which differentiated the groups. Changes on measures of self-concept or self-mastery have been reported in the literature to improve with fitness training, and it is conceivable that such changes underlie the psychological effects of exercise (Folkins & Sime, 1981), including its effects on anxiety or depression (Long, in press-b; Bandura, 1977).

Regarding future work, the present experiments would appear to encourage the use of a longer treatment program using direct measures of aerobic fitness, the use of subjects who are initially highly untrained and who report difficulty in coping with stress, and the continued use of measures related to coping with psychosocial stress. The inclusion of process measures (e.g. mastery) would also allow the teasing out of particular aspects of training which are most essential to its effect. Such a strategy would allow further elucidation of whether aerobic training influences response to psychosocial stress.

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Appendix A

Experiment 1: Informed Consent

As a participant in this physical fitness experiment, you will perform a graded exercise test on a bicycle ergometer and several mental tasks. We will require your participation in two sessions.

Explanation of Graded Exercise Test on Bicycle Ergometer
The work loads will begin at a level you can easily accomplish and will be advanced in stages depending on your work capacity. We may stop the test at any time because of signs of fatigue, or you may stop when you wish to, because of personal feelings of fatigue or discomfort. We do not wish you to exercise at a level which is abnormally uncomfortable for you. Your heart rate will be continuously monitored throughout this test via electrodes attached to your chest.

Explanation of Mental Tasks
These tasks will involve presentation of audiovisual materials as well as answering a variety of test questions. These materials have been designed to elicit both subjective and physiological arousal. Although we would appreciate your cooperation, we will, due to the nature of these stimuli, terminate this part of the session at any time, upon your request.

Explanation of Periodic Blood Sampling
This will be done by an experienced registered nurse and will require only a single insertion of a tiny needle at the beginning of the session. Although this should cause you little physical discomfort, we will stop the experiment at any time upon your request.

Risks and Discomforts
There exists the possibility of certain changes occuring during the tests. They include abnormal blood pressure, fainting, disorders of heart beat, and very rare instances of heart attack. Every effort will be made to minimize these by the preliminary screening and by observations during the testing. Personnel trained in Cardio-Pulmonary Resuscitation will be present to deal with unusual situations should they arise.

Inquiries
If you have any doubts or questions about the procedures used in the graded exercise test or the mental tasks, please ask us for her explanations.

Freedom of Consent
Your performance of the graded exercise test and the mental tasks is voluntary. You are free to deny consent if you desire.

I have read this form and I understand the test procedures and the possible risks and discomfort involved. I consent to participate in these tests. I know of no medical reason preventing me from participating in this research.

Date Signature of Subject Witness

Appendix B

Experiment 1: Physical Fitness Questionnaire

Thank you for participating in this research project. All information provided on this questionnaire will be held in strict confidence and used only for research purposes.

Name:..........................

Phone number:..................

Address:............................

Postal code:..................

Age:...............

Mother tongue:....................If not English, are you completely fluent in English?............

Please answer the following questions carefully.

Do you smoke? yes....... no....... If yes, approximately how many cigarettes per day?...... No. of years.....................

Have you had any medical or surgical problems during the last year? yes....... no.......
Please specify...

Do you suffer from any chronic illness? yes....... no.......
Please specify...

Have you ever had heart trouble of any kind? yes...... no.......
Please specify...

Do you now, or have you ever had high blood pressure?...........

Do you have diabetes? yes....... no.......

Do you suffer from epilepsy? yes..... no.....

Do you have asthma? yes..... no.....

Have you ever had a fainting spell? yes..... no..... If yes, please explain?..

Are you presently, or have you ever been treated for psychological or psychiatric reasons? yes..... no..... If yes, please explain briefly.......................................

Please list any medication that you are presently taking and the reason for taking it?..

Please give the date (or approximate date) of your last medical check-up................

Do you wear glasses? yes........ no.......
contact lenses? yes....... no.......
Are you colorblind? yes....... no.......

Occupation...................

Does your work require a lot of moving around, or are you sitting most of the time?.........................

Although you may not follow an exact pattern of activity each week, please try to estimate the average weekly time you spend doing the following activities.

activity	check if you participate	since when?	avg. no. times/wk.	avg. length time/session
walking				
jogging-running				
cycling				
swimming				
cross-country skiing				
fitness classes				
racquet sports				
others (specify)				

Please state whether you have stopped participating in any of the above sports for at least one month within the past year. If so, for how long?...

Appendix C

Experiment 1: Arithmetic Task Examples

Subtract 3 continuously from 100 (20 secs). Stop!
Subtract 7 " " " " " "

What is 4 times 6 plus 2? (approximately 5 sec intervening between examples)

3 x 7 + 2
5 x 6 + 7
9 x 7 + 15
4 x 5 + 13
7 x 7 + 12
6 x 6 + 12
5 x 7 + 11
8 x 6 + 18
7 x 8 + 9

Subtract 6 continuously from 100 (20 secs). Stop!
Subtract 4 " " " " " "
Subtract 13 " " 425 " " "

What is 3 times 5 plus 2?

7 x 6 + 5
7 x 4 + 8
6 x 7 + 13
6 x 6 + 5
6 x 9 + 9
6 x 8 + 11
8 x 9 + 13
8 x 7 + 16
7 x 4 + 15

Appendix D

Experiment 1: General Knowledge Quiz

1. Complete the following sequence: 2, 7, 12, 17, blank ? A: 22

2. If X is greater than Y and Y is greater than Z, then X is blank than Z? A: Greater than

3. Wheel is to car as blank is to sleigh? A: Runner

4. Which word does not have the same meaning as the other words: eminent, vulnerable, distinguished, outstanding? A: Vulnerable

5. If Y is greater than X, and Z is less than X, then Z is blank than Y? A: Less than

6. Who wrote the novel "A Fable"? A: William Faulkner

7. Kite is to fly as boat is to blank? A: Sail

8. Two-thirds of 7 is blank? A: 4 2/3

9. The intensity of the heat of an object is referred to as its blank? A: Temperature

10. Fill in the blank: Far is to near as tall is to blank? A: Short

11. Who wrote "Paradise Lost"? A: John Milton

12. Complete the following sequence: 7, 9, 13, 19, blank A: 27

13. Who wrote The Iliad? A: Homer

14. Music and sculpture are both blank? A: Art

15. Freedom and justice are both blank? A: Rights

16. Twenty-five coins consisting of nickels and dimes equals $2. How many of each kind are there? A: 10 nickels and 15 dimes

17. Which two words have similar meanings? Greed, stupidity, lavishness and cupidity? A: Greed and cupidity

18. The probability of A winning a race is 1/3 and the probability of B winning is 1/4. What is the probability that neither will win? A: 50%

19. James Ford Rhodes is a famous blank? A: Historian

20. Home is to family as school is to blank? A: Class

Appendix E

Experiment 2: General Knowledge Quiz (Post-test)

1. Complete the following sequence: 6, 9, 13, 18, blank A: 24

2. Which of these words is the opposite of "diffuse": imply, concentrate, or pretend? A: Concentrate

3. Plane is to fly as car is to blank? A: Drive

4. Colour is to spectrum as tone is to blank? A: Scale

5. Paintings and music are both blank? A: Art

6. Who wrote "On Liberty"? A: John Stuart Mill

7. Two-thirds of 11 is blank? A: 7 1/3

8. Abdication is to throne as resignation is to blank? A: Office

9. Immanuel Kant is a famous blank? A: Philosopher

10. 25 coins consisting of nickels and dimes equals $2. How many of each kind are there? A: 10 nickels and 15 dimes

11. The measurement of mass per unit volume is called blank? A: Density

12. If X is less than Y and Y is less than Z, then X is blank than Z? A: Less than

13. The probability of A winning a race is 1/3 and the probability of B winning is 1/4. What is the probability that neither will win? A: 50%

14. "From Here To Eternity" and "Citizen Kane" are both blank? A: Films

15. Complete the following sequence: 3, 7, 11, 15, blank A: 19

16. Which of the following words is the opposite of parsimonious: Affluent, prodigal, initial or impromptu? A: Prodigal

17. Who wrote "Heart of Darkness"? A: Joseph Conrad

18. Fish is to cat as banana is to? A: Monkey

19. If X is greater than Y, and Z is less than Y, then Z is blank than Z? A: Less than

20. Who wrote the play "A Glass Menagerie"? A: Tennessee Williams

Appendix F

Daily Hassles Scale

Name: ______________________

Date: ______________________

INSTRUCTIONS:

Below are a list of situations or events that can occur in your daily life. Some may have occurred in the past month, and they may have been hassling or bothersome for you.

First, please circle those items which have represented hassles for you in the past month.

Then, please indicate how bothersome each of the circled hassles has been for you in the past month by circling a 1, 2, or 3 in the column on the right marked HOW BOTHERSOME.

HOW BOTHERSOME

1 Slightly bothersome

2 Quite bothersome

3 Very bothersome

1. Misplacing or losing things	1	2	3
2. Troublesome neighbors	1	2	3
3. Social obligations	1	2	3
4. Inconsiderate smokers	1	2	3
5. Troubling thoughts about your future	1	2	3
6. Thoughts about death	1	2	3
7. Health of a family member	1	2	3
8. Not enough money for clothing	1	2	3
9. Not enough money for housing	1	2	3
10. Concerns about owing money	1	2	3
11. Concerns about getting credit	1	2	3
12. Concerns about money for emergencies	1	2	3

HOW BOTHERSOME

1 Slightly bothersome

2 Quite bothersome

3 Very bothersome

13. Someone owes you money	1	2	3
14. Financial responsibility for someone who doesn't live with you	1	2	3
15. Cutting down on electricity, water, etc.......	1	2	3
16. Smoking too much	1	2	3
17. Use of alcohol	1	2	3
18. Personal use of drugs	1	2	3
19. Too many responsibilities	1	2	3
20. Decisions about having children	1	2	3
21. Non-family members living in your house	1	2	3
22. Care for pet	1	2	3
23. Planning meals	1	2	3
24. Concerned about the meaning of life	1	2	3
25. Trouble relaxing	1	2	3
26. Trouble making decisions	1	2	3
27. Problems getting along with fellow workers ...	1	2	3
28. Customers or clients give you a hard time	1	2	3
29. Home maintenance (inside)	1	2	3
30. Concerns about job security	1	2	3
31. Concerns about retirement	1	2	3
32. Laid-off or out of work	1	2	3
33. Don't like current work duties	1	2	3
34. Don't like fellow workers	1	2	3

HOW BOTHERSOME

1 Slightly bothersome

2 Quite bothersome

3 Very bothersome

35. Not enough money for basic necessities	1	2	3
36. Not enough money for food	1	2	3
37. Too many interruptions	1	2	3
38. Unexpected company	1	2	3
39. Too much time on hands	1	2	3
40. Having to wait	1	2	3
41. Concerns about accidents	1	2	3
42. Being lonely	1	2	3
43. Not enough money for health care	1	2	3
44. Fear of confrontation	1	2	3
45. Financial security	1	2	3
46. Silly practical mistakes	1	2	3
47. Inability to express yourself	1	2	3
48. Physical illness	1	2	3
49. Side effects of medication	1	2	3
50. Concerns about medical treatment	1	2	3
51. Physical appearance	1	2	3
52. Fear of rejection	1	2	3
53. Difficulties with getting pregnant	1	2	3
54. Sexual problems that result from physical problems	1	2	3
55. Sexual problems other than those resulting from physical problems	1	2	3

HOW BOTHERSOME

1 Slightly bothersome

2 Quite bothersome

3 Very bothersome

56. Concerns about health in general	1	2	3
57. Not seeing enough people	1	2	3
58. Friends or relatives too far away	1	2	3
59. Preparing meals	1	2	3
60. Wasting time	1	2	3
61. Auto maintenance	1	2	3
62. Filling out forms	1	2	3
63. Neighborhood deterioration	1	2	3
64. Financing children's education	1	2	3
65. Problems with employees	1	2	3
66. Problems on job due to being a woman or man...	1	2	3
67. Declining physical abilities	1	2	3
68. Being exploited	1	2	3
69. Concerns about bodily functions	1	2	3
70. Rising prices of common goods	1	2	3
71. Not getting enough rest	1	2	3
72. Not getting enough sleep	1	2	3
73. Problems with aging parents	1	2	3
74. Problems with your children	1	2	3
75. Problems with persons younger than yourself...	1	2	3
76. Problems with your lover	1	2	3
77. Difficulties seeing or hearing	1	2	3

HOW BOTHERSOME

1 Slightly bothersome

2 Quite bothersome

3 Very bothersome

78. Overloaded with family responsibilities	1	2	3
79. Too many things to do	1	2	3
80. Unchallenging work	1	2	3
81. Concerns about meeting high standards	1	2	3
82. Financial dealings with friends or acquaintances	1	2	3
83. Job dissatisfactions	1	2	3
84. Worries about decisions to change jobs	1	2	3
85. Trouble with reading, writing, or spelling abilities	1	2	3
86. Too many meetings	1	2	3
87. Problems with divorce or separation	1	2	3
88. Trouble with arithmetic skills	1	2	3
89. Gossip	1	2	3
90. Legal problems	1	2	3
91. Concerns about weight	1	2	3
92. Not enough time to do the things you need to do	1	2	3
93. Television	1	2	3
94. Not enough personal energy	1	2	3
95. Concerns about inner conflicts	1	2	3
96. Feel conflicted over what to do	1	2	3
97. Regrets over past decisions	1	2	3
98. Menstrual (period) problems	1	2	3

HOW BOTHERSOME

1 Slightly bothersome

2 Quite bothersome

3 Very bothersome

99. The weather	1	2	3
100. Nightmares	1	2	3
101. Concerns about getting ahead	1	2	3
102. Hassles from boss or supervisor	1	2	3
103. Difficulties with friends	1	2	3
104. Not enough time for family	1	2	3
105. Transportation problems	1	2	3
106. Not enough money for transportation	1	2	3
107. Not enough money for entertainment and recreation	1	2	3
108. Shopping	1	2	3
109. Prejudice and discrimination from others	1	2	3
110. Property, investments or taxes	1	2	3
111. Not enough time for entertainment and recreation	1	2	3
112. Yardwork or outside home maintenance	1	2	3
113. Concerns about news events	1	2	3
114. Noise	1	2	3
115. Crime	1	2	3
116. Traffic	1	2	3
117. Pollution	1	2	3

HAVE WE MISSED ANY OF YOUR HASSLES? IF SO, PLEASE WRITE THEM IN BELOW:

118. ______________________	1	2	3
______________________	1	2	3
______________________	1	2	3

ONE MORE THING: THIS INVENTORY HAS BEEN BASED ON SITUATIONS OR EVENTS THAT HAVE OCCURRED IN YOUR LIFE IN THE PAST MONTH. WOULD YOU SAY THAT THE PAST MONTH HAS BEEN FAIRLY TYPICAL FOR YOU?

YES ________ NO ________

IF NOT, WHAT HAS BEEN DIFFERENT?

Appendix G

Self-esteem Scale

Name: ____________________

Date: ____________________

INSTRUCTIONS:

This is an inventory of attitudes and beliefs that you may have about yourself. Please consider each statement below, and indicate how strongly you agree or disagree with it at this time. For each statement, place a circle around the number that is most applicable to you.

1. I feel that I have a number of good qualities.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

2. I am able to do things as well as most other people.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

3. I wish I could have more respect for myself.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

4. There is really no way I can solve some of the problems I have.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

5. I have little control over the things that happen to me.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

6. I certainly feel useless at times.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

7. Sometimes I feel that I'm being pushed around in life.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

8. I feel that I'm a person of worth, at least on an equal plane with others.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

9. I can do just about anything I really set my mind to do.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

10. On the whole, I am satisfied with myself.

   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

11. I often feel helpless in dealing with the problems of life.

    Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

12. At times I think I am no good at all.

    Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

13. There is little I can do to change many of the important things in my life.

    Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

14. All in all, I am inclined to feel that I'm a failure.

    Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

15. What happens to me in the future mostly depends on me.

    Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

16. I take a positive attitude toward myself.

    Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree